Eduard Kirschmann

The Age of Throwers:
A new view of humanity

The Chimpanzee-Thrower-Scavenger-Warrior Model of Human Evolution

Translation by Susan E. Way

Table of Contents[1]

---

[1] Page numbers refer to this English version with German text pages in parentheses.

1 Introduction

1.1 A brief anecdote to begin:

A paleoanthropologist wishes to spend a free evening alone relaxing in front of the television. He picks up the remote control and looks at what's on:

1. A program about the Intifada. Young Palestinians *throw* stones at the Israeli military, which answers with tear gas and rubber bullets.
2. Track and field. A javelin thrower shows a successful *throw*. His 800 g javelin lands near the 90 m line.
3. A documentary on the topic of reunification. The "Reunification Chancellor" is getting tomatoes *thrown* at him.
4. An American comedy. The principal actors are *throwing* pies at each other.
5. An English comedy. A man is to be publicly *stoned*; another asks, "Are there womenfolk present?"
6. An Italian comedy. A woman is *throwing* dishes at a man. He ducks skillfully and gives her a dopey grin.
7. Commercial. A man *throws* a boomerang and sets an apple on his head, which is split by the returning boomerang; this is supposed to prove that one should definitely buy the car he's standing next to.
8. Circus. A scantily clad woman stands against a wooden wall. A man *throws* knives that stick in the wood a few centimeters from her.
9. Baseball. The commentator is explaining that the catcher's protective gear serves to prevent injuries from the balls *thrown* at him. After all, the 149 g ball is *thrown* up to 180 km/hr.
10. News. Right-wing radicals are *throwing* Molotov cocktails at a refugee shelter.
11. Western. An Indian is *throwing* his tomahawk.
12. War movie. The hero is *throwing* a hand grenade into the enemy ranks.
13. Children's movie. Children are having a snowball fight.
14. Animal documentary. At the Arnheim Zoo, chimpanzees are *throwing* everything they can get their hands on at a stuffed lion. They never hit their target; the lion is on the other side of a several-meters-wide moat and – for chimpanzees – too far away.
15. Documentary. At a fair in a village in the Cordilleres, ritualized battle games get out of control. At the end, groups from different villages *throw* stones at each other. The end

result is 4 or 5 deaths and satisfied men from the host village, because their village only has one death to mourn this year. The other victims come from the surrounding mountain villages.

16. News. At a demonstration, rabble-rousers *throwing* paving stones encounter riot police with helmets and shields.

Disappointed, the paleoanthropologist *throws* down the remote with the words “everywhere the same” and decides to continue writing a technical paper:

“… in light of their obvious defenselessness (they had neither claws nor large canines), our ancestors had only one way to escape the dangerous predators of the savannah: they had to become more intelligent. …”

1.2 The main players

The list of living and extinct human relatives is long, and each one rightly claims its place in a scenario that has human development as its subject. As it is always quite embarrassing when one doesn't know how to arrange one's own relatives (this danger will be laid out constantly for the reader throughout the course of this book), the most important characters are first briefly summarized in the following overview. With the exception of the African apes, it is a matter of hominids:

Ardipithecus ramidus: at 4.4 million years (MY), the oldest hominid currently known from fossils. Its canine teeth were already shortened and it probably already walked erect.
Australopithecus anamensis: is dated to the time frame of 4.2-3.9 MY ago and is thereby the oldest known australopithecine.
Australopithecus afarensis: lived ca. 3.9-3.0 MY before our time. It is a well-represented, above all by the famous "Lucy," type of australopithecine in the fossil record. *Australopithecus afarensis* could be the ancestor of all later hominids, including humans.
Australopithecus africanus: was made famous by the "Taung child." This child's skull, discovered by Raymond Dart in 1924 in South Africa, was the first australopithecine ever found and called the attention of many researchers to Africa as a possible place of origin in hominid evolution. *Australopithecus africanus* is settled in the timeframe between 3.0-2.0 MY before our time. It likely descended from *Australopithecus afarensis* and could also be the ancestor of all following hominids; this point is controversial; fortunately, it plays no role in this book.
Australopithecus robustus and ***Australopithecus boisei***: peaceful(?), vegetarian relatives of humans (guaranteed not their ancestors). Descended about 2.5 MY ago from a line that specialized in eating large quantities of nutrient-poor food and distinguish themselves primarily through a corresponding chewing apparatus. The teeth of *Australopithecus boisei* earned it the nickname "Nutcracker Man." The two robust australopithecines died out about 1 MY ago – in well-informed circles, stubborn rumors circulate that our direct ancestor from this time, *Homo erectus*, may have had something to do with this.
Homo habilis: claims to be the first human and refers as evidence to the first stone tools in hominid history, which were produced – supposedly by it – around 2.5 MY ago. It can also bring to the field a marked increase in brain volume in comparison to *Australopithecus*

africanus and the African apes. On the other hand, the fragmentary skeleton OH 62 of a female *Homo habilis* indicates very clearly that this species was still a typical australopithecine. In any case – in the model of human evolution presented in this book, *Homo habilis* plays a rather short but very important role at about 2 MY ago. It likely descended from *Australopithecus africanus* or directly from *Australopithecus afarensis* and stands as the ancestor of *Homo erectus*.

Homo erectus: the "chief witness" for the thrower hypothesis presented in this book. For me, it is the first hominid with the fully developed human physique. It appeared for the first time around 1.8 MY ago and was only replaced in the last 0.5 MY by other kinds of humans. According to the latest findings, there were presumably individuals of this species still on Java 30,000 years ago – as contemporaries of fully developed *Homo sapiens*. *Homo erectus* marks, in the view of the thrower hypothesis, a long phase of human development that was characterized by significant intraspecies conflict involving the use of stone projectiles. The indications are increasing that *Homo erectus* isn't just a matter of a single species but rather a whole series of species with quite similar properties. One of these types is among our ancestors.

Presapiens: not really a species, but rather a catchall for fossil finds that no longer fit under *Homo erectus* and don't yet belong with Neandertals or modern humans. Indicates a change in selection criteria at the end of the *erectus* phase.

Homo sapiens neandertalensis: the Neandertal, Ice Age contemporary but not ancestor of modern humans. Its range extended from western Europe to northern Iraq. In the Near East, it coexisted for about 50,000 years with *Homo sapiens sapiens*, but was then displaced and died out within a few millennia (most recent find is 33,000 years old).

Homo sapiens sapiens: the modern human, the "crown of creation" and possibly the greatest natural disaster of all time rolled into one. *Homo sapiens sapiens* is the only extant hominid – which it presumably arranged intentionally for itself. Because it has since expanded into every corner of the earth it is surely known well enough to the reader and need not be explained in further detail.

Pan troglodytes: the common chimpanzee, African ape and one of the two closest living relatives of humans. It plays a decisive role in the model of human evolution presented here, because it is called on as the primate model: that is, the model for the ape that stood as ancestor at the beginning of hominid evolution.

Pan paniscus: pygmy chimpanzee or bonobo, also an African ape and just as closely related to humans as the common chimpanzee. Most scientists currently would probably give it priority in choosing a primate model.

Last common ancestor: African hominoid that, ca. 5 MY ago, became the ancestor of the chimpanzees as well as the hominids. The model of hominid evolution presented in this book operates from the position that it was substantially similar in physique and behavior to the modern *Pan troglodytes*.

Gorilla gorilla: African ape that takes on an important role in that it is less closely related to chimpanzees than they are to humans. It follows from this that most qualities shared by gorillas and chimpanzees probably developed before the human line split off. They were therefore also characteristic of the last common ancestor of chimpanzees and humans.

1.3 Why a new model of human evolution?

In the book before you, a new model of hominid evolution is presented that rests on the thrower hypothesis, that is, on the assumption that in the course of hominid evolution very extensive adaptations for aimed throwing occurred. It is thus a **C**himpanzee-**T**hrower-**S**cavenger-**W**arrior model (CTSW [SWAK] model) of hominid evolution.

It is certainly not the only model of hominid evolution that can be constructed with special consideration for the thrower hypothesis – actually it's not even the first, as some importance was already attributed to throwing within the hunter model. This is, however, to be seen more as a liability for the thrower hypothesis, as it has since been recognized that the early hominids didn't make very believable hunters.

Of course, I could have limited myself to the "pure" thrower hypothesis, which can be verified quite well through the enormous demands of the first-class human throw and through fossils. Nonetheless, I decided to produce a work that goes much further and in some portions perhaps seems unnecessarily speculative. I would like to give my reasons for this approach here.

In 1981, Nancy M. Tanner published her noteworthy book On Becoming Human (German title: "Wie wir Menschen wurden. – Der Anteil der Frau an der Evolution des Menschen" ["How we became human. – The participation of the woman in the evolution of humanity"]). Therein she likewise presented a new model of human evolution. In the front, generally held portion of her book, she discusses the question of why one should try to develop a broadly applicable, multidisciplinary model of human evolution. Her explanations are today still so current and in part agree so well with my own thoughts on this point that I would simply like to cite the following passage in order to explain my motivation for producing a model of human evolution based on the thrower hypothesis. The few points on which I hold a different opinion are indicated with italics (Tanner, 1997):

[TRANS. NOTE: THIS IS MY BACK-TRANSLATION OF KIRSCHMANN'S TRANSLATION OF TANNER. READERS SHOULD OF COURSE REFER TO THE ORIGINAL TEXT FOR TANNER'S EXACT WORDS.]

> "Today there is there is an abundance of information about fossils, animal behavior, and in particular about the social behavior of the great apes; the same applies to modern humans who gather and hunt in small groups, *similar to populations of Homo sapiens in the past*. This accumulation of material represents a certain challenge. Which model for the social life of the first humans can be developed from the

> available material and lead to important questions for continued research? In order to limit the possibilities, the origin model and every step of human evolution must be precise. Certainly, such a model is more controversial, as the underlying assumptions are distinctly formulated and clear interpretations are made. It follows from this that an evaluation of the model is possible, that it can be discussed, that its internal logic and its agreement with the available data are testable. A consistent argumentation and a logical construction become the touchstone for the overreaching correctness of the model. An explicit model is better suited for interpretation, and the significance of new data is easier to gauge. In addition, the formulation of further corollaries or modifications to the model in light of new finds is simplified.
>
> Enlightening insights don't just appear from the "facts;" much more, facts can only be deciphered when they are placed in a theoretical context. The model to a certain extent creates an analogy to the complete picture. One must develop a concept of how the complete puzzle should look in order to find how the pieces must be put together. The collection of data and their interpretation are not two separate enterprises; rather, they complement each other. An effective model ties the data together and gives them meaning; it develops new lines of questioning, points out new paths for research, and defines the framework in which hypotheses are tested and can be compared with existing as well as new data.
>
> The central analytical task in the development of a model of early human evolution consists in incorporating the element of chronological progression into the model. The question of how and in what order behavior patterns originated and were passed on is a firm component of the internal logic of the model presented in this book. … For an effective model of human evolution, one needs a specific starting point – in this case the original hominoid population. Afterwards, hypotheses must be constructed to explain how the changes came about that led to the *transition from apes to the first humans*. Put differently: it is necessary to concern oneself with behavioral changes over the course of time."

The italicized points on which I am of a different opinion are not a matter of theoretical considerations, but rather basic assumptions of Nancy M. Tanner's model. She called on modern hunter-gatherers as a model for reconstructing the behavior of early hominids, whereby she considers the australopithecine brain to be pronouncedly humanlike in its basic construction. Both [points] are probably not justifiable from the present view.

If Nancy M. Tanner wrote already in 1981 that the accumulation of material represented a certain challenge, today one can hardly find words for the collected contributions of individual subject areas to the question of human evolution. And never before were cross-disciplinary models of human evolution so desperately needed to bring order to this chaos of accumulated puzzle pieces as today. On the other hand, there is hardly a simpler way for a specialist to discredit him or herself in the eyes of colleagues and to provoke open attack than to publish an evolutionary model of this sort. Nancy Tanner may have come away from that very well, since in her case overly passionate criticism can quickly be interpreted as male arrogance. Through her – surely justified – suggestion that the part of women and children in human evolution had been plainly ignored in model building by male-dominated science, she protected herself from too-hostile attacks, although this suggestion by itself of course says nothing about the merit of her own model. Worse befell Owen Lovejoy, who at first received much recognition for his pair bonding hypothesis, but over the course of time also reaped open scorn. Such an example doesn't exactly encourage new attempts, although his drive certainly did the scientific discussion good and led to interesting controversies.

New model attempts are exactly what are most desperately needed, in light of the present flood of information, in order to advance our understanding of human evolution. Completely independent of what becomes of my attempt, perhaps a regular prize for the construction of productive models of hominid evolution should be established. A consortium of experts could judge the contributions for originality, concurrence with the findings of individual disciplines, and internal consistency. Model building doesn't differ much in principle from the production of technical and architectural drafts, and is surely worth backing with similar means.

Perhaps a well-known historical example will help me to illustrate how important the right modeling approaches are to the human cognitive process, and at the same time help me counter the reproach that with such methods one can necessarily only find what one is already looking for. For nearly a millennium and a half in the Western world, the Ptolemaic system ruled the perceptions of the learned of the movements of the stars. The movements of the planets as observed from Earth appeared very complicated, and it served as legitimate evidence of the brilliance of the Alexandrian intellectual Ptolemy that he was able to draft a mechanism to explain these movements. In the Middle Ages, he was still generally revered for this masterwork. Hardly any educated person could have imagined a simpler explanation for the movements of the planets. Today we know, after a simple shift of the coordinate origin from the Earth to the Sun, that the planets' courses turn out to be ellipses. And these are among the simplest geometric figures in existence.

A perspective better suited to the problem, a more fitting approach, can often do more for the solution of an unclear question than the life's work of many brilliant scientists who take pains to collect as many facts as possible. Not least because of this, enormous scientific conceptual breakthroughs occur again and again when a person like Darwin or Copernicus tries out an explanatory approach that is better suited to the question at hand. We are thus inclined to glorify such people, because we generally tend to equate success with ability – for myself, I am not certain that Copernicus was more brilliant than Ptolemy.

Anyone who has worked in mechanics possesses, independent from the above example, quite clear ideas about the advantages of choosing problem-appropriate parameters (perspectives). In comparison to human evolution, mechanical problems are as a rule quite simple, very well investigated, and, owing to the insights achieved, somewhat clear. Whoever studies physics or mechanical engineering must deal with, among other things, the production of movement equations, and discovers in doing so that there are many correct but only a few usable approaches to investigating a problem. When one chooses coordinates that are appropriate to the problem, the calculation can be completed in two lines and the results are accessible to interpretation at a glance. If one chooses equally correct, but unsuitable, coordinates to describe the problem to be solved, the calculation will stretch across multiple pages and the result is reached by a very complicated path that cannot be tested at a glance – never mind that a few errors have doubtless slipped in somewhere in the long calculation. One learns very quickly to quit a calculation and try a new approach when the terms become unclear.

The reproach mentioned above, that one can only find what one is already seeking in the investigation of new model approaches, though theoretically true, is nonetheless counterproductive in practice and inhibits scientific progress. It is completely pointless in a complex line of questioning to consider all potential solution paths. When we concern ourselves with such questions, we always use a number of assumptions – if only to order the many facts somehow. Our view of things is always speculative and based on model approaches – that is even true of the "elementary" level of visual perception, which eludes our conscious control.

The only practicable way to a better understanding of things consists in the attempt to replace the model approaches we use in any case with more efficient ones. If a more efficient approach that is more suitable to the question under investigation is then actually applied, it will usually identify itself as such quite clearly. The "new view of things" seems simpler and more plausible – just as was the case in the above-cited cases of planetary movements or the production of movement equations. For this reason, parsimony is one of the most important criteria for judging the quality of a scientific hypothesis. Internal logic and agreement with known facts are other quality criteria. And finally, every new model has sufficient opportunity to defend itself in that it is used as the basis for predictions whose validity can subsequently be tested.

The last point is of decisive importance. A scientific hypothesis should always be formulated precisely enough to use as a basis for genuinely falsifiable predictions, or else it is cognotheoretically useless.
It is relatively easy to develop with commonly held, hardly more comprehensible notions a scenario that has the potential to contain a solution but still has enough play in its possible interpretations to elude every attempt at falsification. In this context, one should explicitly avoid "principles" – overlying notions that one can construe differently as needed. Such notions, beloved in philosophical circles, are justifiable when writing a summary of a scientific hypothesis for which every reader knows that specifics are to be found in the actual text. They can also be quite useful during the search for new approaches to a solution. They should, however, be defined precisely in the actual solution method without exception.
He who declines to make "detailed speculations" in the creation of a scientific hypothesis of course protects himself from demonstrable false inferences, and also from criticism. With regard

to one’s own career, it may therefore appear advisable to avoid such speculations – with regard to scientific conceptual progress, one should demand them.

Even William Calvin, whom we will encounter all the more often in the following and who has earned the designation of supporter of the throwing hypothesis, expresses the supposition that stone throwing is an activity that has been ignored in the discussion of human evolution because it hasn’t left behind any characteristic traces, such as for instance spear points. He also cites in this context a statement of Darlington’s with the substance that modern evolutionary theorists concentrate on what they can see and measure. This is good, [he claims,] although only up to a certain point. Some aspects of evolution that cannot be measured today were probably important, and throwing could be one of them (Calvin, 1983). These remarks are indicative of the difficulties with which the throwing hypotheses have had to deal thus far. They are not, however, indicative because they are true, but because they are false in a characteristic way.

Throwing is criminally underestimated even by proven supporters of throwing hypotheses, in that it is simply postulated to have left behind no traces demonstrable today. Throwing hypotheses are thereby unnecessarily banned to the realm of pure speculation, as they supposedly fail to meet a decisive criterion for the quality of scientific hypotheses – the potential to be falsified – by their “nature.” In reality, it’s more the case that previous supporters of throwing hypotheses haven’t done their homework. They have failed to hone their ideas to sufficient precision and thereby further develop them into scientific hypotheses that meet the requirements of modern science.

When Raymond Dart held the first australopithecine skull in his hands in the Twenties of our century, he understood the importance of this fossil for human evolution very quickly, in part because he recognized that the position of the foramen magnum indicated an erect gait. In light of the high importance that has been assigned to walking erect from the beginning of the discussion of human evolution, it is no wonder that scientists have developed this and other criteria to determine whether or not a newly discovered fossil came from an individual adapted to walking upright.

The high-performance human throw places perhaps even substantially higher demands on the human body structure than walking upright. It would be quite remarkable if – assuming a good knowledge of anatomy – useful criteria could not be developed here also, with whose help fossils could be evaluated in relation to their degree of adaptation for throwing.

Neither are stones exactly inclined to disappear into nothing. If our ancestors, during the course of their evolution, specialized in throwing stones, then it is to be expected that at some time stones that are handy and particularly well suited to throwing will be found in the archaeological record. At least a few stones should differentiate themselves from common ones in that they are found separate from their natural, geological points of origin. Stones that meet these criteria have long been known and substantiated in strata as old as 2.6 MY. They are in fact the first known stone tools – obviously, they were used not just for throwing from the beginning. If, however, they were also used for throwing, then this could have left entirely characteristic use marks on them. It comes back again to sharpening the eye for such marks and to working out criteria for their identification. The adaptations of the brain to throwing might also allow themselves to be identified today – I will make some falsifiable predictions in this direction at an appropriate point.

The knowledge that has been accumulated about human evolution has become enormously unwieldy. Moreover, human ancestors have run a real developmental marathon in the past five million years. Individual complex, and technically very demanding, capabilities have been driven to extremes in this with a certainly enormous developmental expenditure.

I can only imagine such dynamic development as the consequence of quite rigorous and sustained selection of very specific abilities over the course of evolution. Only when pursuing clear developmental objectives can one put forth individual performance items especially quickly and far. One must thus expect clear developmental lines in a representation of human evolution, and if these have not yet come unequivocally to light and clarified for us how and why we have come to be the way we are, this is not really unusual with such confusing lines of questioning and is due to no one having yet investigated a useful approach.

In no case can one conclude from the fact that human evolution currently presents itself as confusing that there can be no simple model for this evolution. Statements about how complex a case really is are only possible when it has been fully explained (As mentioned already, part of how one generally recognizes the “right” solution is that it is simpler (more parsimonious) than other possible solutions).

I for one think I have stumbled over the usable approach mentioned above through an appropriate consideration of throwing adaptations. I have sifted through some of the technical literature in order to test and improve it. In this, I often found it downright ridiculously easy to give simple answers to questions that the field makes difficult for itself. And by now I would either have become a megalomaniac or begun to doubt my intelligence if I didn't know how important a suitable approach is to an effective model and how much the choice of a suitable approach to confusing questions has to do with luck.

In any case, the thrower hypothesis seems to me to be the fitting means for bringing order to the chaos of the data that lie before us in human evolution, and the CTSW model is the result of my corresponding efforts. This can mean two things: Either the throwing adaptations are as decisive as I think, or I have created a masterpiece of self-deception – a further discipline in which some experts certify humans to have enormous capabilities. I am very curious to see how well my model will prove its worth in the discussion.

At this point, a few more clarifying words on the importance of throwing adaptations to hominid evolution are certainly fitting. The experience I have collected in confronting experts with my thoughts shows that the impression is quickly made that I want to explain every human characteristic with the throwing adaptations alone.

This impression arouses a healthy mistrust of such an "umbrella hypothesis" that tries to cover as much as possible with a single argument. This mistrust is not based, however, on cognotheoretical considerations, rather on bad experiences of such hypotheses within paleoanthropology. On the one hand, they are easily shared with the general public, as they are quite simple to grasp. On the other hand, they are hard to kill once in circulation because criticism of them is generally far less easy to grasp. This kind of hypothesis then circulates for decades and is repeatedly thrown back at the expert, to his or her vexation (for instance by contrary students), even though it has long since been rejected in the professional field for good reasons. A good example here is the aquatic ape hypothesis, which assumes a phase in human evolution in which our ancestors became adapted to living in coastal areas and feeding in the sea.

The fear that the CTSW model could be another such "figment of the imagination" is, in light of such experiences, quite close by for paleontologists at first glance. This nonetheless is not a justification for denying the model a thorough investigation from the start. Ease of grasp may be typical of annoying false doctrines that get on one's nerves again and again and are proclaimed almost fanatically by their followers; however, it is no less typical of truly successful solutions. Just because a hypothesis is easily grasped, it doesn't have to be false – one must only think of Copernicus to realize this in all clarity. The heliocentric model of planetary motion is also an "umbrella hypothesis."

If I am right that throwing ability goes back to important human adaptations whose importance has not yet been sufficiently appreciated, then the corresponding correction should be expected to present itself as an "umbrella hypothesis." I hold the throwing adaptations to be an important aspect of hominid evolution. Their significance to human evolution is not, in any case, greater than that of the development of language or of social group organization. For the **understanding** of human evolution, however, they are of absolutely decisive, central importance to the present state of the scientific debate precisely because they have not yet been considered in accordance with their actual importance. In a complex system whose function depends on the interaction of many important subsystems, the faultiest subsystem will automatically determine the functionality of the whole system. It therefore offers the greatest potential for its improvement.

If stone projectiles became the most important and most dangerous weapon of the hominids – and this is, as we will see, actually to be assumed independent of the thrower hypothesis – then throwing ability determined the absolute extent of hominid fighting strength. It follows from this that this key measure has also been falsely evaluated, since no one has subjected throwing ability to a thorough investigation.

Fighting strength and armament play an important role in social behavior, in defense against predators, and – for meat eaters (among human ancestors, the great importance of animal foods in the last 2.5 MY is uncontroversial) – also in the acquisition of food. In addition to the interpretation of a whole series of human characteristics as throwing adaptations (thrower hypothesis), a consideration of the throwing abilities of humans must also lead to corrections in all these areas – and already the thrower hypothesis turns into a new model of hominid evolution that creates the impression of being an "umbrella hypothesis."

Taken exactly, this impression is actually wrong, as I really do not claim to explain all of hominid evolution with throwing adaptations. I claim solely to be able to eliminate decisive faulty conclusions and gaps in the current understanding of hominid evolution through consideration of throwing adaptations and the availability of an efficient distance weapon based thereon.
The extent of the corrections that appear possible to me is admittedly so large that I see fit to speak of a new model of hominid evolution. I also do this above all to make clear that the CTSW model contains a whole series of new hypotheses, of which some could be wrong without affecting the others.

Naturally, the CTSW model of hominid evolution does not consist only of these new hypotheses. The actual relationships might best be illustrated with a metaphor:
In the edifice of scientific thought about hominid evolution, I have actually only brought one piece of furniture that was gathering dust in the basement up to the living room and moved the other furniture around (and in part removed it) so that the room again creates a cozy impression. In this book, I primarily describe the advantages of this piece of furniture I found in the basement and explain how and why I had to rearrange the other furniture. This other, proven furniture is not ordinarily described; rather, at best, it is mentioned as an old acquaintance. The result of my redecorating project is a living room that looks very different and that I identify proudly as "my new living room," although strictly speaking the living room as well as most of the furniture it contains were already there before my interference. And that old, proven furniture also continues to play a decisive role in the fact that the living room works; it continues to have its place in "my living room" even when it is only mentioned in my report because it had to be moved.

This book concerns itself primarily with the changes that I believe are required in the consideration of hominid evolution and claims that these changes are so important that one can speak altogether of a new understanding of this evolution – a new model. Nevertheless, these changes, most of which are related somehow to throwing, represent in all only a limited part of a model of human evolution; this is already evident alone from the fact that I only handle the last 5 million years of evolution and therefore begin with a highly developed African ape that already demonstrated the majority of "human" characteristics. That's why the accusation that I want to explain everything with throwing proves upon closer inspection to be baseless.

1.4 Overview

Since time immemorial, a human deprived of all weapons has appeared defenseless against dangerous predators. His furless skin offers no protection to speak of against claws and canine teeth; his arms are five times weaker than those of his nearest relatives, the chimpanzees; his canines – a dangerous weapon in the apes – are basically no longer canines, but line up unobtrusively with the incisors.

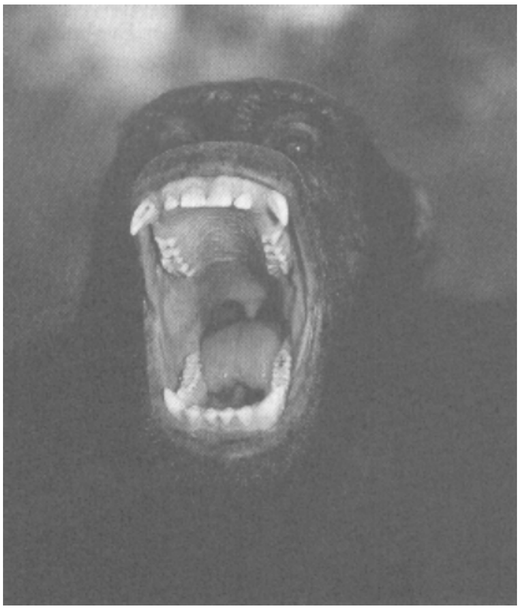


Figure 1: In chimpanzees, teeth don't just serve for chewing but also as a dangerous weapon. (Photo: K Ammann, Wildlife)

Weapons used by humans are traditionally viewed as cultural products. And as humans without weapons or the often overly glorified fire appear defenseless and therefore unable to survive, they appear "quite obviously" to differ from all other organisms through their dependence on culture. Actually, the thought of being unable to survive without cultural help should frighten us and fill us with reverence for the animals that are able to survive in the wild without such help. We are, however, cut from a different cloth [lit.: "carved from different wood"] than that. At least in the European cultural diaspora, nothing worse could befall humans than to be placed on the same level as other animals. And so humans, in a manner that is hardly logically defensible, make a virtue out of an obvious weakness and draw self-confidence from it. Driven from the center of the universe by Copernicus and robbed of the central position in earthly "Creation" by Darwin, humanity satisfies itself with the role of the essentially weak, the strength of its unusual mental abilities and cultural achievements dominating the animal world and – how reassuring – being basically incomparable to any other animal after all. For if Man, as he is today, is unable to survive without cultural help, then he can only have developed his unique characteristics under the protection of culture and differentiates himself elementarily from all other animals as the product of a unique, culturally stamped environment.

If I am not greatly deceived, there stands before humanity a further disillusionment. A large step in this direction is presented by the observations and study of chimpanzees in the last few decades. The more we learn about our nearest living relatives, as they hunt, cooperate, make war, and make tools in the wild, the narrower the behavioral distance to humans we can identify – this process, however, may not yet be finished.

Chimpanzees namely do not at all depend exclusively on the strength of their arms or the length of their canines in battle. In defending against enemies and in power displays, they really like to use sticks or branches and all possible projectiles – in particular also stones. If one tries to judge how prepared to fight humans really are without including the cultural help available only to them, one must allow them at least the same repertoire of weapons available to chimpanzees – and here the fairy tale of the defenseless "naked ape" meets its end. One need only think of a basically unarmed group of humans that crosses over into violence against another group (perhaps at a demonstration that gets out of control) to recognize what the human really is – a thrower. And woe to the chimpanzee that comes within range. At least on open ground where there are no barriers to the use of distance weapons, a human with practice in throwing and who has suitable projectiles at hand surpasses any chimpanzee. Just the statement in the last sentence should cause the ears of those members of the readership who have occupied themselves with the problems of hominid evolution to prick up, as:

- Throwers are superior on open ground – most experts assume that the special developments of hominids were set in motion through the adaptation of African apes to live in increasingly open habitats. One of the most important, not yet conclusively answered questions therein is how they dealt with the accompanying predators.
- Throwers are only superior when they have suitable projectiles at hand – herein are included two interesting issues in the evolution of early hominids. First is the reference to the hand. The development of the human grip still belongs among the unexplained adaptive achievements of the hominids. The assumption that has thus far dominated the discussion, that tool manufacture presented the decisive pressure, shows notable weaknesses. In throwing, the hand takes on a very important function, and the human grip is substantially superior to that of any African ape in this aspect. The second reference to hominid evolution is contained in the dependence of a thrower upon the availability of suitable projectiles. When one is very reliant on the availability of an object in an emergency, one should carry it along for safety's sake. The carrying of particular objects is again repeatedly offered as a possible explanation for the transition to walking upright. And this adaptation marks, according to the current state of the science,

the beginning of hominid evolution and is supposedly somehow related to the colonization of open habitats.

Throwing adaptations thus offer the potential to answer three central questions about the evolution of early hominids at once:

1. How did early hominids deal with the increasing predation pressure?
2. Why did the early hominids develop the human grip?
3. Why did the early hominids go over to an upright gait?

Throwing adaptations, moreover, have much more to offer than just the potential to add another explanatory approach to the development of the early hominids to the many already offered. On the one hand, they offer the opportunity to develop a more parsimonious model of hominid evolution; on the other hand, in light of the enormous technical demands of human throwing performance, there can hardly be any doubt that our ancestors really did become adapted to targeted throwing.

Parsimony is an important criterion in the construction of hypotheses. Of two conceivable explanations, the more parsimonious one, which manages with a smaller number of unproven assumptions, is generally the more probable. Of course, one does not get a more parsimonious model by striking one assumption only to replace it with another. The uniqueness of the thrower hypothesis given the current state of scientific discourse is, however, that the most important assumptions need no longer be introduced at all. Namely, the assumption has appeared for a long time (since Darwin) that in the course of human evolution "the weapon characteristic was transferred from the teeth to the hands" (although in view of the performance of chimpanzees in the use of sticks and stones I would speak more of a specialization than of a transfer). The thrower hypothesis simply represents a long overdue attempt to evaluate the consequences of this assumption for hominid evolution, whereby for example it turns out that an additional assumption for the explanation of the development of the human grip is no longer required. Here again, the possibility also presents itself to clean up evolutionary models through the unqualified removal of the toolmaker hypothesis, which in any case is no longer very convincing.

In approaching the technical demands upon human throwing performance, one should understand that human capability in throwing is something very special, something that deserves to be placed on the same level as the ability to speak. To be able to substantiate this initially provocative-seeming claim, one must observe that which humans are able to achieve in throwing through the eyes of an engineer.

What Man – and here in particular the male *Homo sapiens sapiens* – is able to achieve in throwing is demonstrated impressively in sports like baseball and javelin. 149 g balls are thrown at up to 50 m/s (180 km/hr) with such accuracy that they hit a 43 cm-wide surface from 18 m away (baseball). The margin of error for lateral deviation remains below 0.7°. In javelin, 35 m/s (126 km/hr) are reached with 800 g sports equipment. The throwing parameters (release angle and speed) in both sports are generated in a coordinated series of movements that includes one rotation of the entire body, two rotations of the upper body, the rotations of the upper arm, lower arm, and hand, and the release. In a timeframe of only ca. 0.13 seconds, practiced throwers create a windup with the whole body and release it with the throw.
This series of movements is ballistic, that is, it takes place so fast that no close-loop-control can take place. The entire series of movements must therefore be planned in advance and be "kept on call" in the brain. Moreover, rotations place very high demands on the overall coordination of the movement. Deviations in the timing as well as in the spatial course of each of the six involved rotations lead to errors in the release angle. Further sources of error are the joints, which as "technical" joints of course have some clearence and the transfer of energy from the hand to the projectile. The errors in this transfer of energy are already sufficient alone to allow the throw to go wrong. In baseball, the ball is essentially gripped so that the fingertips come to rest on the hard, somewhat prominent seams. One thus ensures that the transfer of energy from the hand to the ball occurs exclusively through the sensitive fingertips. Obviously, elite performance in throwing can only be achieved when the thrower possesses good fingertip sensitivity and also takes measures to apply it.

In a ballistic movement with so many sources of error, a total error in throwing direction of less than 0.7° is astounding. No less astounding is a throwing speed of 50 m/s – in order to reach this, the thrower must apply ca. 50 times the acceleration of the Earth to the ball.

Although the mastery of this exceptionally demanding series of movements with the precision achieved by humans already seems, in light of the fact that no close-loop-control is possible, to be a true natural wonder, the demands upon a good thrower exceed this by far. The throwing parameters must not only be generated but also initially determined ahead of time. A central problem herein proves to be the ascertainment of distance to the target.

In order to counteract deviation due to gravity, the thrower must be able to determine the distance. Interesting in this context is how much humans can accomplish over constantly changing distances when they have nothing left but to rely on their own distance perception. When a baseball pitcher throws the ball in the direction of the batter, this is not the case, since the distance is always the same and one can adjust to that with years of practice. The situation looks different when the distance to the target constantly changes. A basket from the 9-m line in basketball already demands more from the player than binocular vision can achieve. Even more impressive are aimed passes between outfielders in baseball across distances of about 70 m. Since research subjects allowed only the use of binocular vision and the focusing of their lenses as "direct" methods of measurement through suitable experimental conditions can only deliver usable distance estimates within a close range of 3 meters, humans must have use of an additional, substantially more powerful method to estimate distances greater by more than an order of magnitude. And it is certainly the human brain that produces this performance through an improved analysis of the visual environment, since humans have not developed a special organ for the determination of larger distances.

With the claim that can be drawn from this, that in the course of human evolution the capability for visual perception has increased significantly, the CTSW model should be met with open arms [lit.: should run into open doors] by modern cognitive researchers. Here there has already been, in the mid-seventies, a deep-reaching rethinking. While sight and recognition were previously held to be two strongly separate functions of the human brain, we now go on the assumption that the interpretation of visual stimuli, or "recognition," is an integral part of actual perception – and thus inseparably tied to "seeing." In consequence of this, the thought is obvious today that superior human cognitive ability could be a byproduct of an improved visual perception capacity. If, moreover, the high level of cognitive ability in humans should ultimately be based upon their throwing adaptations, then it is more than justifiable to place the throwing adaptations on the same level as the development of language.

Overall, the human aimed overhand throw might be by far the most demanding course of action observable in living nature. That this is a case of a "natural" course of action rather than a "cultural" one, such as perhaps juggling six balls, is very probable in that throwing belongs to the ancient behavioral repertoire of many primates and was not discovered first by humans.

It is above all the enormous demands of the aimed human throw that make it obvious that we are looking at an important hominid adaptive achievement. A decisive problem in the understanding of human evolution consists in differentiating adaptations and emergent characteristics (characteristics that appeared "incidentally" as consequences of other adaptations). Humans stand out above all because of their very powerful brains, which on the other hand stand out because of their multifaceted usefulness. Cognitive performance potential developed in the course of evolution for the solution of one task can very easily be applied to the mastery of other tasks.

As higher performance potentials are generally also attached to higher, fitness-relevant costs, one can assume in the framework of fitness-optimizing organic evolution that performance potentials are only made available at the levels actually required for the mastery of adaptive performances. An important criterion for differentiating adaptations and emergent characteristics results in that the emergent characteristics can never be more technically demanding than the underlying adaptations. They must just get by with the performance potential that was made available in the course of organic evolution for achieving the adaptations and that does not exceed the demands of these adaptations.

The higher the technical demands of an ability, the less likely it becomes that one is dealing with an emergent characteristic. A good example here is the human ability to speak. In light of its complexity, one generally assumes that the ability to speak is an adaptation that developed through a lengthy evolutionary process.

A further important criterion for whether an ability is an adaptation is the question of whether that ability could have been important in the course of hominid evolution. On this criterion, for example, the abilities to read and write fail. Reading and writing are guaranteed to have had no meaning for hominid evolution, since writing is a quite recent discovery of the "fully developed" *Homo sapiens sapiens*. The fact that humans are capable of it nonetheless is evidence that the human brain met its requirements in the course of hominid evolution with solutions to other, at least equally demanding tasks that presented similar requirements.

Throwing is a behavior typical of many primates, and no scientist seriously questions that human ancestors in the course of hominid evolution actually engaged in this activity. Thus, the second criterion is met without doubt. In addition, I found occasion above to describe human throwing performance as a true natural wonder – with such natural wonders, the first criterion for adaptations has probably been met. It is, however, also easy to interpret many anatomical features of humans by which they differentiate themselves from African apes and that are simultaneously helpful for throwing as adaptations to throwing, in order to achieve a parsimonious model of hominid evolution.

Precisely those anatomical adaptations, whose development can be demonstrated from fossils, allow us the possibility in considering human evolution to develop a concept of when, how, and why throwing adaptations took place. They contribute a lot toward making the throwing hypothesis easy to see and for that reason alone push themselves into the foreground. The most important argument for the idea that very demanding and extensive adaptations for aimed throwing happened in the course of hominid evolution does not, however, come from the fact that decisive changes in the body plan of hominids can be interpreted as throwing adaptations. The soundest argument by far for the throwing hypothesis is the enormous demands of the human high-performance throw. And the highest demands, those that leave the typical animal range far behind, are placed on the steering of the throw and thus on the brain. Only a few proportions were altered in the body – the brain entered entirely new realms of achievement.

Starting from the assumption that very demanding and extensive adaptations to aimed throwing occurred during the course of hominid evolution (the throwing hypothesis), I have undertaken the attempt to integrate the knowledge at hand into a chimpanzee-thrower-scavenger-warrior model of hominid evolution (CTSW model).

The throwing hypothesis is in itself not new. The American neurobiologist William H. Calvin attributes a tremendous importance to throwing in human evolution. Calvin’s contributions, however, show a whole series of inadequacies. He considers only a fraction of the demands of throwing. His main attention lies on the difficulties that ballistic motions bring with them. It is precisely here, however, that a mistake in the evaluation of the demands of aimed throwing slipped in, from which his conclusions suffered greatly. Beyond this, he sees the throwing development as part of a hunting scenario, whereas hunting has practically no importance for human evolution in the CTSW model. In this model, the more current and, from the point of view of the throwing hypothesis, more plausible statement that early hominids entered a scavenger niche is made.

From the present viewpoint, australopithecines play a key role in the understanding of human evolution. During somewhat more than the first half of the time since the split of the human developmental line from that of the chimpanzees, our ancestors were numbered among the australopithecines (I count *Homo habilis* among the australopithecines also). The precision grip of the hand, right-handedness and with that probably also the marked functional asymmetry of the brain, and of course walking erect are adaptive achievements of the australopithecines.
On the other hand, australopithecines possessed a brain that, while it grew in the course of their evolution, was still quite small in comparison to modern humans. They probably also had not begun the development of language. Therefore, they should be much easier to understand in terms of their adaptations than humans, for whom multiple cultural achievements allow the number of possible interpretations to increase tremendously and insights gained in the rest of the animal kingdom often do not help.

The australopithecines once again stand much closer than humans do to chimpanzees in terms of developmental history, and fossils indicate a pronouncedly chimp-like forbearer at the beginning of australopithecine evolution. Chimpanzees thus downright offer themselves as a model for the ancestors of australopithecines. Herein, I have chosen *Pan troglodytes* (common chimpanzee) over *Pan paniscus* (bonobo or pygmy chimpanzee). The choice of *Pan troglodytes* for the ancestral model, which proves itself prominently within the model of hominid evolution presented here, I will substantiate more thoroughly at the first opportunity (Chap. 2). This is done in great detail, since the bonobo presently counts as more original and also shows greater anatomical similarities to *Australopithecus afarensis* than the common chimpanzee.

The characteristics of australopithecines were not developed with the intention of leading down the path to humans, but instead represented adaptations in service of their own survival strategies. A hypothesis of human origins should therefore build upon a self-contained hypothesis of the adaptive achievements of the australopithecines. These are, on one hand, part of human evolution, and on the other hand, entirely independent of what followed them. When one has developed a usable australopithecine model, then one also has a usable ancestor model for humans. This should then be helpful for the explanation of the last two million years of human evolution. In order to prevent circular logic, human characteristics should be considered as little as possible in the explanation of the adaptive characteristics of australopithecines. It becomes particularly tricky here when one calls on human behaviors that, through cultural developments, can change more in a hundred years than the behavior of wild chimpanzees changes in millions of years.

Of course, humanity essentially gives the most evidence about its own development, since this has doubtless left behind marked traces on it. Unfortunately, it [humanity] has nonetheless become so variable in its behavior through the immense cultural development of the last 70,000 years, and has become so strongly alienated from the time when it developed biologically, that we simply don't know which human behaviors to pay attention to in order to get information about human development.

A scientific approach to the clarification of this question is the comparison of remaining tribal societies. Since these cultures have been separated for a long time, all common behaviors are presumably quite old. One unfortunately cannot assume, however, that they are old enough to be applied to the understanding of human evolution. In recent years, the understanding has surfaced that anatomically modern humans not too long ago – about 50,000 to 30,000 years ago – spread out from Africa and replaced all other human populations of the time. Presumably, this expansion outside Africa followed an expansion within Africa, which proceeded about 70,000 years ago from a local population of on the order of only 10,000 individuals. Thus, all modern cultures are based on one, or several perhaps closely related, cultures in Africa ca. 70,000 years ago.

Homo sapiens sapiens as a species is at least 100,000 years old, and a ready explanation for the sudden expansive success of a component population of this species consists in that important cultural changes directly preceded the expansion. Inasmuch as these would have been changes that led to superiority over other human populations, we are dealing with important advancements, and it would not be surprising if behaviors introduced then have been carried through to the present day or form the basis for local variations. In any case, such late advancements would not have had the slightest influence on human evolution. They must make sense, however, within an evolutionary hypothesis as results of evolution. Thus, they limit the number of usable solution approaches and present thoroughly valuable material for the falsification of hypotheses.

We cannot even assume, therefore, that so-called universalities of human behavior are older than 70,000 years or that they played a role in human evolution. I follow the course that human behavior is only permissible as direct evidence for an evolutionary hypothesis when it is a matter of demonstrably inborn behavior. Otherwise, it may not present the basis of such a hypothesis, but must fit in the picture proposed by the hypothesis, and the more a hypothesis can easily explain, the better off it is. "Demonstrably inborn behavior" is an exceptionally rare commodity in humans. As a rule, disposition and environmental influences both play a role in behavior, so that today we prefer to speak of inborn behavioral predispositions, and how these look is also usually not clarified in detail. The demand to call only upon inborn human behavior in constructing hypotheses comes very close to the demand to ignore human behavior completely.

From that presented above, it naturally results that humans are least suited to be called upon for reconstructing the behavior of hominids in the course of their evolution. And this is even valid without considering that humans are usually very strongly biased toward themselves. The human image of humans is always strongly influenced by the particular culture and personal surroundings. Every moral code, for instance, is based on a series of assumptions about the "true" nature of humans. Religious convictions can limit the possible solutions in undue ways, in that dogma, even if subconscious, is taken as certain knowledge to be considered in the construction of models.

Humans serve me above all as a model of the optimal thrower with which to illustrate the adaptive achievements of the australopithecines. This is justified because the bodily features that make humans the best throwers of all time were developed, for the most part, during the course of australopithecine evolution, which is again sufficiently verified through fossils. Precisely the ability to throw well stood, in my view, in the foreground of nearly all of australopithecine evolution and dominated the adaptations. In the assumption that humans are physically primarily chimpanzees optimized for throwing, my throwing hypothesis manifests itself practically. The call upon humans in their physical characteristic as throwers for the explanation of australopithecine evolution and the physical characteristics of australopithecines shown by fossils thus serves as the basic assumption of my hypothesis and not as evidence for it. Since the features being considered are a matter of physical features that were undoubtedly genetically determined, calling upon humans in this case presents no problem anyway. Ideas that I develop about the behavior of hominids are in contrast oriented not toward humans, rather to the greatest extent possible toward the primate model taken as a basis, *Pan troglodytes*.

Of course, this is an extreme presentation of the data. Approaches that suppose human peculiarities such as lifelong bonds between sexual partners or pronounced food sharing as early as 2 or even 4-5 MY ago are, however, no less extreme and have nevertheless dominated scientific discourse for a long time. They are also not gone from the table today by a long shot. That is why it came to me to present thoroughly the opposing extreme of the possible spectrum of interpretations. I will state in this book that a course of human evolution under the assumption that our ancestors' behavior was pronouncedly chimplike until the transition to the Late Paleolithic about 70,000 years ago is readily imaginable. This would mean that our "natural" group organization and our "natural" social behavior correspond substantially to those of chimpanzees!

The CTSW model begins about 5 MY ago with an ancestor similar to recent *Pan troglodytes* that advanced from a habitat on the edge of the savannah, as is occupied by recent chimpanzees, into drier habitats. It reacted to the significantly increased danger from predators through increased use of sticks and stones for defense – just like *Pan troglodytes* would. The human capacity for throwing suggests the assumption that thrown stones above all came into use here. Presumably, our ancestors began arming themselves for crossing open country by collecting and carrying suitable weapons. The degree of foresight required for this is also shown by modern chimpanzees, which carry appropriate tools for cracking nuts over distances of several hundred meters.

The transport of multiple stones at once required the upright gait. At the same time, stiff wrists – as adaptations to knucklewalking – hindered an effective additional acceleration at the wrist that is of great importance in throwing. Seen from the standpoint of a thrower, an erect gait was substantially superior to the knucklewalking of African apes in two important points at once. The transition to walking erect, which was probably already complete in *Ardipithecus ramidus* 4.4 MY ago but definitely in *Australopithecus afarensis* 3.9 MY ago, finds an adequate explanation with this. The development of the hand grip can be explained in the same context, since the three-finger power-and-precision grip of *Australopithecus afarensis* was much better suited for the aimed throwing of stones than the power grip or precision grip of a chimpanzee – in principle, this grip suffices to hold a ball as one does for the fastest throw used in baseball, the "fastball." The wide pelvis of *Australopithecus afarensis* also fits into the picture, since it offered a stable platform for activities of the upper extremities (arms) and thus stood throwing in good stead.

About 2.5 MY ago, at least one australopithecine species changed over to using its throwing abilities in the acquisition of carrion. The penetration of the scavenger niche occurred about 2.5-2.0 MY ago with a gradual entrance of these gracile australopithecines into the ranks of predators that competed for carrion. With this, the throwing abilities were also significantly advanced. The relatively large brain of *Homo habilis* 2.0 MY ago can presumably be traced back to the improvement of control and therefore of aim in this time period. As a result of *Homo habilis*'s advancement into the ranks of predators, it disappeared from their menu. The reduction of predation pressure then led to a surplus of births, which thenceforth carried over into intraspecies conflicts in a manner typical of chimpanzees. Here the CTSW model touches on the conclusions that Richard Alexander has drawn for the development of the human psyche. He assigns a central importance to warlike group conflicts.

Homo erectus, appearing for the first time 1.8 MY ago, already demonstrates extensive adaptations to intraspecies conflicts involving the use of stone projectiles. The thickness of the long bones in its extremities and of its skull, the pronounced browridges, the lengthened parietal bones, the receding forehead and pronounced occipital angle, the receding chin, and the overall oblong and flat shape of the skull are identifying characteristics of *Homo erectus* that at the same time minimized risk of injury from thrown stones. The body proportions of *Homo erectus* corresponded for the first time to those of modern humans and permitted the use in throwing of the whole-body windup typical of humans. At about 1.80 m, early *Homo erectus* already had the optimal body size for a thrower.

A further consequence of intensive conflicts between neighboring groups may have been the development of language. When groups use long-distance weapons to fight each other, cooperative action can play a large role from strategic points of view. A precise exchange of information can be very helpful in this, and verbal communication offers the advantage that it can take place without visual contact. In conflicts involving the use of a visually controlled long-distance weapon, one ought rather to keep the opponent in view. I will, however, favor a somewhat different approach to language development in this book, whereby the focal point of this development falls at a later time.

In contrast to recent *Homo sapiens*, we can assume of *Homo erectus* that good throwers had a reproductive advantage and that everyone practiced throwing. Every *Homo erectus* man was therefore a talented and practiced thrower, in comparison to whom we must be classified as domesticated and less capable. Only from specialized elite athletes can we expect a similar level of performance today. It follows from this that *Homo erectus* men, whom we describe as having been exceptionally athletic, should have been capable of flinging stones weighing 800 g at their opponents with a speed of 120 km/hr – in order to reach a top performance of 92 m in the modern discipline of javelin, which has identical requirements for the series of movements, one needs a throwing speed of 126 km/hr. As we have gotten somewhat out of practice at throwing, because humanity has since developed much more powerful weapons, it is difficult for us to recognize immediately the dangerousness of the weapon that was thus already available to early *Homo erectus*. I therefore recommend the following procedure as an illustration:

- One should find a handy stone with a weight of ca. 800 g – a round stone of this weight is about the size of an ordinary orange and sits very well in the hand.
- One should become comfortable with the stone by weighing it in the hand and perhaps tossing it in the air and catching it again. (It is also very helpful to drop it on a foot from shoulder height – in doing so it is, of course, recommended to put on sturdy shoes first)
- One should find a high-rise building with more than 20 stories and stand before it with the stone in hand.
- One should weigh the stone in the hand again and imagine that someone were to drop this stone from the 21st floor (height of 63 m). In this fall, the stone would namely reach bottom (ignoring air resistance) at the speed with which one must throw an equally heavy javelin in order to achieve a top performance.

Already 1.8 MY ago, the physique of *Homo erectus* possessed all the features necessary for such throwing performances. In light of such performances, neither his avoidance by predators nor his robusticity is surprising. The human physique makes humanity the most dangerous primate of all time and should have made possible, independent of any cultural development, survival in open habitats with any level of predator presence. The human physique is also not to be interpreted as especially unspecialized, rather quite on the contrary as very highly specialized and optimized for a difficult task.

Meanwhile, I even go so far as to suggest that the human high-performance throw places similarly high demands on the brain as does language development and higher demands on the physique than walking upright (the transition to walking upright is itself presumably at least partly to be interpreted as an adaptation to the improved use of projectiles). If one subjects such an adaptation to no closer investigation, one can certainly develop no deeper understanding of human evolution.

On the contrary, a proper consideration of the throwing adaptations automatically opens the way to a new view of hominid evolution and makes it easy to create a new model of human evolution. Especially important in this context is the determination that already early *Homo erectus* at around 1.8 MY ago at least met the anatomical requirements for being as good a thrower as the modern human potentially (with corresponding practice) is. At the same time, its tools were ridiculously primitive and the development of language had at best just begun.
Thus, throwing adaptations presented the first huge step on the path from a presumably chimpanzee-like ancestor to humans and helped determine the conditions for further development in a decisive way. My aforementioned assumption, that the natural group structure of *Homo sapiens* was still pronouncedly chimp-like, therefore only makes sense upon consideration of intraspecies conflicts involving the use of a long-distance weapon. Major differences between humans and chimpanzees in the sexual arena can be explained against this background without supposing fundamentally divergent social behavior.

Before Jane Goodall demonstrated that wild chimpanzees also make tools, this ability was really treated as the definition of humanity. It was taken to be a matter of a decisive difference from all other organisms. The basis of this view was the toolmaker hypothesis, which attributes decisive bodily and mental developments on the path to humans, such as the grip and geometric thinking, to the production of tools. In the CTSW model, on the other hand, it is assumed that tool production played hardly any role in hominid evolution. Humans did not become what they are through the production of some sort of tools – rather, through adaptation to the use of a naturally occurring tool. And this tool – the stone used for throwing – had already been used by a whole series of other primates for the same task.

Human versatility, in the CTSW model, is an emergent characteristic that results from the enormous demands of the special ability to which humans adapted. The better part of the specific bodily adaptations of humans can be traced to specialization for stone throwing. To these belong all the characteristics that until now have repeatedly raised questions or that were answered with the toolmaker hypothesis, such as the transition to walking upright, right-handedness, the precision grip, and the robusticity and shape of the skull in *Homo erectus*. Above all, though, the demands on the brain presented by the human high-performance throw are so enormous that adaptations to throwing must be admitted to have had an important role in brain development, while the importance of cultural development to the evolution of human cognitive abilities should at least be critically reconsidered.

Humans are, in the CTSW model, no longer the "unadapted being." Their adaptation is also not "unadaptedness" – to utilize another popular term that is used to describe the same ideas. They are – as far as their organic inheritance is concerned – a strongly specialized mammal, of which there are many. This is tied to weighty cognotheoretical advantages for the CTSW model. Namely, in order to prove "unadaptedness," one must show that all conceivable adaptations do not apply – and that is plainly impossible. On the other hand, if one has a clearly outlined adaptation to deal with, as we find with all other animals, then it should further not be difficult to test whether it applies or not. The mark that the throwing adaptations have left behind is in fact so broad – as we will yet see – that one must wonder that it could have been ignored so extensively for so long.

In the CTSW model of hominid evolution, humans present themselves as a somewhat out-of-place ape whose ancestors, after very demanding adaptations to aimed throwing – and probably not least because of these adaptations – developed the ability to speak in a second developmental step. These two adaptive complexes proceeded by the same rules of organic evolution that we find everywhere else in the animal kingdom. At the end of this development stood the fully developed *Homo sapiens sapiens* and some other "human types," whereby one can argue about whether they represented different races of the same species, multiple subspecies, or even multiple species.

Only at the end of this organic development, which clearly fits within the known rules of organic evolution, did the members of an African population of *Homo sapiens sapiens* under use of the language turn into expressly cultural beings through a “cultural revolution” about 70,000 years ago.

The human developmental line was presumably not subjected, as is often assumed, to a lengthy evolutionary special development through the increasing importance of cultural achievements. The assumption appears more plausible that human cultural capacity arose as a by-product of adaptations to throwing and the development of language ability.

The actually surprising thing about the CTSW model is, then, that it is precisely human cultural capacity, the characteristic about which we are most conceited, that should turn out to be an emergent characteristic (which places fewer demands on the brain than the preceding adaptations). First at the transition to the Late Paleolithic, which in this book is placed at ca. 70,000 years ago, did a small population of *Homo sapiens sapiens* – at the time, this was just one of many extant species of humans, which were all capable of culture in principle – make a particularly productive use of their cultural capacity. The result was the transition from the original horde to the tribal association and the extermination of all other branches of the human genus within fewer than 40,000 years.

2 Choice of Primate Model

2.1 *Pan paniscus*

The primate model one takes as a basis in the construction of a model of hominid evolution is the species of primate on which one orients one's ideas about how the last common ancestor of hominids and extant apes, which marks the starting point of hominid evolution, behaved and looked. Since we now know from molecular biological studies that humans and chimpanzees are exceptionally close genetically and their developmental lines presumably first separated about 5 MY ago (Miyamoto et al, 1987), the two chimpanzee species are the most obvious candidates for a primate model.

Fossils also point in this direction. Fossil finds directly attributed to the common ancestor of chimpanzees and hominids admittedly do not exist. The prospects of finding such fossils are quite small, since apes basically leave behind very few fossils. In jungle habitats, the conditions are very bad for making fossils. However, the more frequently found hominid fossils become more similar to chimpanzees the older they get and the nearer they come to the common ancestor. Both species of chimpanzees do equally well as candidates for a hominid ancestor model when viewed from the standpoint of kindred closeness. Before I explain why I have chosen the common chimpanzee, I would like to introduce both species. The presentation thereby of the bonobo comes out much shorter for two reasons. First, I need more extensive information about the common chimpanzee because I will refer to it frequently in developing the CTSW model; second, the common chimpanzee is much better studied than the bonobo.

The bonobo or *Pan paniscus* is the ape that was discovered last by science. Only in the early Thirties of our century was it described as a separate species. Although the bonobos are also called pygmy chimpanzees, they are not smaller than the smallest of the three subspecies of common chimpanzee. Bonobo males show an average weight of 45 kg; females average 33 kg. The habitat of the bonobos is the thick jungles of Zaire, a territory in which observation of this shy animal is very difficult. In zoos as well, one mainly finds common chimpanzees, so that knowledge of bonobos only increases slowly, but that which is already known about their lifestyle sufficed to arouse a lively interest.

Bonobos differentiate themselves from common chimpanzees through a somewhat more gracile physique. They have somewhat longer legs and can almost straighten their knees, from which a somewhat more effective upright gait results than in common chimpanzees (although

chimpanzees are adapted to knucklewalking, they are entirely capable of walking on two legs). They have, in contrast to the common chimpanzee, a dark face and show an orderly central [hair] part (de Waal, 1991).
Above all, though, they contrast with common chimpanzees through their social behavior. Indeed, bonobo females leave the social groups into which they were born just like common chimpanzees, but for them this does not lead to close cooperation among the closely related males who remain in the group. Bonobos show, conversely, how the females of a chimpanzee society can take the rudder through emphasis on sexuality and intensive cooperation with each other. The normally unrelated bonobo females create strong bonds among themselves through use of sexuality.

The same-sex sexual activities of the females are so important that the females are physically adapted to it. Their clitoris is enlarged and oriented forwards. This permits the species-typical G-G rubbing – two females rub their genitals on each other, during which they hug each other often and turn their faces toward one another. The females dominate bonobo group organization and a male can only achieve high rank if he is descended from and supported by a high-ranking female. A close cooperation between males, which sociobiology would predict on the basis of their relationship, as mentioned, does not, in contrast to common chimpanzees, take place.

Bonobos are surprising in their peaceable nature. They utilize sexuality to prevent aggressions. Instead of fighting, for example, over food, they prefer to put on a sexual orgy and share the food afterwards. Presumably because of the high importance of sexual attractiveness for *Pan paniscus* above and beyond reproduction, their [reproductive] periods are much longer than those of *Pan troglodytes* females. Estrus swellings are shown over 75% of their [reproductive] periods, in comparison to 50% in common chimpanzees. Additionally, sexual intercourse also takes place when no redness is present in the females (unlike humans, chimpanzee females display their ovulation through estrus swelling and reddening, so that the males possess information about when a female can be impregnated).

The peaceable nature of bonobos, the strong position and constant sexual attraction of the females, the relatively long legs whose knees almost straighten out during upright locomotion, and not least the frequently-observed frontal position during sexual intercourse make the pygmy chimpanzee, which is after all as closely related to us as the common chimpanzee, a sympathetic candidate for a hominid ancestor model. It seems downright predestined, among the different approaches to the reconstruction of human evolution, to support those that build on the "good" in humans. It grants refuge from the nasty face of a brutal, cannibalistic ancestor, to which we thought we had to become accustomed as a result of the observations of common chimpanzees. Refuge from the image of an ancestor that would not have known where to begin with demands like "equality of the sexes" and "make love, not war."

The peaceable nature and the related strong position of females doubtless appear from the viewpoint of a halfway "enlightened" Western society as desirable characteristics that we would like to find in our ancestors. Under the living conditions that one can assume for the early hominids and their immediate ancestors, however, such characteristics would hardly be an advantage. During World War II, all of the bonobos in the Munich Zoo died of heart attacks during the nighttime bombing raids – the more robust common chimpanzees withstood the burden on their nerves.

If I were chief of personnel and had to decide whether I should recruit a group of common chimpanzees or a group of pygmy chimpanzees for the task of colonizing a new, expressly dangerous habitat, my choice would certainly not fall upon the pygmy chimpanzees.

In human history, peace and the equality of women represent very recent cultural demands. We should not repeat the old mistake of attributing characteristics to our ancestors that appear desirable to us from a recent societal perspective.

2.2 *Pan troglodytes*

Common chimpanzees also live in forests, but their habitats are generally drier and more open in comparison to those of bonobos, and they also inhabit savannah habitats in part. This results in greater endangerment by predators.

In a more dangerous environment, as is occupied by *Pan troglodytes*, a higher degree of cooperation and aggression on the part of the males is already required for predator defense alone. This is also emphasized by the longer canine teeth that the common chimpanzee shows in comparison to the bonobo.

It is to be asked whether, in habitats typical of common chimpanzees, a matriarchy such as is observed in the bonobos can be constructed. In any case, the relationships are very different in *Pan troglodytes*. Coalitions among the males are decisive here for rankings within the group. It is part of the career of every male to subjugate all the females during his youth; only then does the climb through the hierarchy of males begin. A female displaying in front of a male, as can be observed in bonobos, is unthinkable among common chimpanzees (Power displays are a behavior of decisive importance in determining rank order in a chimpanzee group. Chimpanzees try, during display, to appear as threatening as possible. They scream, beat on tree trunks with hands and feet, drag branches behind them, shake small trees, or throw stones and sticks. In general, a high-ranking animal does not tolerate displays in its presence by a lower-ranking one.). Among females, cooperation mainly takes place between mothers and daughters or between sisters. Homosexual practices are not observed, and no physical adaptations for them exist.

Who has access to an estrous female is determined among the males. According to their positions within the group and presumably also their particular disposition and upbringing, the males pursue different reproductive strategies.

Males orient themselves upon the genital swelling of the females and above all at the time of ovulation, which is indicated by maximal swelling, try to mate with them and to keep them away from other males. This doesn't mean they know what they're doing – chimpanzees of course don't understand the first thing about reproductive relationships. It is simply the genital swelling that makes the particular female especially attractive and desired. Males that find this swelling attractive are more reproductively successful and have therefore predominated in the population. Chimpanzee males are expert at knowing how "ripe" a female is. They are very interested in the condition of the swelling and enlist the help of their noses in connection with this (Goodall, 1986). In contrast to bonobo males, they show no sexual interest in females presenting no genital swelling.

In the case of a strong position of power within the group, an alpha male is able to monopolize an estrous female (a female showing genital swelling) temporarily during the days important to fertilization. If the boss is strongly dependent on an important ally in order to maintain his position of power within the group, he will also tolerate the efforts of his vassal toward attractive females. On the other hand, he would do everything at his disposal to keep a rival for power away from the reproductive resources.
Males that are neither at the top of the rank order nor among the privileged allies of the boss must think of something else in order to reproduce. The most important strategy in this context is the – as documented by Jane Goodall – so-called “honeymoon.” The male tries to lead the female to the outer edges of the group’s territory, where an encounter with a higher-ranking male that would fight him for the female is unlikely. The association inherent in the term “honeymoon” to the institutionalized, ideally lifelong pairbonding in humans I find rather hasty in this context. Jane Goodall supposes to have found the path to the origin of the human inclination to pairbonding; I will take another position in my treatment of human behavior.

Often, estrous females join the patrols carried out by males along the borders of their territory, or vice-versa, males that have met with an especially attractive female undertake a patrol and take the female along. In such a case, only the highest-ranking male on the patrol would have a chance to isolate the female. It is often observed that no male manages this – or it is only attempted – and that the female is mounted by all the males in series. Such observations led, in the early era of research on freeliving chimpanzees, to the mistaken opinion that chimpanzee males know no jealousy. One must be careful, however, in the interpretation of such observations.

Sociobiology is a relatively young scientific discipline that has set for itself the goal of interpreting behavior from an evolutionary-theoretical angle. Behavior is taken as a characteristic of organisms influenced just as much as physical characteristics by evolution. From this is derived the central paradigm of sociobiology, which states that individuals behave in ways that maximize their overall fitness. Overall fitness is the genetic reproductive success of an individual, to which its own descendants and, to a lesser extent, the descendants of its relatives contribute. At least in its use on animals, sociobiology meanwhile has notable successes to show. Also, the degree to which one can observe from the behaviors of male chimpanzees that they experience something like jealousy is easier to understand when one keeps their fitness interests in mind.

Young, newly sexually mature females show regular estrus swellings in the first two years of their sexual maturity but are nonetheless infertile. Thus, it isn't "worth it" to compete over them excessively. Even in fertile females, only a few days are productive for impregnation. The estrus swelling lasts longer and the females mate before and after fertilization with many males, but it is only "worth it" for males to attempt to keep others away from the female during the days of greatest fertilization probability.

In addition, it must be noted that females often show genital swellings even months after impregnation and continue to copulate with all of the males. The reason why females try to copulate with as many males as possible may lie in the fact that chimpanzee males are inclined to kill the offspring of strange females. They may do this so that the females become receptive again quickly. With the next child, they would then have the opportunity to reproduce themselves. Following this logic, the males should spare the offspring of females with whom they themselves had sexual intercourse, as it could always be their own offspring.

Jane Goodall supposes, though, that attacks on the offspring of strange mothers take place in the context of group conflicts in order to weaken neighboring groups in the long term. The [attacker's] own reproductive success seems to play no great role in this. Only young females are namely recruited to one's own group. Older females not belonging to the group are, in contrast, often victims of attack, and their children are attacked even when they could be descendants of the aggressors. Perhaps, then, the tendency of females to copulate with as many male members of their own group as possible serves more to cement the social ties of the mother than to prevent danger to the future child from these males.

Although chimpanzee females show a genital swelling, the males also face the problem that this swelling does not correlate at all dependably with the reproductive value of the female. The males therefore consult additional sources of information in evaluating female attractiveness. Attempts by high-ranking males to prevent other males from copulating with a female are primarily observed when the probability of fertilization is highest. The probability that a genital

swelling really indicates that a female is fertile is highest when the female has not ovulated for a long time because of rearing a child and she shows a genital swelling again for the first time. Such females are surrounded most closely by adult males. And the greatest probability also exists with them that serious attempts will be made to suppress copulation with other males.
It need by no means be, however, the highest-ranking male that behaves pronouncedly jealously. It also happens that a male aggressively prevents copulations by lower-ranking males with the female he desires, but demonstratively overlooks the approaches of higher-ranking males.

Low-ranking males under such circumstances hardly have any chance of impregnating an exceptionally attractive female. With the aforementioned "honeymoons," however, there is a strategy by which they, too, can get their chance. If a male can lead a female to the edge of the group's territory at the earliest phase of her genital swelling, then the chances are not bad at all that he will not be disturbed by a higher-ranking male and that he will be the only one with access to the female on her fertile days. At this early stage, however, females ordinarily try to prevent such recruitment to a "honeymoon." They always succeed in this when they encounter a higher-ranking male on the way. The affected females thus call upon all sorts of reasons for delaying the march in order to increase the chances that they will have recourse to a higher-ranking male.
I would like to relate such a case here as an example of a situation in which the female must at least be intellectually equal to the male in order to protect her own reproductive interests. This type of conflict of interest between members of the two sexes will yet play a certain role in the discussion of the development of human cognitive abilities:
Jane Goodall describes a female (Goodall, 1991) that wore the patience of her inexperienced suitor in the extreme, in that she discovered after a few steps that she was hungry. The female (Gremlin) then climbed into the nearest tree and began in all comfort to eat, until the patience of the male (Freud) had obviously come to an end. When this staged was reached, the female gave in, climbed down, and followed the male willingly for a bit until he had calmed down somewhat. Then Gremlin again felt an unspeakable appetite for some fruit or greenery, and the whole story (or should one rather say the farce [lit.: "monkey theater"]) started from the beginning. For the male, all of these efforts ended in a fiasco; in eight hours, the couple barely covered 500 meters. Then Gremlin began a whole hour and a half before sunset to build her sleeping nest (chimpanzees spend the night in tree nests made of interwoven branches), and Freud resigned himself to the same. As they were still located in the center of the group's territory, it was no

surprise that they encountered a troop of other chimpanzees the next morning, and Gremlin wasted no time in taking the opportunity to switch to this troop.

Precisely the sexual behavior of chimpanzees offers, in my opinion, decisive assistance in understanding human evolution. I will present in this book a model of natural human sexuality that substantially corresponds to the relationships of *Pan troglodytes* (Chap. 5).

Forty years ago, chimpanzees were still counted as peaceful vegetarians. The first cracks appeared in this image through Jane Goodall's observation of an organized hunt conducted by the Gombe chimpanzees (the chimpanzees observed over many years by Jane Goodall and her coworkers live in Gombe National Park in Tanzania). It is now well known that captured meat is an important component of the common chimpanzee's diet and that it is highly valued by these animals. Of course, this revitalized the old hunter hypothesis of hominid evolution. After all, chimpanzees display a high level of cooperative behavior in the hunt. The human food-sharing society also seems easy to grasp in this context, as it is almost exclusively the males that handle the hunt, and females usually only get some of the prized meat if a male relinquishes it to them. Even the gesture with which chimpanzees beg for meat looks charmingly human – it is the palm-up, open hand with which a beggar would ask for alms.

The degree of cooperation between males is obviously a result of the demands of the hunt, and the readiness to share the booty depends upon how strongly the successful hunter was dependent on the assistance of others.

In the high and relatively thick forests of West Africa, monkeys are by far the most important prey and are more difficult to capture than among the sparser, smaller trees of Gombe. Consequently, the chimpanzees of the West African jungle are compelled to a higher degree of cooperation in hunting. They typically conduct chase-hunts, wherein most of the participating males run along the ground and chase the prey in a certain direction. There, they are awaited by the most skillful climbers of the group, which climb the trees and catch the prey. As the hunters are dependent upon the support of the chasers, which themselves would have no chance to make a kill, sharing of prey in the jungle is a given.

Things look different at Gombe. The trees are shorter and farther apart. Under these circumstances, a skillful chimpanzee hunter is entirely capable of succeeding alone. The males do normally hunt in groups, whereby each male increases his own prospects of success, but no such express division of labor occurs. All participating males hunt and are sufficiently motivated by the prospect of making a kill themselves. Sharing of prey is less marked at Gombe and serves more to cement coalitions or for other interests. How high the chances are to get something depends primarily on the quality of relationships to the giver. Frequently, meat is snatched from a successful hunter by higher-ranking males; however, it is emphatically defended. Those of lower rank try primarily through begging to gain the pleasure of fresh meat.

When a female occasionally gets some meat, she is hardly prepared to share; only close blood relatives have a realistic chance. Males are more easily moved to hand some over. They prefer estrous females for this and it is not seldom that an actual exchange – meat for sex – can be observed.

The common chimpanzee is also known for the use of tools in the wild.

In the jungle, chimpanzees use stones or hard wood to crack nuts. In this, they proceed according to the so-called "hammer and anvil" method. The nut is placed on the anvil and cracked with the hammer. Hard, prominent roots may serve as anvils; stones or suitable pieces of wood are used as hammers. Suitable hammers are relatively rare in the thick jungle and are sometimes carried over long (several hundred meters) stretches. Thus, the chimpanzees obviously have a clear idea of where they can locate a suitable stone (usually at another nut tree) and fetch the tool that requires the least transportation effort for the most use (Bösch & Bösch, 1984).

Widespread among chimpanzees – above all among females, who rarely take part in hunting – is termite fishing. Here, a thin, flexible, defoliated twig serves as a tool. This is carefully chosen and prepared according to specifications in order to be introduced into a hole in the termite mound created by the chimpanzee. The hole is defended against intruders by the termites. The termite soldiers therefore bite the twig. A skillful termite fisher waits a moment until the termites have bitten down, whereby she also tries to animate them to bite down by moving the twig slightly. Then the twig must be pulled out carefully, so as not to knock the termites off. Once outside, the termites are swept off with the fingers and directed into the mouth. Termite fishing is a very time-consuming method to provide oneself with valuable animal food. The males, which in the hunt have an easier way to get animal protein, don't usually have the patience for long sittings at termite mounds. Nutcracking as well as termite fishing are quite demanding activities and require years of practice to reach a certain mastery.

Additionally, chimpanzees use chewed up leaves as sponges in order to get water out of small hollows or to clean themselves. It is thoroughly justified to speak of tool cultures among chimpanzees. Use and production of tools is learned in the group. Different populations of chimpanzees display different tool cultures.

My special interest is naturally in the use of objects that are applied as weapons. Common chimpanzees like very much to use sticks and branches in their displays, occasionally also stones, these most particularly in displays against strangers or non-chimpanzees. Sticks and stones are also used for defense against dangerous predators. In actual attacks on strange members of the same species or in hunting, however, chimpanzees mainly use their own bodily armament. They trample, hit, bite, and tear. Once, a thrown stone was observed at Gombe in conjunction with a hunt. It did not serve, however, to kill the prey – a young bush pig – but to drive away its angry mother. The young [pig] was then killed in the customary fashion.

2.3 Territoriality of *Pan troglodytes*

Perhaps the greatest surprise in the observation of freeliving chimpanzees was caused by the determination that they are exceptionally territorial. Reports published by Jane Goodall have changed our perceptions of our nearest relatives in lasting ways. Chimpanzees are very hostile to members of other groups and thus share this characteristic with humans. Adult males and estrous females patrol the borders; mothers with children or females without genital swellings generally do not participate in the patrols. The participating females in estrus usually take the position at the end of the troop and seldom show the typical male behaviors.

In the areas that overlap the territory of other chimpanzee groups, the patrols move noiselessly; the participants peer into the unknown and hug each other frequently to reassure each other of their mutual support. When chimpanzees hear calls from the neighboring group, they only answer in the case of numerical superiority. In such cases, they also attack. In cases of clear inferiority, they retreat calmly and quietly. When the groups are about equally strong, they usually conduct power displays, in the course of which branches are shaken and stones are also thrown.

Females from other groups that are encountered in border areas are often the victims of attacks. Such females, however, cause conflicting feelings among the males. Interest in the opposite sex can certainly dominate over xenophobia – and use of this term for chimpanzees is, according to Jane Goodall, appropriate. The males recruit young females in estrus, and pubescent females whether they are in estrus or not, for their own group. These females are induced, by force if necessary, to accompany the patrol back to its core area. Older females that show no genital swellings are usually attacked and can come away with fatal injuries. Also, the children of strange females can become the targets of attacks; sometimes, they are actually taken as prey and eaten.

The territoriality of chimpanzees first observed at Gombe has since been verified by multiple sources and is viewed as a consequence of their social organization. Among chimpanzees, it is the females that leave their natal groups. This is admittedly not absolutely the case for all females – the most reproductively successful female at Gombe, Fifi, stayed in her natal group. It is, however, decisive that males remain in their natal groups. The thus closely related males defend together the territory in which the females they claim live. From a sociobiological viewpoint, this is interpreted as a consequence of so-called kin selection – related individuals have many genes in common and can therefore increase the proliferation success of their own genetic material not just through their own reproduction but also through support of kin.

The conflicts at Gombe could be documented so well because the participating groups had arisen through fission of the group that had been observed for many years. Thus, the chimpanzees of both groups were accustomed to the presence of the researcher and permitted the observation. In 1972, the Kahama society split off from the original Kasakela society; in 1977, the Kahama society was wiped out.

The original Kasakela group (KK) began, in the view of Jane Goodall, to disintegrate already between 1962 and 1965. She supposes that this process was delayed by the provisioning with bananas that was carried out intensively at the beginning of the observations at Gombe. Both groups came into camp to feed on the bananas, so that contact between the groups was not broken completely until 1971. The Kahama group no longer visited the camp after 1972; both subgroups saw each other only rarely; some peaceful meetings were observed, but as a rule, the males avoided one another.

During meetings of the subgroups it was observed that males of the southern group, later the Kahama group (KH), presented power displays that led to the scattering of the northern group (KK). Both groups at that time moved in the direction of enemy terrain only in closed groups numbering at least 5 males.

The sizes of the two groups were different from the beginning. The Kasakela group included 8 adult males and a whole series of females; to the Kahama group belonged 6 adult males and one subadult (Sniff). The smaller KH society also included substantially fewer females than the KK group, with only 5 animals.

At the beginning of 1973, KK males patrolled Sleeping Valley (the rest of the range was divided between the two groups). On patrol, they sat down quietly and listened. Only when voices could be heard in the distance did they stay to eat. Opposing power displays were also observed.

The brutal encroachments began in early 1974. The KK range was expanded to ca. 15 km² by the end of 1974. The range of the southern KH group was thus reduced from the original 10 km² at the beginning of 1973 to 3.8 km². Already during the rainy season of 1974/75, the four remaining males had only a 1.8 km² area available. The following attacks were observed (Goodall, 1986):

Godi, January 1974: The patrol (KK) consisted of eight individuals. Six males, a subadult male, and a female in estrus traveled quickly and quietly in a southerly direction, until they encountered Godi. There followed an attack that lasted 10 minutes. Blows to the back and shoulders with flat hands and fists were observed. A KK male stood erect and threw a large stone at Godi after everyone had released the victim, but the throw came up short. Godi was seriously injured in this attack and was never seen again.

Dé, February 1974: 3 males and a female of the KK group attacked Dé. At the beginning of the attack, another two KH males were present; however, they fled quite soon. Yelling, the attackers dragged Dé around on the ground; they tore fur from Dé's legs several times with their teeth. The attack happened over a total of 20 minutes. Two months later, Dé was observed, severely damaged. His testicles were shrunken to 1/5 of the normal size, and he had serious wounds that did not heal. He could be observed for another five days, but then disappeared entirely.

Goliath, February 1975: 4 [adult] males and a subadult male engaged in the attack. Goliath was hit and dragged on the ground. He, like Dé before him, gave up quickly and did not try to resist. A KK male tried during the course of the attack on Goliath to twist off his leg – a behavior that is not normally observed in conflicts with members of the same species, but rather in hunting other animals. The attack lasted 18 minutes. Goliath was never seen again, despite an intensive search.

Sniff, November 1977: All 6 adult KK males and Goblin conducted a downright hunt for the half-grown Sniff, who was probably the last male of the Kahama group. Willy Wally, another KH male, of whose whereabouts nothing is known, by this time had not been observed for a long time. The attack on Sniff was also very brutal. He bore many bite wounds from it and probably had a broken leg. Satan distinguished himself in the course of the attack by drinking blood from the wounds of his victim. On the day after the attack, Sniff, barely able to move, was observed once more. His condition was so poor that it was decided to put him out of his misery. This remained undone, however, as he could not be located again.

In addition to the males, an old female (Madam Bee) of the KH group was also attacked by the KK males, and also finally killed. Three attacks were observed, and it could be determined from the observed wounds that a further attack had also taken place. Madam Bee had two daughters. One of them switched to the KK group, although she must have seen multiple attacks by this group on her mother, including the fatal one.

In contrast, her little sister never entirely joined the aggressors, although she was sighted several times over the next three years – always in estrus – in their territory. Of the whereabouts of the remaining two females from the KH group, nothing is known. It is quite conceivable that they switched to the Kalande group living farther south – Jane Goodall thinks it more probable that, in view of the hostility of the chimpanzees toward foreign mothers, they met the same fate as Madam Bee.

After the eradication of the KH group, the KK group predominantly chose their sleeping and feeding sites in the area that in previous years had made up the core range of the KH group. To the south lived the Kalande group (9 adult males). The Kasakela patrolled the south of their territory with increased intensity and often sighted individuals of the Kalande group.

In early 1980, Passion, who preferred to live in the southern regions, was seen injured. Her son was also injured. After that day, Passion was never again observed in the southern part of the territory. Jane Goodall presumes that Passion and her child were attacked by males of the Kalande group patrolling the northern part of their own territory. In 1981, the Kasakela range shrank to 9.6 km²; the chimpanzees rarely left their main area (at the time about 5.7 km²). The group then included 11 females and their families. Around this time, Humphrey disappeared and his skull was found, and the Kasakela females lost children that were 1-3 years old. One female was observed a short time after the loss of her child with bad wounds to the face, hand, and leg. In 1982, 4 Kalande males pressed into camp and lightly attacked Melissa and her son. Fifi was able to flee northward with her family. A couple of days later, the scientists heard the Kalandes' calls from a ridge to the north; Mitumba males answered from two ridges over. The Kasakela were in between and made no noise for the next three days. It looked as though the aggressors had become the victims of other chimpanzees. During the dry season of 1982, however, the Kasakela could expand their range to the north because some males had reached adulthood and the subadult males also took part in the patrols.

Jane Goodall believes chimpanzees to be territorial, but in a different way than other mammals: they have no ritualized acts, but instead are more aggressive. Chimpanzees don't just drive invaders out of their patrol areas; they injure or kill them. They don't just defend their range and resources, but enlarge their territory opportunistically, when the neighbors are weak. They don't just protect the “resource” of females; they actively and aggressively recruit new sexual partners from neighboring groups.

2.4 Chimpanzees as a usable ancestor model

Chimpanzees are the nearest living relatives of humans, and they are doubtless much more primitive. Among chimpanzees, in turn, the common chimpanzee occupies habitats that border the savannah. Such habitats are most similar to those that are supposed to have housed the direct ancestors of the hominids. For this reason, Louis Leakey initiated the observation of the common chimpanzees at Gombe by Jane Goodall (Goodall, 1993). For the same reason and because of the close kin relationship, I believe *Pan troglodytes* is the best available ancestor model for hominid evolution.

It doesn't lack a certain irony that exactly those unexpected parallels to human behavior discovered by Jane Goodall, such as express xenophobia and murderous conflicts between groups, have contributed to a preference for the peaceable bonobo as an ancestor model.

On the scientific plane of discourse, it is brought forth above all that the bonobo is more primitive, that it is less fixed in its locomotion than the common chimpanzee (Savage-Rumbaugh & Lewin, 1995). One is thus to presume that apes, which did develop originally as pure tree-dwellers, are more primitive the less they have settled on a particular means of moving on the ground.

With such thoughts, however, the more recent past of the chimpanzees is insufficiently considered. The bonobo with its physical proportions and behavior only meets the requirements placed on it by its habitat. It could therefore only be more primitive if its environment were also more primitive. This is doubtful, though. It is questionable whether the equatorial jungles inhabited by bonobos existed in this form during the Ice Age. During the Ice Ages, the vegetation zones in Africa shifted toward the equator, where typical habitats disappeared (Figure 2). The remaining jungle refuges were surrounded by savannah and therefore probably offered living conditions similar to those of the habitats of recent *Pan troglodytes*. It is adapted to such habitats, and so one should take into account the possibility that the ancestors of *Pan paniscus* presented similar characteristics during the Ice Ages to those of *Pan troglodytes* today. There may thus have been, for example at the time of the Neandertals, no habitat into which the modern bonobo with its characteristics would have fit.

Even in the event that the bonobo existed in its present form during the last Ice Age, it is not to be expected that it is the more primitive chimpanzee. The last common ancestor of the two chimpanzee species namely lived in Africa ca. 2.5 MY ago (Morin et al, 1994), at the peak of a pronounced dry period (Schrenk, 1997) of which it should be understood as a survivor. *Pan troglodytes* would doubtless have accomplished this task better than *Pan paniscus*, adapted to the thick jungles of Zaire. The division of the two lines could have resulted following the dry period as a reaction to the resumed spread of tropical forests. In this case, we would be dealing with an adaptive radiation in which the bonobos had to develop new features for settling a new kind of habitat. The common chimpanzee, in contrast, offers itself as the ancestor model of all chimpanzees and is, therefore, surely also more primitive than the bonobo. Thus, it also stands closer to the common ancestor of chimpanzees and hominids in its characteristics.

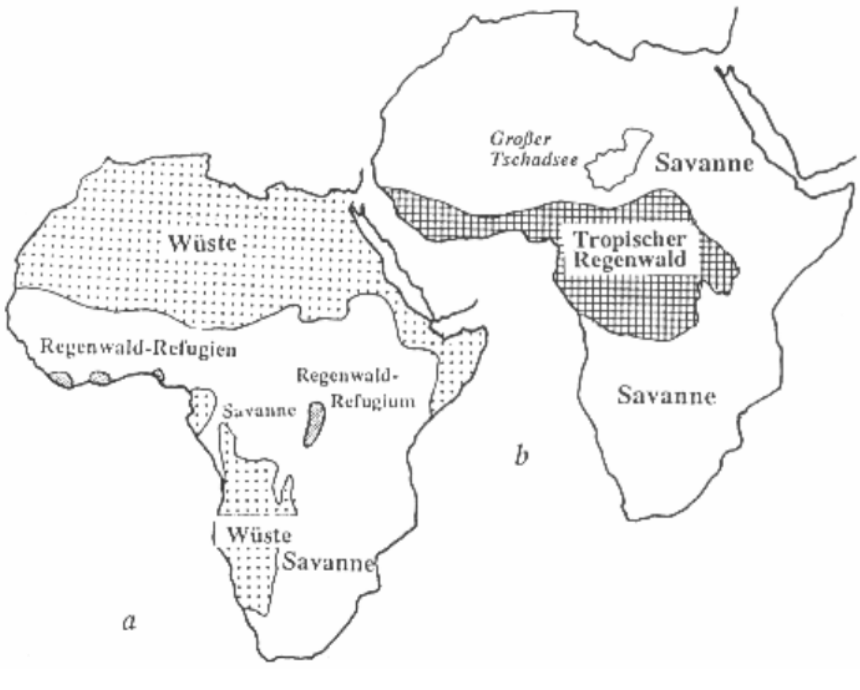


Figure 2: Spread of African rainforests in the change from the Ice Age (a) to the interglacial (b) (source: Henke & Rothe, 1994)
[TERMS IN FIGURE: Wüste = desert; Regenwald-Refugien = rainforest refuges; Savanne = savannah; Großer Tschadsee = Great Lake Chad; Tropischer Regenwald = tropical rainforest]

The pronounced sexuality of the bonobos, which is happily compared to that of humans, probably serves to stabilize larger groups. With their groups numbering up to 100 individuals, bonobos are more able to exploit the nutritional resources of their habitat. Their main foods are fruits, which ripen in great quantities at limited times and places. A good feeding place offers enough food for many animals, but the problem is to find trees with ripe fruits all the time. Large groups with large ranges are therefore at an advantage in their habitat, since ripe fruit can always be found somewhere in the group's territory (Savage-Rumbaugh & Lewin, 1995).

If, however, the observed group size and accompanying sexuality that far exceeds the requirements of reproduction are adaptations to the food supply in the bonobos' present habitat, then their ancestors of 12,000 years ago, at the end of the last Ice Age, may have behaved considerably differently.

Evaluating the greater similarity in physical proportions compared to *Australopithecus afarensis* as evidence that the bonobo provides the better ancestor model for hominid evolution I also believe is risky, given the rapid development of hominids in which *Australopithecus afarensis* represents only a momentary snapshot from one to two MY after the beginning of this development. All the more because this animal was adapted to very different environments than the modern bonobo. The longer legs, in comparison to the common chimpanzee, of *Australopithecus afarensis* for example find fully sufficient explanation in the adaptations to bipedality that took place and can hardly serve as evidence of the physical proportions of the last common ancestor of hominids and chimpanzees. On the contrary, it would be surprising if the transition to bipedality, which was already completed in *Australopithecus afarensis*, were not to correspond to changes in the proportions of the extremities.

On the other hand, knucklewalking is probably a matter of a very old adaptation of the African apes, which the common ancestor of chimpanzees and gorillas (and therefore hominids as well) already possessed ca. 7 MY ago. If one considers how the hominids developed the most important features of their physique in two short thrusts – one at the beginning of hominid evolution and the other at the transition to *Homo erectus* – then 7 MY are a tremendously long time. In comparison to this time period and to the speed with which anatomical changes in a hominid line (and therefore certainly also in the closely related chimpanzees) can obviously take place, the anatomical differences between the bonobos and the common chimpanzees are unimportant; they could have occurred and been reversed fifty times in the meantime. On the whole, both species possess the same spectrum of movement possibilities, and if the common

chimpanzee takes knucklewalking a bit more seriously, then it's probably out of consideration of the demands of its habitat and not because it is more capable in this area than the bonobo.
I would also like to refer in this context to the results of studies that say that even among humans, whose common roots do not lie nearly as far back as those of chimpanzees and hominids, anatomical features reflect climatic determinants in the areas of settlement more than relationships of descent.
Luca Cavalli-Sforza states that anthropometric methods are poorly suited for deducing family trees. Similar environmental determinants lead to similar features and suggest close relationship, so that Australians approach Africans and Europeans approach Indians [Native Americans] – both contradict the relationships determined by molecular biology (Cavalli-Sforza, 1994). Of course, an attempt to reconstruct the ancestors of Europeans and Indians [Native Americans] based on their anatomical features would fail in such circumstances. If this is already true after 40,000 years, how thoroughly must such a trace have been erased after 7 MY? And who would think it possible, based solely on anatomical features, that chimpanzees are more closely related to humans than to gorillas? This is nevertheless, as molecular biologists have shown us, most likely the case (Lewin, 1998).

Therefore, I plead for taking the adaptations of chimpanzees more seriously than parallels that result with the physical features of the early hominids, and for giving the common chimpanzee precedence in the choice of an ancestor model, instead of imagining an ancestor similar to *Pan paniscus* living in an environment typical of *Pan troglodytes*.

Even if *Pan troglodytes* is the better candidate for an ancestor model, that certainly doesn't have to mean that our ancestors were really the same as common chimpanzees. Attaching the characteristics of living species to ancestors that lived a long time ago is a risky undertaking. Scientists repeatedly indicate that modern apes have undergone an equally long, separate (further) development since the time of the split of their developmental line from that leading to humans. They are therefore just as far away in their developmental history from the common ancestor as humans are. If one observes the number of mutations that have appeared in that time, it is up to even 20% higher in chimpanzees, our closest living relatives, than in humans. This is probably primarily related to the long generation time in humans. The decisive question in the attempt to reconstruct the lifestyle of our common ancestor is, however, how much chimpanzees have distanced themselves in physique and behavior from this ancestor, and that may not be very far. It is, after all, the human developmental line that has gone through the large changes.

1.6 MY ago, there lived on Earth early *Homo erectus* on the one hand, and the last common ancestor of two since-divided chimpanzee populations on the other hand. It is namely that long that the West African subspecies of *Pan troglodytes*, *Pan troglodytes verus*, has been isolated from the other two subspecies of the species, according to new molecular biological studies (Morin et al, 1994). This surprising finding suggests, in the opinion of some scientists, that this subspecies should be elevated to the rank of species.

In these 1.6 MY, brain volumes in *Homo* have nearly doubled. In the same time period, two separate developmental lines of *Pan troglodytes* have accumulated so few differences in appearance and behavior that without the molecular biological findings, it would never have occurred to us to talk about two different species. It is difficult to imagine the common ancestors of the common chimpanzees living today as something other than typical *Pan troglodytes*. All characteristics differing in comparison to the common ancestor must, under the current "model," have developed along a path of parallel evolution, in the western *Pan troglodytes verus* on the one hand, and on the other hand in the two eastern subspecies of *Pan troglodytes*. Chimpanzees thus give the impression of being a quite stable species in equilibrium with their environment. The stated 1.6 MY nonetheless make up only the last third of the time during which the developmental lines of chimpanzees and humans have been separate. The thought that the common ancestor of humans and chimpanzees was particularly chimplike is, in light of the obviously very limited tendency for chimpanzees to change, at least in the last third of the time since the divergence of the hominid line, not to be rejected out of hand. This is even more so when one considers that in these last 1.6 MY, the climate has repeatedly changed significantly in a constant alternating of ice ages and interglacials. If chimpanzees have distinguished themselves through exceptionally high phenotypic stability in such a changeable environment, then they certainly could have done so in the preceding millions of years as well.

Because of molecular biological studies, we also know today that all hominoids originating in Africa (humans and African apes) are descended from a single species, an ape that lived in Africa perhaps 7 MY ago. Was there, at some point, only one species of ape in all of Africa? Or, if not, what is the basis of the extraordinary success of the common ancestor of hominids, chimpanzees, and gorillas? In light of the relatively high age of the apes (>20 MY) and the size and geographical diversity of Africa, I do not believe that there was only one species of ape there seven million years ago. This is supported by fossils that indicate that there was a whole series of different apes in Africa in the Miocene. How, then, did that line distinguish itself that was the only one to leave descendants today?

About 7 MY ago, the gorilla branch split off from this line. About 5 MY ago, the split into a hominid line and a chimpanzee line ensued. Thus, this line produced in short order at least two branches that, over the course of time and in different ways, crossed over to pure terrestriality (gorillas and hominids).

The chimpanzees are doubtless the most primitive of the hominoids of African origin alive today, since they are still most strongly adapted to life in the trees, where primates developed. And of the chimpanzees, the bonobo seems to be the more primitive, since it is less fixed in its locomotion than the more knucklewalking-adapted – and therewith terrestrial – *Pan troglodytes*. On the whole, though, chimpanzees are in no way especially primitive, as they demonstrate with knucklewalking a very far-developed adaptation to terrestrial life. And knucklewalking was presumably already developed at the time of the divergence of the gorilla line; otherwise, gorillas and chimpanzees must have developed this demanding adaptation independently, in parallel to each other.

It is possible that the explanation for the relatively recent common roots of all hominoids of African origin lies right here. As already cited, there was a phase in Africa 2.5 MY ago with very little living space for primitive apes. At that time, the polar ice caps grew in the course of a global cooling, and Africa became substantially drier. As was also already introduced, climate zones slide toward the equator during a global cooling, such that habitats typical at the equator disappear and their inhabitants become extinct. Among those habitats that disappeared then, as well as repeatedly in subsequent ice ages, those that correspond to the ones occupied by bonobos today would also belong. The common chimpanzee is the better candidate for survival in Ice Age scenarios. The jungle refuges that remained at the time of the ice ages would have corresponded to some of the habitats that it occupies today.

The hominoids that lived in the moister habitats of Africa up to 2.5 MY ago and that we can assume to have been at least in part much more primitive than any chimpanzee, died out then. Only one *Pan troglodytes*-like chimpanzee survived as a specialist for drier, but still enclosed,

forest areas. In addition to it, the gorillas and the hominids – adapted to even drier habitats than *Pan troglodytes* – survived.
That is why there are no truly primitive apes without adaptations to terrestrial life, such as the Asiatic gibbons and orangutans, to be found in Africa today – the last may have gone extinct 2.5 MY ago. And the bonobo is a chimpanzee that – as much as is possible for a chimpanzee – simulates a primitive ape, because it advanced into a habitat after the last Ice Age in which a primitive ape would do better than a chimpanzee. The accuracy demonstrated by the bonobo Kanzi in his method for making stone tools after some practice (see Chap. 6.2) could be evidence that his ancestors once had to use themselves this weapon (stones) – as we observe today in common chimpanzees – and had already completed some adaptations to this.

In light of its phenotypic stability in the last 1.6 MY, *Pan troglodytes* would be a suitable ancestor model in such an evolutionary course for hominids as well as for the gorilla and the bonobo. A chimplike ape – that 7 MY ago was perhaps Africa's most strongly specialized (i.e., the "least primitive") ape – had achieved, with its knucklewalking, its defense-ready social structure, and the use of weapons, the possibility of leaving the protection of the trees for longer periods of time, and thus prepared the way for gorillas as well as for the hominids.
The ancestors of the gorillas stayed in the forests and specialized in feeding on large quantities of low-nutrient food. Such a feeding pattern suggests the development of a large body, which in turn makes climbing difficult, so the path of the gorillas led to a purely terrestrial life. The enormous body size in this developmental line made the application of the body's own weapons again particularly efficient, such that in the remainder of its course, the use of weapons could be declined. Gorillas thus allow themselves to be interpreted quite well as specialized chimpanzees. That the same applies to hominids, whereby in this case the use for defense of weapons already used by chimpanzees stood central to the adaptations, is a core statement of this book.

The same characteristics that smoothed the way for the development of gorillas and hominids permitted those chimpanzees that held conservatively to their adaptations to survive the Ice Ages, during which Africa became extremely dry and no longer offered more primitive apes much, or perhaps any, room to survive. As the most primitive ape remaining after the Ice Ages, a chimpanzee similar to *Pan troglodytes* would have had the best prospects of all African hominoids to occupy the tropical forests that spread out again during the interglacial periods.

Possibly, therefore, side branches of chimpanzees arose repeatedly during the interglacials that adapted themselves to the transitorily reappearing tropical forests and therefore seemed more primitive than *Pan troglodytes*. The pygmy chimpanzee, which presently occupies habitats that disappeared during the Ice Ages, would be a current branch of this type.

I would like to add an oversimplification [lit.: “milkmaid calculation”] here. The West African subspecies of *Pan troglodytes* has developed in isolation over the past 1.6 MY. Thereby a genetic distance has accumulated between this population and other populations of the common chimpanzee that approximately corresponds to the one that lies between the common ancestors of this chimpanzee population 1.6 MY ago and the common ancestors of chimpanzees and humans 5 MY ago. If the living conditions of chimpanzees did not change much more drastically in the period between 5 and 1.6 MY before our time than in the last 1.6 MY, then one can certainly expect that the chimpanzees of 5 MY ago (our ancestors) didn’t differ more from the chimpanzees of 1.6 MY ago (the common ancestors of different *Pan troglodytes* populations) than do the different populations of *Pan troglodytes* today.
And there is no basis to the assumption that the conditions of that period changed in a way relevant to the common chimpanzee, since even the extreme climate changes of the last 1.6 MY have obviously done nothing to it. Climate changes happen very slowly compared to everyday events. When climatic zones move in the course of a climate change, organisms have no difficulty in following their ancestral habitats. It only becomes problematic when geographic barriers are in the way or when entire climatic zones run together at the equator and disappear. *Pan troglodytes*, therefore, provides the best available primate model for hominid evolution not just because of its habitat and its close relationship to humans. It is also the more primitive chimpanzee and distinguishes itself through a very low tendency to change. It is easily conceivable that our ancestors behaved and looked just like common chimpanzees.

Of course it could be that the ancestors of chimpanzees 5 MY ago, when the hominid line branched off, had not yet fully matured in their adaptations, so that in the period of time between 5 MY and 1.6 MY before our time decisive adaptations still took place. It speaks against this, though, that an extremely modern feature of chimpanzees – knucklewalking – was probably already fully developed 7 MY ago.

Owing to all of these considerations, I have decided to take *Pan troglodytes* very seriously as an ancestor model and refer abundantly to the observed behaviors of this species in the CTSW model.

Although I do not find pygmy chimpanzees to be a suitable primate model for hominid evolution, they are worthy of consideration too, since they show a possible direction in which a wild-living chimpanzee population can develop and could help in the understanding of human evolution, especially on the points in which they are more similar to humans than common chimpanzees. Parallel evolution could be present here, whereby the reasons for the changes that took place can be understood more easily in the culturally unaltered bonobo than in humans, and explanatory approaches to human development may thus appear.

3 Development of the Early Hominids

3.1 Australopithecines

In the book “LUCY – The Beginnings of Humankind” by Donald Johanson and Maitland Edey, *Australopithecus afarensis* was described as a being with a humanlike body and an apelike head (Johanson & [Edey], 1982). This description, which above all possesses the advantage of underlining the evolutionary position of australopithecines between apes and humans, serves at best today as a first approximation. The australopithecines showed significant differences to humans below the neck, also. They were obviously not simply adapted in their locomotion to an upright gait as we are, but rather showed their own adaptive pattern (Brandt, 1995).

The australopithecines were less specialized in their locomotion than humans; their bodies were adapted to upright progression on the ground on one hand, and to climbing on the other hand. Their bodies also were not an unstable, transitional form between an ape body and a human one – on the contrary, they show a remarkable stability of physical features over the entire timeframe of the appearance of the australopithecines. And this timeframe is notable. The first australopithecines surely already existed more than 4 MY ago; the last would have died out ca. 1 MY ago. We thus have every reason to assume that the physique of the australopithecines, as it was, represented an optimized solution for survival on the savannah under application of the strategies employed by the australopithecines. For comparison: the human “prototype” surfaced only with *Homo erectus* ca. 1.8 MY ago.

The most interesting and evidential among the old hominid fossils are attributed to the species *Australopithecus afarensis*, which became particularly well known through “Lucy.” Lucy is a 3.18 million-year-old skeleton of a female that was discovered in 1974 in the course of an expedition conducted under the leadership of Donald Johanson in the Afar Triangle of Ethiopia (Johanson & White, 1978; Johanson & Edey, 1982). In the professional literature, she appears under her catalog number, AL 288-1.

With Lucy, about 40% of the skeleton is preserved and, because of the symmetrical features of the body, about 70% is known – a true El Dorado for paleoanthropologists, who are used to having to put up with individual teeth or jaw fragments. Lucy also made clear for the first time how small in particular the female australopithecines were. As an adult female, she had barely exceeded a height of one meter and probably weighed on the order of 30 kg. In size, then, she corresponded to a not-too-large female chimpanzee, but had shorter canine teeth and presumably occupied a much more dangerous habitat.

On the next campaign of the same expedition, the “First Family” was also found. That is a case of fossils belonging to at least 13 different individuals. This find led to long-lasting conflicts among experts. The controversy of the find hinges on whether the strongly non-homogenous material consists of a single species with strongly developed sexual dimorphism, i.e., the males and females were very different from one another, or whether the fossils found together represent two different species.

In the background of these conflicts was that Donald Johanson and Tim White, who proposed the single species hypothesis and named this species *Australopithecus afarensis*, proposed this species as the ancestor of all other previously discovered hominids. This also introduced, through her, a clear upper limit for the age of an independent human line.
On the other hand, Lucy was very primitive in her characteristics and still doubtless very far from being human. That the “crown of creation” could have developed from such an animal in only 3 MY, many researchers considered to be downright nonsense. These researchers still typically assumed, though – in spite of the results of molecular biological studies that indicated otherwise – that the lines of apes and humans had already divided by at least 15 MY ago.
If one assumes that by Lucy’s time, human ancestors had already gone through 12 MY of independent development, and perhaps has in mind a linear progression from apes to humans in the last 15 MY, then Lucy is in fact too “primitive” to be a human ancestor.

Since then, it has been demonstrated with increasing frequency that in evolution, short periods of intensive changes and long periods of phenotypic stability generally follow one another, such that we cannot speak of a linear progression. In addition, the molecular biologists who assume a last common ancestor at about 5 MY ago have prevailed. The “molecular clocks” they use have since been accepted as important – if not easily operated – sources of information (Lewin, 1998). The assessment that fossils previously taken as evidence for a greater age of the independent line had been falsely interpreted contributed in no mean way to a change of opinion in favor of the molecular biologists. Today it is safe to say that Lucy presents as a plausible candidate for human ancestry (perhaps we also simply needed some time to get used to the idea).

The single-species hypothesis suffered long from the fact that no skull of *Australopithecus afarensis* could be found. *Australopithecus afarensis* only finally prevailed because of a skull found in 1991 (Kimbel, Johanson, Rak, 1994).

The *Australopithecus afarensis* of East Africa was long the only hominid known for the period of 3.9 to 3 MY ago and counted as the probable ancestor of all subsequent hominids, including humans. Since then, sensational new finds have altered the picture substantially; nevertheless, *Australopithecus afarensis* remains the early hominid best represented through fossils and most thoroughly studied.

From the timeframe of 3.5-3.2 MY, new finds arose from Bahr el Gazal; this lies 2,500 km farther west, in Chad, and thus in a completely different region of Africa (Schrenk, 1997). Whether an independent species designation is appropriate for these finds may be left open to further technical discussion. They were described as *Australopithecus bahrelgazali* and thus demarcated at the same taxonomic level as *Australopithecus afarensis*. In any case, the location of the find made it clear that it is dangerous in model building to tie oneself to East Africa as the place of origin of the hominids just because the best and oldest fossils have been found there. East Africa offered above all very good conditions for the creation of deposits leading to fossilization, which today, due to favorable geographic relationships, frequently lie on the top layer again and because of erosion, offer up the embedded fossils again. This could be a sufficient reason why the most important fossils have been found here. Evidence that the origins of the hominids were a local, East African event can hardly be derived from this at the present moment.

For my taste, some ideas about the evolution of the hominids place much too much value on assumed processes of geographical isolation and genetic drift. These concepts are postulated by population geneticists to be important driving forces in their considerations of the generation of new species and play an important role in the *East Side Story* propagated by Yves Coppens (Coppens, 1994). As far as I understand this, one cannot assume that the mechanisms for speciation are already clear. In the case of the human developmental line, molecular biological investigations indicate that the number of individuals involved in reproduction since the split from the chimpanzee line never amounted to less than 10,000. It is thus doubtful that genetic drift, i.e., the significantly increased probability in small populations that a variation in the population prevails through pure chance, ever played a significant role in the last 5 MY of human evolution.

In this book, I consciously pass up evolutionary theoretical considerations of how individual speciations occurred. Such considerations present hypotheses that on their part build upon unproven hypotheses and are thus quite speculative. As long as sufficient "harder" data are available for developing an evolutionary scenario, this kind of detailed evolutionary theoretical considerations should, in my opinion, be excluded.

So, East Africa's *Australopithecus afarensis* is no longer the only hominid of its time. Additionally, new finds have also ensured that it is no longer the oldest known hominid. Here, two newly named species have already gotten the better of it.

The ca. 4.4 MY-old finds discovered since 1992 in Aramis in Ethiopia have even been registered with a new generic name. They are attributed to *Ardipithecus ramidus*. This need not be the last word on the topic by far, since it is really questionable whether there is enough room left between the last common ancestor of humans and chimpanzees, ca. 5 MY ago, and the australopithecines for a new genus (*ramidus* means "origin" or "root" in Afar; the choice of this name should make plain that *Ardipithecus ramidus*, with its numerous chimplike features, stands very near the fork of the chimp and hominid lines).

The finds attributed to the new species *Australopithecus anamensis* are dated to the time of 4.2 to 3.8 MY ago (Leakey & Walker, 1997; Schrenk, 1997).

Both species are too new to be considered in this book. Still, *Ardipithecus ramidus* seems to show the combination of features of already shortened canines and bipedality. Therefore, it fits prominently into the CTSW model of hominid evolution, particularly because it differentiates itself from the australopithecines in that its tooth enamel is not thick, but still thin like in chimpanzees. The canines thus apparently began to forfeit their weapon characteristics before adaptations to the consumption of dry foods occurred. This is an indication that at the beginning of hominid evolution, the canine teeth lost their importance as weapons without this development being required by changed feeding habits.

The most expressive material on the evolution of the early hominids and the basis for the considerations on the theme presented in this book continues to rest provisionally on the by now abundantly researched and professionally discussed *Australopithecus afarensis*. While its brain, at 380 to 450 cubic centimeters, was only insignificantly larger than the recent apes, with 300 to 400 cubic centimeters, and no worked stone tools can be identified in association with it, it was obviously already well adapted to walking upright. The famous Laetoli footprints, with an age of 3.6 MY, can probably also be traced back to it (Hay & Leakey, 1982).

These footprints are a nearly unbelievable stroke of luck for paleoanthropology and prove, independent of the interpretation of rare fossil bones, the existence of bipedal hominids at that time in East Africa.

Owen Lovejoy even claims that the adaptation to bipedality in *Australopithecus afarensis* was so one-sided that this species was downright condemned to pure terrestriality (Lovejoy, 1989). Here, he stands in opposition to the majority of his colleagues, who point to a whole series of anatomical characteristics that are interpreted as adaptations to occasional arboreality. Especially important is the discovery of an australopithecine foot by Ronald Clarke in the year 1994. The foot comes from the Sterkfontein clay pit in South Africa, is dated to an age of ca. 3.5 MY, and demonstrates both an apelike big toe and a humanlike ankle. This foot indicates a continued high importance of climbing for australopithecines and fits very well in the Laetoli footprints (Clarke & Tobias, 1995).

Investigations of the labyrinth by Spoor point in the same direction (Spoor, Zonnefeld, Wood, 1994). Spoor supposes a relationship between the form and position of this balance organ and the type of preferred locomotion. The labyrinth is no greater than one centimeter in expanse and is located in the interior of the skull. Through use of computed tomography, Spoor was able to investigate form and size of the labyrinth without damaging valuable fossils. According to his results, the australopithecine labyrinth differs from that of humans. *Homo erectus* is the first species that shows the labyrinth typical of humans, and thus probably the first hominid species adapted one-sidedly to walking upright and terrestrial life. The generally peculiar-looking results for *Homo habilis* I will consider at the end of this chapter.

Why the australopithecines as well as – if one accepts the new *Ardipithecus ramidus* as a new genus – the ardipithecines developed the upright gait is presently the object of many considerations.

Henry McHenry and Peter Rodman have come to conclusions that are apparently held to be particularly promising. They see an explanation in that the upright human gait is more energetically favorable than the knuckle gait of chimpanzees. This is certainly an interesting point of view for a habitat in which food is spread out over a large range (Rodman & McHenry, 1980), as we presume for the australopithecines. But they determine themselves that for chimpanzees, knucklewalking and walking upright do not differ energetically. Thus, there exists on the one hand no energetic Rubicon, but on the other hand no selective advantage for the beginning of the transition to bipedality. And comparison of the two species of chimpanzees living today points in the opposing direction:

Pan paniscus, appearing in the moist jungle ranges of Zaire, is less physically specialized than the common chimpanzee (*Pan troglodytes*). It moves much more often on two legs – particularly when it carries something on the ground. *Pan troglodytes* inhabits, compared between the chimpanzees, the drier habitats. In this [species], primarily the males travel considerable stretches on the ground, whereby the obtainment of food stands less in the foreground than watching over the borders of the group's territory. In spite of this, it is more specialized to knucklewalking (de Waal, 1991). This would sooner indicate that knucklewalking is, for the chimpanzees that move a lot on the ground in a habitat typical for the early hominids, more favorable. One should not forget here that in comparison to the bonobo, the common chimpanzee is [more] often observed using tools in the wild. Here also, an upright gait could be an advantage – at least the good old theories of Man the toolmaker assume this – and nevertheless, *Pan troglodytes* is the stronger champion of knucklewalking between the chimpanzees.

Knucklewalking could be more advantageous for safety reasons, as long as the canines play an important role in defense against enemies – and "safety considerations" are a high priority for apes on the ground.

In a tree, an ape is the biggest and the strongest and hardly has anyone to fear – on the contrary, the chimps are the ones that hunt the other monkeys. Because of the minimal predatory pressure in the canopy, the apes could specialize in the birth of fewer offspring. They invest strongly in the quality of their offspring, at the expense of quantity.

On the ground, low fertility quickly becomes a problem, since here the losses to predators increase. An ape specialized for walking erect offers a bigger target and has much more difficulty getting its teeth between itself and its attacker. Particularly the legs are quite far removed from the teeth. With a knucklewalker, in contrast, the entire surface to be defended can be covered quite quickly with the head. In addition, the upright gait is not especially stable, and a biped knocked to the ground is rather defenseless (characteristically, even small children try to knock down their opponents (Eibl-Eibesfeldt, 1995)). It is thus quite natural that common chimpanzees, which spend more time on the ground and above all in more dangerous locations than bonobos, are more consistently specialized for knucklewalking.

Knucklewalking also requires long arms and relatively short legs – proportions that are unproblematically compatible with good climbing abilities. Since we now know that climbing still played an important role at least for *Australopithecus afarensis*, we can assume that it bought its bipedality at a high price. And the presumably more terrestrial males [paid] a higher price than the females.

The claim that the transition to walking erect must have had very well-founded reasons is additionally supported by the observation that bipedality is an exceptionally rare means for mammals to get around.

As an explanation for a development bound to so many heavy disadvantages, an initially barely tangible energetic advantage does not, in my opinion, suffice. This does not mean that it played no part whatsoever. Evolution is an integrative process in which all the advantages and disadvantages of a variation for the fitness of the bearer undergo simultaneous consideration. If the transition to bipedality went along with an improvement in energy endurance, then this would certainly have eased the transition; I do not believe, however, that this advantage alone sufficed to outweigh the aggravating disadvantages appearing on the other side.

In any case, the question arises whether we, in these times of apparent energy shortage with potentially catastrophic consequences for our society, have developed an – for evolutionary theoretical interests – excessive sensitivity to energetic points of view. For chimpanzees, other points of view are quite obviously much more important. This is exemplified by the enormous “waste of energy” by children playing and males displaying or conducting extensive border patrols. Even time spent in long fur grooming sessions could be spent better, from an energetic point of view, in acquiring food.

These considerations do not just affect the transition to walking upright. There is also a popularly presented calculation that concludes that the replacement of Neandertals by modern humans in Europe, with which we have yet to deal, could be explained simply because *Homo sapiens* was able to use the resources 2% more effectively. Such calculations are perhaps appropriate to bacteria, which compete with one another solely and simply on the level of food acquisition – in complex, social organisms that compete aggressively with one another in groups for resources, such as chimpanzees and humans, such an observational approach is pronouncedly reductionist and inadequate.

About the hand of *Australopithecus afarensis*, the experts are of divided opinion. On the one side, it is described as astonishingly modern; on the other, its similarity to ape hands is emphasized. The fingertips of *Australopithecus afarensis* were still narrow and the thumb shorter than that of humans. The width of the fingertips corresponds directly with the number of nerve endings, and with that, the sensitivity of the fingers. The long, opposable (i.e., can be placed opposite all the other fingers) thumb of humans is of decisive importance for the typical human precision and power grips.

Now, the *afarensis* thumb was shorter than the human one, to be sure, but also longer than that of chimpanzees. It could also, according to Marzke (Marzke, 1983), be placed in opposition to the index and middle fingers already, such that the so-called three-finger precision-and-power grip was possible. In the case of the hand, *Australopithecus afarensis* would thus actually be a good example of mosaic evolution, but that fits poorly into the picture as long as one tries to attribute the development of the precision grip of the hand to the production of tools.

The first worked stone tools appeared just 2.5 MY ago, 700,000 years after Lucy. If one wants to hold fast to the toolmaker hypothesis for the development of the grip, then one must not only assume the production of other tools for more than 3 MY, but also that the production of these tools required more than the grip of an ape could achieve. Above all, I doubt the second assumption. I would not know, for instance, what in the production and use of digging sticks would be beyond the potential of a chimpanzee. Presumably, gathered horns were used for this anyway, which didn't have to be reworked at all.

Striking is the significant difference in body size between male and female australopithecines. While with chimpanzees and humans, the males/men are about 20% heavier than the females/women, the difference in *Australopithecus afarensis* was substantially larger. Weight estimates themselves rely on guesses based on few finds and vary strongly by author and method, but we can assume body size differences of between 50 and 100%. The upper value corresponds to that of gorillas and orangutans. In these, the males are around twice as heavy as the females (Henke & Rothe, 1994).

Thereupon are based the assumptions that in the australopithecines, there was a similar competitive situation among males over reproductive resources as appears in the harem-building gorillas and orangutans. The sex differences in *Australopithecus afarensis* are not, however, limited to body size, so that Stern and Susman proposed as an alternative explanation for the characteristics of the postcranial skeleton that the more gracile females were decisively less terrestrial than the more robust males (Stanley, 1992).

In the period between three and one MY before our time, a whole series of hominids appeared and then disappeared, except for one, *Homo erectus*, which first appeared ca. 1.8 MY ago and is considered our ancestor. The multitude of recently named species in this period provides for ongoing discussions among experts about the ordering of fossils and the descent relationships between species recognized at this time. Further fossil finds are apparently always able to turn currently favored family trees inside out, as the "Black Skull" impressively demonstrated when it finally forcefully muddled the branches of the favored family trees (Henke & Rothe, 1994).

The lines of questioning concerned with the naming of species and the kin relationships among hominids go, on the one hand, very strongly into detail, and on the other hand leave a lot of room for arbitrary perspectives. The scientific disagreements over the ordering of fossils hold a special zest, in that species, genera, etc. in an evolutionary scenario are, to be precise, not at all clearly defined from the start.

These terms were put in place by Linnaeus as categories in his "Systema Naturae" in order to organize organisms into a comprehensive scenario according to observed, stepwise degrees of similarity to one another.

The Systema Naturae, as well as the similarity of organisms, was then interpreted by Darwin as the results of evolution, i.e., as that which occurs when one looks at where evolution led to at a particular time.

If one considers the evolutionary scenario at a particular point in time, then uninterrupted developmental lines, which were connected somewhere in the past, degrade into points (populations) with generally clearly defined distances between them. Considered on the genetic level, members of a population generally stand substantially closer to one another than do individuals from different populations. The amount of relational closeness between different populations is, following Darwin's explanatory approach, associated with a corresponding amount of physiological similarity and thus forms the basis for categorization into species, genera, families, or higher levels in a Systema Naturae.

The evolutionary scenario takes place in a space larger by one dimension – time – compared to the Systema Naturae. One can imagine the Systema Naturae as a plane in evolutionary space that results from viewing only a particular point in time. The terms developed for determining a position in a Systema Naturae are therefore just as insufficient for determining a position in evolutionary space as it is impossible to identify unequivocally a point in three-dimensional space with the two Cartesian coordinates on a plane.

As long as one assumed that all species are unique and unchanging, the arrangement of extinct species in the Systema Naturae presented no difficulties, since the species were supposed to be immutable over time and thus should show no dependence on time. After the introduction of evolution by Darwin, someone should have thought about whether the systematics used in the Systema Naturae could do justice to an evolutionary scenario. Instead, they spoke constantly about the changeability of species and continued to classify them as though they were unchangeable.

One can use a thought experiment to clarify for oneself what problems are thus essentially presented. As a grossly simplifying – but halfway plausible – basic assumption, it should be taken that speciation and genetic distance are strictly associated with one another. The species is the only category in the Systema Naturae for which there is an exact and (at least for living organisms) testable definition. All organisms that are unrestrictedly capable of reproducing with each other belong to the same species. Unrestricted means, in this case, that the offspring are also fertile. With horses and donkeys, for instance, this is not the case, as the offspring are sterile.

We assume, then, in our thought experiment, that reproduction no longer functions as soon as a certain genetic distance between the partners is exceeded. This distance is called upon again to determine whether ancestors and descendants within a developmental line still belong to one species. Of course, this cannot be tested directly as long as there are no time machines (and it does not seem very sensible to wait for the development of this technology).

Since different genera in the Systema Naturae are associated with a larger distance, individuals that belong to different genera should show an even greater genetic distance among themselves than among individuals that are only differentiated on the species level. This continues accordingly for higher levels of differentiation. Now we assume that the genetic differences in two reproductively isolated populations increase linearly with time, whereas each population undergoes the same amount of different change. What follows from this in the framework of our thought experiment for an evolutionary scenario?

1. At any point in development, the distance between two lines evolving in parallel is twice as great as the distance at that time to the common ancestor, as the genetic changes in both lines pile up.
2. The offspring in both lines need only half as much time to develop into different species as they do to cross the species barrier relative to the common ancestor. Genetically, the common ancestor thus stands exactly [halfway] between the daughter species and not somewhere behind them.
3. In the above example, both daughter populations still belong, from the viewpoint of the mother population, to the same [original] species when they have, seen relative to one another, long since belonged to different species. Just because individuals A and B belong to the same species and individuals B and C also belong to the same species, one cannot conclude in an evolutionary scenario that A and C also belong to the same species. In an evolutionary scenario, there are no more clearly-outlined groups of individuals that, together, constitute a species. Such groups only appear through the slicing of the transition to the Systema Naturae, in which the connected lines that stretch out across time are capped. The species can be defined in the evolutionary scenario only as a relative term. It thus makes sense to speak of a species only when one also provides a reference point (a particular individual or a chronologically and geographically clearly defined population).
4. The differentiation of two reproductively isolated populations on the species level occurs only a considerable time after the division of the lines and chronologically precedes a differentiation on the generic level; even later after the branching does it come to a differentiation on the higher level of the family, etc. It makes absolutely no sense to speak at the branching point already of two new species, new genera, or even families.

Let us now refine these thoughts further with the example of hominid evolution. From *Pan troglodytes*, we know that in this sister-species to humans, 1.6 MY of isolated development were not sufficient to cross the species boundary. In the zoological gardens of the world, individuals belonging to different subspecies of this species with the corresponding genetic distance are cheerfully crossed with one another.

It thus stands to reason that in a direct developmental line of chimpanzees – and surely also in the closely related hominids – 3.2 MY are not sufficient to make members of different species from the ancestors and descendents. Soberly considered, we must assume that the 3.2 MY old Lucy would be capable of unrestricted reproduction with any male *Homo sapiens* (with the limitation, insignificant to the thoughts considered here, that mother and child might only be able to survive the birth if a Caesarian section were performed). Equally, she must have been able to reproduce without restrictions with every male of the common ancestral population of humans and chimpanzees ca. 5 MY ago. From Lucy's point of view, the whole of hominid evolution was thus an intraspecific process. From our point of view, though, Lucy was perhaps the first to belong to our species, and the species boundary perhaps runs through the middle of the time period of 3.9-3.0 MY ago, during which the fossils of our ancestors are presently classified as *Australopithecus afarensis*.

Just for fun, let's look again to see who else, from our perspective (*Homo sapiens sapiens* today), might have belonged to our species if we assume that a division on the species level occurs after 1.6 MY of separate development or 3.2 MY of development along a line.

If the line of the robust australopithecines split from ours 2.5 MY ago, then these belong to our species in the first 0.7 MY of their own development; that is, until 1.8 MY ago. Afterwards, they belonged to a different species. As they died out 1 MY ago and developed separately among themselves for a maximum of 1.5 MY, they must have been unrestrictedly interfertile at all times and therefore always belonged to the same species. And our ancestors belonged to the same species as long as the robust australopithecines existed, because these died out after only 1.5 MY of independent development and thus were never able to cross the species boundary to the contemporary representatives of our developmental line.

If different lines of *Homo erectus* are to have developed in reproductive isolation for 1.8 MY, then they still all belonged to our species for 1.4 MY. Among themselves, they were unrestrictedly interfertile at least until 0.2 MY ago.

That the Neandertals, whose line diverged from ours only ca. 0.5 MY ago, always belonged to our species appears downright obvious. Should our line produce offspring 2.2 MY from now, then these will be the first able to claim that the last Neandertals, who died out 30,000 years before our time, do not belong to their species.

Let us look, in comparison, at that with which the paleoanthropologists please us. It's an absolute rule that after the passing of no more than one MY within a developmental line of hominids, a new species must be introduced. Lucy (*Australopithecus afarensis*, 3.2 MY), Lucy's Child (*Homo habilis*, 1.8 MY), and the Turkana Boy (*Homo erectus*, 1.6 MY) may be representatives of a single developmental line. If this is true, then they had a genetic distance amongst themselves that in the largest case (between Lucy and the Turkana Boy) was half as large as that between a male *Pan troglodytes schweinfurtii* and a female *Pan troglodytes verus*, which at the moment are happily reproducing in a zoo somewhere. In spite of this, they are placed in three different species of two different genera.

The question of whether the Neandertals should be numbered among our own species is occasionally equated with the question, not at all relevant in this context, of whether they are among our ancestors. They did not belong to our ancestors, but neither could they have belonged to a different species after only 0.5 MY of independent development.

The joy of the naming of new species, as we also know it from collecting butterflies, seems here to have run rather wild [lit.: "to be strongly shot into the plant"].

That too many species have presumably been named is, however, a superficial problem. Much touchier is the habit of speaking of two new species, genera, or even families already at the point of division. This contradicts the expectation that these categories should be associated with the genetic and temporal distance of the populations compared to each other and the point of division of their lines, and therewith also Darwin's explanatory approach to the origin of the relational similarities on which the Systema Naturae is constructed – i.e., evolutionary theory.

These problems are fortunately almost entirely decoupled from the question complex to which I attempt to provide answers with my hypothesis. I come to grips with the global border specifications of hominid evolution, and for this, the prominent common characteristics of hominids are of importance, not the fine differences that are called upon to uncover kin relationships that have their fallout in family trees. In principle, I could thus use the names as they are and not concern myself further with their justification. For the most part, I will do this from now on. I only took up this point because I have the feeling that terminological difficulties that result from trying to understand an evolutionary scenario with the insufficient vocabulary of a Systema Naturae lead to grave problems in understanding evolutionary processes.

If one is, for instance, convinced from today's point of view that the transition to walking erect belongs among the most important innovations of hominid evolution, then one uses this knowledge to differentiate *Ardipithecus ramidus* from the common ancestor with chimpanzees on the family level; that is, even above the generic level. At its time, 4.4 MY ago, it was possibly just a somewhat funny chimpanzee (funny in comparison to the chimplike ancestors of recent chimpanzees at the same time) that walked erect constantly instead of just occasionally and was in principle still unrestrictedly interfertile with its chimp cousins, from whom it had only developed in reproductive isolation for a short time. There thus exists a well-founded suspicion that here, two populations that belonged biologically to the same species are being placed in different families!

An extraterrestrial (non-bipedal) biologist would hardly, in visiting the Earth 4.4 MY ago, have found enough differences between the ardipithecines and the closely-related ancestors of chimpanzees living at the same time to differentiate them on the generic level – not even to mention classification in two different families. If this biologist coincidentally happened to be a quadruped, he would more likely have supposed the evolutionary potential to produce a highly intelligent life form of the representatives of the chimpanzee line. The ardipithecines would have been described, in contrast, as already too strongly specialized and therefore too limited in their developmental possibilities, rather than as having hopes of finding survival possibilities outside their niche.

Of course, thoughts on evolution are strongly distorted when one knows where a new development is going to lead. It is exactly this knowledge from which we must attempt to gain distance. In connection with hominid evolution, this difficulty in finding the right perspective is embodied in the key word anthropocentrism, which has repeatedly led scientists onto thin ice [lit.: "slippery ice"] in constructing hypotheses. The fact that walking upright offers me the important prerequisites for typing this text on the computer with my hands today hasn't the slightest thing to do with the question of why this characteristic developed in our ancestors. If, however, one calls upon exactly those characteristics that one holds to be exceptionally indicative of the course from today's view (retrospective) to decide differences on the species or higher levels in long-extinct organisms, then exactly that knowledge from which one should distance oneself in the construction of evolutionary scenarios is having massive influence in classification.

One then operates in hypothesis construction with names that suggest relationships that may never have existed.

Another prominent example here is *Homo habilis*, the “handy man.” Its placement in the genus *Homo* was based on the assumption that it was the maker of the first stone tools. Thereby, it had founded a tradition that bore rich fruits two million years later. The name thus reflects no biological relationships, but rather the fact that the namers followed the toolmaker hypothesis. On the other hand, the morphological differences between Lucy’s Child (*Homo habilis*) and Lucy (*Australopithecus afarensis*) hardly suffice to constitute a difference on the species level.

I will, as mentioned, use the existing names from now on and even allow myself to get carried away into suggesting changes that operate within the logic used until now in giving names, and at the same time within the logic of my evolutionary scenario. Mostly, though, I will limit myself to dividing up the australopithecines in a very large-scale manner into robust and gracile australopithecines. Among the robusts, I count *Australopithecus robustus*, *Australopithecus boisei*, and *Australopithecus aethiopicus*. As I also place *Homo habilis* with the australopithecines; it, together with *Australopithecus africanus* and *Australopithecus afarensis*, makes up the group of gracile australopithecines.

In light of the great importance that I attribute to the developmental phase that *Homo habilis* represents within human evolution, and in order to prevent unnecessary confusion, I typically handle *Homo habilis* specially and also retain the name unchanged. Independent of this, I plead for changing it to *Australopithecus habilis* or, in case it appears more appropriate, to give that up in favor of *Australopithecus africanus*, as it is all the same in the end whether *Australopithecus africanus* was an ancestor or a South African contemporary and conspecific of *Homo habilis*. In the end, the enlargement of the brain is greater at the time of *Homo erectus* than in the entire course of the evolution of the gracile australopithecines, without **this** being called upon to divide *Homo erectus* into two species (we will yet see that it has meanwhile been attempted to split *Homo erectus* into multiple species for other reasons). Of course, my ignorance regarding the allegedly high importance of the first stone tools is reflected in this adjustment – but I will express my views on this thoroughly later.

Some scientists divide the material attributed to *Homo habilis* again into two species, *Homo habilis* and *Homo rudolfensis*. This is motivated primarily by the expectation that the direct ancestor of *Homo erectus* should not have exhibited any extreme sexual dimorphism, since in *Homo erectus* already only a slight sexual dimorphism showed. Also, investigation of the labyrinth of a small, thus – if we are dealing with one species – female, *Homo habilis* seems to speak for the assumption of two species. The aforesaid labyrinth was an outlier, as it was even more apelike than all australopithecine labyrinths studied. It was most comparable to the labyrinths of gibbons. This indicates a strong adaptation by the owners of these labyrinths to life in the trees. The investigation of the labyrinth of a large *Homo habilis* has yet to be done.

I will point out that substantial sexual dimorphism in *Homo habilis* presents no difficulties at all within my model of hominid evolution; on the contrary, it was precisely *Homo habilis* that took sexual dimorphism to the extreme. Thus, express adaptations of the females to life in the trees are obvious. These alone would let a strongly deviating form of the labyrinth in males not appear unusual. Presumably, a division of the *Homo habilis* hypodigm (fossil material attributed to a hypothetical species) within my model is thus superfluous, and so *Homo rudolfensis* is also presumably superfluous. But this is, as already mentioned, a point that only touches my line of questioning at its edge.

3.2 Australopithecines as apes of the savannah

However the adaptive traits of the australopithecines – to which our ancestors also belonged – were individually disposed, they enabled them generally to survive in relatively dry and open habitats. Baboons occupy habitats of this type today and have adapted to them in their way. The upper canines of male baboons have developed into frightful weapons; they are almost as long as those of a leopard and are polished razor-sharp on the back edge. Additionally, baboons normally cross open territory in formations that minimize losses to predators (Angst & Kummer, 1975).

Baboons thus reckon with the fact that in open grasslands, a much higher danger from predators exists than in close forests. Grasslands produce a huge quantity of usable fodder. They are occupied by a plethora of large, grass-eating mammals and are therefore also the habitat of many large predators that could become dangerous to a baboon as well as a chimp-sized ape. At the same time, trees and cliffs on which primates can find security are only found sporadically.

As the adaptive traits of the baboons clearly show, endangerment by predators belongs among the greatest challenges in the occupation of open habitats. This obtains even more to apes, with their substantially lower reproductive rate compared to baboons.

A baboon ["Mantelpavian"] female reaches sexual maturity already at 5 years and bears young every 22 months (Kummer, 1992). Chimpanzee females (*Pan troglodytes*) have, in contrast, their first offspring only at 11 to 12 years. The juveniles are typically weaned at the end of their fifth year, after which the next pregnancy follows (Goodall, 1986). For bonobo females (*Pan paniscus* or pygmy chimpanzee), Frans de Waal actually reports an age of 13 to 14 years for the first birth (de Waal, 1995). For recent primitive people and nomads, an interval of 4 years between births is generally given (Eibl-Eibesfeldt, 1995). A higher birthrate probably became possible for humans only after the transition to farming and animal domestication ca. 10,000 years ago, as a result of permanent settlements and the availability of high-quality child nutrition.

It is hardly to be assumed that the australopithecines were able to raise their reproductive rate substantially over that of chimpanzees. Reproductive strategies in the animal kingdom are quite well researched by now, and it is a basic rule that high offspring quality comes at the cost of quantity. The somewhat larger brain, in comparison to chimpanzees, of the australopithecines leads to the conclusion that a development in the direction of increased quality occurred with them, a development that could normally have left no room for a simultaneous increase in the number of offspring.

Of course, we could assume nonetheless that the early hominids had already managed the feat of increasing quality and quantity of offspring at the same time. It was exactly there that Owen Lovejoy saw the decisive adaptive trait of the early hominids, and [he] built his model of hominid evolution and his explanation for the transition to bipedality upon it (Lovejoy, 1981; Steitz, 1993). But even in this extreme scenario, there could hardly have been great changes in the relatively high age of females at their first pregnancy, which in itself contributes greatly to low fertility and begs the question how enough females could become old enough in the dangerous savannah to ensure reproduction.

In the CTSW model, I decline to assume an adaptation among the still extremely chimplike early hominids of 4-5 MY ago that leaves the framework of what is possible in the animal kingdom so far behind it as Owen Lovejoy's pairbonding model.

I have fewer doubts here considering the capabilities of animals than in consideration of the questions of whether human behavior is at all optimized regarding reproduction. I assume that the development of lifelong pairbonds in a closed social group to which a large number of adult men belonged was possible for humans only in the context of intensive cultural evolution. Why should a higher-ranking male decline to increase his reproductive success by pairing with the female of a lower-ranking male? The examples of monogamous behavior in the animal world that are popularly paraded [lit.: "led into the field"] by no means prove that such behavior can come to be under natural conditions, i.e., in the case of a behavior oriented toward maximizing fitness.

Gibbons do live together in pairs, but the pair simultaneously constitutes the entire social group of these animals. There are thus no other males among them also belonging to the group that make claims to the female and, in the case of higher rank, can also carry them out.

With monogamous birds that breed in colonies, we also cannot speak of a closed social group with an express rank order. That is a case solely of congregations of animals that have found themselves together because they can rear their young with lower risks in a group, or simply because suitable nesting places are rare.

Should the lifelong pairbonding occasionally observed in humans be a product of cultural evolution, then it would require a well-developed language ability that doubtless did not yet exist at the beginning of hominid evolution. We touch upon the fundamental question here of to what extent the instrumentation of sociobiology is useful on humans. This question has been hotly debated since Wilson published his book *Sociobiology* in 1975. I will occupy a position clearly in this debate, as I assume that this question allows itself to be led analytically to an unequivocal answer.

In the CTSW model, then, we will stay with the thoroughly obvious assumption that the fertility of australopithecines was substantially lower than that of baboons. Hereon rests again the supposition that the australopithecines must have followed a survival strategy that allowed them to keep losses to predators even significantly lower than they are in baboons.
It does not suffice here to assume for the australopithecines an effective social organization or early recognition of predators – in both areas, baboons also perform notably. Nonetheless, baboons are dependent on their dangerous canines and a higher birthrate.
The australopithecines definitely did not specialize in rapid flight – the specialization to bipedality would then have been a step in the wrong direction. The same is true for hiding; he who wants to remain unnoticed should make himself small and not strut around propped up high on two legs. To identify predators early, it is sufficient to stand up on the hind legs now and then – baboons do this also, without finding it necessary to quit moving around on all fours.
The idea that the upright posture was so unusual to predators accustomed to quadrupeds that they didn't trust themselves to taste australopithecine meat for several million years also deserves no more than to be mentioned as a curiosity. Even today, in a world clearly dominated by humans, it sometimes happens that a predator becomes a man-eater and consequently loses its fear of humans. Such an animal can then easily kill several hundred humans, and also passes this "tradition" on to its offspring. Only when human hunters have bagged this man-eater is such a tradition cut off. In past millions of years as well, the defenses of hominids would regularly have been put to the test by predators. Whoever assumes that highly developed predators like lions and leopards would let a pure superficiality hold them back over such long periods of time from opening up an interesting new food source underestimates not only these animals but also the enormous achievement of our ancestors, who managed to claim the savannah for themselves.
The hominids could hardly have defended themselves through pure intimidation of the predators of the savannahs – only threats that are followed by serious deeds stay effective permanently.
As further explanation for the transition to bipedality, it is also suggested that it permitted a lower exposure to the solar radiation of the savannah and at the same time improved cooling by the

wind. Thus, the australopithecines could have used the food sources of the savannah during the midday heat, while predators avoided leaving their shady spots. This is another strategy by which they could have combated the increased predation pressure of the savannah. In the same context, the development of intense head hair as protection against direct solar radiation from above and – for cooling – the simultaneous development of a near-hairless body covered in sweat pores could be explained. This explanation seems, however, to agree poorly with the new *Ardipithecus ramidus*. It [*A. ramidus*] apparently indicates that the transition to walking upright preceded a change in food, since its tooth enamel was not yet thickened. In addition, such a behavior would hardly have sufficed to deal with the higher predation pressure. This namely results not only because there are no places of refuge in open country, but also from the absolutely higher predation pressure in the savannah. In addition, the predators in this scenario wouldn't necessarily have to go out into the heat to get hold of the australopithecines. If these strutted around in the midday heat, visible far and wide in the open country, to seek refuge in woodlands afterward, then a prominent opportunity presented itself every time to waylay them on their return, lying in the shade and cover of the forest's edge.

I also wonder how well the assumption that our ancestors specialized in being preferentially active in the hot midday under the burning sun of the African savannah fits with the observation that our conspecifics today have a pronounced tendency, under similar climatic conditions, toward a daytime siesta.

One reaches similar conclusions when assuming a hypothetical chimplike ancestor and then comparing it to the australopithecines. In the course of their development, the early hominids pushed forward into progressively more dangerous habitats. At the same time, their own bodily armament continued to decline, as their canines became shorter and their mobility was limited by the transition from knucklewalking to bipedality.
Jawbones and teeth are very hard and because of this remain preserved relatively easily. Therefore, they are significantly overrepresented in fossil finds and attest to the deconstruction of the canines in the course of hominid evolution (Johanson & Edey, 1982). General defensibility, though, should have increased over the course of the evolution of early hominids – as a reaction to the increased requirements in this area of the habitats into which they advanced. The obvious

functional losses in bodily armament were thus presumably more than made up for elsewhere. This indicates the intensive use of defensive weapons by the australopithecines.

The majority of these thoughts cannot claim to be new. Much sooner, they present starting conditions of hominid evolution generally recognized among experts.

It has already been pointed out often that the hands were freed up in the transition to walking upright for the transport and use of tools and thus, among other things, weapons. That the increased use of weapons corresponds to the reduction of the canines is also commonly advocated – this assumption can be traced back to Darwin.

That someone nevertheless drafts a scenario for which a weighty change of elementary behavioral strategies is taken as a basis, that changes selection criteria fundamentally and therefore must have been followed by extensive consequent adaptations in physique, brain, and behavior, is barely noticed. One should try to picture, for comparison, what value a thorough investigation of the behavior and physical construction of a rattlesnake would have were one to fail to consider the fact that it is a poisonous snake.

In particular, the question presents itself why the use of defensive weapons plays no greater role in the discussion of the origin of upright walking. As mentioned, even Darwin saw a relationship between short canines and the use of the hands for the handling of weapons, and with it the erect gait, through which the hands are freed from the requirements of locomotion. Of course, at his time it was also completely plausible to assume an enlargement of the brain in the same context – [but] this assumption was not inevitable.

The causal relationship postulated by Darwin between the upright gait, the use of weapons, and the shortened canines is still on the table [lit.: “still stands in the room”], even in light of the meanwhile-known fact that there was no significant enlargement of the brain at the beginning of hominid evolution. This is underlined through the newly discovered *Ardipithecus ramidus*, since of the many new features developed in the course of hominid evolution, just the upright gait and the shortened canines are present in this oldest known hominid. Precisely these two physical features mark the beginning of the line that brought forth the hominids, and with that, in my view, Darwin is back on the cutting edge.

I have already put forth that weighty reasons must have existed for the development of walking upright. The development of a new defense strategy, going along with the specialization on the use of a weapon, doubtless has the potential to be such a “weighty reason.” This results from the low fertility of an ape, in light of the higher predation pressure on the savannah, and is also supported by the observation that the development of different "weapons systems" in nature has always rated enormous expenditures. The list of highly developed adaptive traits in this direction is long. One need only think of sharp canines, claws, fangs, poisonous and nonpoisonous stingers, various armor, horns, electric shocks, the "chemical club" of a skunk, etc.

On the search for an answer to the question of what weapons the australopithecines used, one must obviously orient oneself not to humans, but toward the underlying primate model. This means, in the framework of the CTSW model, that an answer to the question of which weapons the australopithecines could employ to survive in the savannah, habitat of dangerous carnivores, can soonest be expected from common chimpanzees.

Pan troglodytes is known for the application of sticks and branches as well as for its capacities in stone throwing. Both strategies find their uses in defense against enemies as well as in power displays. Thus, for instance, a male chimpanzee in Gombe National Park threw a total of 13 stones during a power display in the direction of strange chimpanzees, which subsequently dispersed (Goodall, 1986). Adriaan Kortland confronted chimpanzees that had grown up in a West African savannah biome with a leopard dummy holding a baby chimpanzee in its claws. The chimpanzees attacked the dummy with the sticks at hand. An impact speed of 80 km/hr was measured (Goodall, 1986).

Of course, the use of sticks is easy for the chimpanzees. They are adapted to getting around in the branches, and whether one uses the hand to move the body relative to a branch or the branch relative to the body – the requirements differ only trivially. Thus, the grip of a chimpanzee is also best suited to wield a stick (this also includes horns used as digging sticks).

On the other hand, the use of stone projectiles offers the advantage that hand-to-hand fighting, with its high risk of injury, can be avoided from the start. The stone is thus doubtless a very attractive weapon, and when the regular provisioning at Gombe led to increasing confrontations among the chimpanzees and between chimpanzees and baboons, the chimpanzees switched over to throwing stones much more often.

It is also very interesting in this context that these changes in behavior immediately trickled down into the play behavior of the subadult males, who then preferentially included throwing in their displays (Goodall, 1986). In this manner, a significant increase in the abilities to handle stones was possible through strengthened practice within one generation. Higher capabilities in handling a particular weapon can again lead to preferential use of this weapon, and therefore to a marked shift in selection criteria within a single generation.

In comparing the abilities of a chimpanzee to hit and throw with the corresponding abilities of humans, it becomes obvious that the australopithecine-descended human is greatly superior just in throwing. It is therefore easy to assume that the australopithecines (or ardipithecines) specialized in the use of this already trustworthy primate strategy for defense against predators. Maybe this path was blocked to the baboons because they are not anatomically capable of throwing overhand. Nevertheless, baboons also use projectiles in predator defense (Becker, 1993) – despite their rather modest throwing abilities. This clearly points to the suitability of throwing for intimidating dangerous opponents.
Jane Goodall interprets the following facts of the case similarly: The chimpanzees at Gombe often hunt juvenile baboons, but even when they are caught at it by furious male baboons and held down on the ground, they are never injured. Jane Goodall supposes that the chimpanzees have established themselves as the dominant species because they are able to throw cudgels and stones at their opponents. They have thus led the baboons to the assumption that they are stronger and more dangerous than they are in reality (Goodall, 1986). (It is conspicuous that Jane Goodall disputes the baboons' ability to throw, although throwing is verified for other baboon populations. Perhaps the baboons at Gombe simply don't dare to throw in light of the superiority of the chimpanzees with this type of weapons.) The chimpanzees at Gombe thus show us exactly by what means they would solve the australopithecine problem of being better defended than baboons.

When I assume that australopithecines adapted primarily to throwing, that does not mean that they used no sticks. Chimpanzees are very competent in the application of sticks. In light of this capacity, it should hardly be assumed that australopithecines did not also reach for sticks. In the case of a chimplike ancestor, however, only a little evolutionary potential for improvement still existed for the use of this defensive weapon. At the same time, stone projectiles had clear advantages as distance weapons, and with the use of this weapon, a chimplike ancestor had tremendous developmental potential, as comparison with humans clearly shows.
Since stone projectiles play an important role even for chimpanzees, with their more modest throwing abilities compared to humans, it stands to reason that throwing adaptations in the course

of hominid evolution led to the stone projectile becoming the most important weapon. Particularly at the beginning of the throwing adaptations, it is to be expected that sticks found continued use and thus expanded the defensive options of a group in emergencies. The best was presumably to hold a predator far enough off through the use of stone projectiles that a stick was of no use. If this didn't work, it was certainly good if at least one group member had one on hand.

There then exist enough reasons to assume that the early hominids employed weapons for their defense, and there exists in addition the well-founded suspicion that stone projectiles played an important role from the beginning that increased over time. Let us now concern ourselves with the difficulties that throwing brings with it. I suggest, specifically, that throwing has generally been overlooked as a central adaptive trait of the hominids because the high demands of this activity have not been recognized. That humans can throw is sufficiently known – so what? – what is so remarkable about that?

3.3 Hominids are throwers

3.3.1 Requirements of a good thrower

The targeted throw is – as one can easily fail to notice – a structurally very demanding activity. Before the level of performance of modern humans could be reached, enormous improvements thus had to take place in the anatomy as well as the cognitive capacity of our ancestors.

One of the central problems in throwing is that no closed-loop-control can be applied. In closed-loop-control, fed-back (observed) quantities are consulted to correct the course of the action (if no quantity-feedback is used, then one speaks instead of steering or open-loop-control). The application of closed-loop-control permits high precision and reliability with relatively low investment. Thus one looks, for example, at how far a thread is from the eye of a needle and corrects its position in order to thread it. Imagine in contrast what physical control a human must possess in order to thread a needle after one look, with the eyes closed, without touching the needle.

Of course in throwing, a correction of the flight path is no longer possible from the moment at which the projectile is released – and thus also no closed-loop-control. In addition, the throwing motion takes place so fast that no closed-loop-control can be applied to its coordination, either. This point in itself was enough to stimulate the neurobiologist William Calvin to extensive speculations about the potential importance of throwing to human evolution (Calvin, 1983; 1994 a; 1995). We will have to concern ourselves thoroughly with his contributions in relationship to the development of the human brain.

In most skilled trade activities, unlike in throwing, one can apply closed-loop-control. This has the consequence that even very demanding work demands less of the tradesman than a targeted throw, which looks so simple at first glance.

Although the difference between open- and closed-loop-control is elementary, and, I am convinced, it played a very large role in human evolution, it is difficult actually to quantify it. I know of no works in which it is estimated how much higher the expenditure is for the solution of a task under restriction to steering compared to the use of closed-loop-control for the solution of the same task (this will, in any case, differ greatly from task to task). I would therefore like at this point – in a scientifically imperfect way – to take refuge in an anecdote in order to illustrate how important this point is.

In the context of a professional practicum, I once spent several weeks at the Institute for Product Automation (IPA) of the Fraunhofer Company in Stuttgart. The introduction of closed-loop-control - mechanisms into automated production processes is a focal point of activity at this institute, and so they had also found means and ways to illustrate the advantages of closed-loop-control.

Main players in this were an IBM robot with a purchase price of half a million Deutschmarks and a simple, inexpensive robot with a value of 10,000 DM. It was said of the IBM robot that it could only be put into serious service once, by a Ph.D. – in hindsight, no wonder, since just reading the user's manual for this wonder of technology required half a year. This robot could demonstrate its enormous performance potential in that it could grasp a raw egg in its insensitive grasping arm so precisely that it could be manipulated on the one hand, but on the other hand was not crushed. For comparison, the same problem was solved with the application of closed-loop-control. For that, the inexpensive robot and a specially developed, relatively simple grasping arm that possessed a pressure sensor – itself not that expensive a piece – sufficed. With them, this robot was able to regulate the pressure it applied to the egg directly and to handle it equally destruction-free.

In order to embarrass the IBM robot completely, the emergency stop button was then pressed at the end of the demonstration. In contrast to the inexpensive robot, it namely had the habit, in the case of such an interruption, of crushing the egg after all.

I find this example very illustrative (and not just because the egg was squashed at the end). On the one hand, a highly cultivated, 500,000 DM robot that has to give its best to deal with the problem without closed-loop-control and required half a year of familiarization before it could be put into service at all. On the other hand, the cheapest and simplest to operate robot, which accomplished the same task problem-free with the application of closed-loop-control.

Anyone who has ever held a catalog with all the possible sensors that are now available for application in automatic production, and that ultimately serve to permit closed-loop-control - processes, can also derive from this a feeling for how weighty the advantages of closed-loop-control in comparison to steering are.

That closed-loop-control is impossible turns the apparently so simple activity of throwing a stone, with high requirements on range and accuracy, into a task that demands higher precision in the steering of participating body parts than most skilled trade activities.

Since one can exert no more influence on the motion of a projectile after its release, the starting conditions for the flight must be ascertained and predetermined with corresponding precision in order to hit a given target. Errors in throw direction and throw speed (this is a possible set of starting conditions) must be prevented from the outset – a lot to demand when one considers that the course of movement by which the starting conditions are generated cannot even be regulated itself. This accelerating motion is described by William H. Calvin as ballistic because it occurs so quickly that there is not enough time for feedback (Calvin, 1995) (see also Chap. 3.3.3).

In order to compensate for deviation due to gravity, which gains importance with increasing distance, a stone must be thrown at a certain angle to the line between thrower and target at a given speed. In order to determine the correct angle, however, one must know the distance. I will yet show that the capability that humans demonstrate in targeted throwing over longer distances demands much more from their ability to judge distances than binocular vision, as a direct method of measurement, can achieve. The human brain has apparently specialized in the use of an indirect and, from the point of view of the brain, monstrously expensive method of measurement.

In order to throw a stone at the correct velocity, one must be able to guess its weight exactly to then apply the force that leads to the desired acceleration. In order to throw the stone in the right direction, one must not only master a very demanding, composed, ballistic movement but also have a precise grasp on it and let it go in a coordinated way, without causing acceleration transverse to the direction of the throw. Also, geometry and mass distribution vary from stone to stone. From all this – for the range and accuracy achieved by humans – result the highest requirements upon the precision of the grip and the sensitivity of the fingers of the hand guiding the stone. This hand has a particular meaning, since it serves as a generalized interface between the acceleration-generating body and a variable tool.

With increasing range, accuracy naturally decreases, since the same directional error in throwing leads to a larger deviation at the target. Even weightier is that progressively more body parts must become involved to achieve the necessary acceleration. After all, the courses of movement of all of the body parts involved in the acceleration must be precisely coordinated so that the projectile receives an effective acceleration, and the desired vector in space results.

Chimpanzees carry out their overhand throws more from the elbow than from the shoulder (Becker, 1993). An effective additional acceleration from the wrist is hindered because their grip is poorly suited to this throwing technique, and they cannot bend their hands backwards (Savage-Rumbaugh & Lewin, 1995).

In the human overhand throw, in contrast, a rotation of the entire body relative to the (usually) left foot, two rotations of the upper body (in the first rotation, the upper body is thrown forward in a "jackknife" motion; the second rotation takes place along the long axis of the upper body), and the rotations of the upper and lower arms and the hand all add up. Thus, practiced athletes build up an impressive windup over the entire body that is released with the throw (Tittel, 1994). In total, then, no less than six rotations are involved in the acceleration procedure. Rotations are not commutative; that is, it is not irrelevant in principle in what order they are carried out. Deviations in the chronological as well as spatial course of every single rotation (in whose implementation a plurality of muscles is simultaneously involved) lead to errors in the direction of the throw.

In consideration of ballistic courses of motion with whose coordination we normally have to deal in the animal kingdom, we can assume for purposes of approximation that in comparison to the extremities, the much heavier torso either doesn't move at all or moves uniformly through space. The movements to be coordinated allow themselves to be described essentially as movements of the extremities relative to the trunk, whereby the simultaneous movement of two extremities also doubles the effort required for steering – two tasks of equal degrees of difficulty must be carried out at the same time.

In the human throw, the relationships are very different. The torso is here itself very dynamically moved and is far from only moving uniformly through space. The motion of the trunk is an integral part of the coordinated overall movement, wherein the complexity of the ballistic movement to be steered is higher by at least three degrees of freedom than we normally find in primates – e.g., in cracking nuts. Primates already belong among the top athletes of the animal kingdom, when it comes to movement steering, because of their arboreal lifestyle. That chimpanzees require years of practice to master the cracking of nuts with the hammer and anvil method thus clearly illustrates the high requirements of ballistic movements.

Raising the complexity of a motion by a degree of freedom is a qualitatively very different process than adding another movement with the same complexity. The task then becomes more complex not just by a factor, but by an entire dimension – and in the course of human evolution, at least three such dimensions have actually been added. The satisfactory coordination of a ballistic movement that includes six rotations through large angles and a well-coordinated release, and thus generates a well-defined path of acceleration through space, is surely more than a chimpanzee could ever achieve, and is presumably even more than any animal before the appearance of the hominids had ever been able to achieve in the area of movement coordination. An example from sports illustrates how high even just the requirements of the grip for this are. For the pitch in baseball, the ball is basically held so that the fingertips come to rest on the hard, protruding seams. This basic rule ensures that the transfer of power from the hand to the ball occurs almost exclusively over the sensitive fingertips. Only someone who has very sensitive fingertips and knows how to apply them can achieve top performances in aimed throwing. At this point, a "contradiction" may have occurred to an attentive reader: on the one hand, sensitive fingertips are supposed to be required for throwing, i.e., a good sensory apparatus; on the other hand, no measurements can be considered during a ballistic movement because there isn't enough time for that. Upon closer observation, this is not a contradiction, but rather a confirmation of the tremendous requirements of throwing. The application of the sensory apparatus of the hand must namely take place before the actual accelerating movement. The stone (ball) must be analyzed in terms of its geometric and inertial properties and thereupon be grasped in the optimal position. Only then does the motor apparatus come into operation. The stone is accelerated, for which the brain can only use the sensory data that were acquired prior to the beginning of the movement. On the basis of these data, the entire acceleration course must be calculated in advance, whereby every imprecision in the starting data can lead to a multitude of consequent errors that can no longer be corrected through regulatory processes. – Precisely because the sensitivity of the fingertips cannot be applied during the actual acceleration movement, it is a necessity to have a very highly developed sensory apparatus in the hand of a thrower.

Needless to say, humans rise significantly above all other animals through the degree of their "fingertip sensitivity," which again is connected to the enormously large areas in the motor and sensory cortex in which the hand is represented, and thus with particularities in the construction of the brain.

The mastery of a course of motion as demanding as the human targeted overhand throw, with the precision necessary for human accuracy, can surely be explained, in light of the relative ease with which a human can learn it, only as a consequence of extensive adaptations in the steering organ, i.e., the brain, in the course of evolution (see Chap. 3.3.3; 3.3.4). These adaptations can have taken place in significant part only in the course of hominid evolution, since earlier, the underlying courses of motion were not at all anatomically possible.

The additional acceleration from the wrist was only limitedly possible at the beginning of hominid evolution, if we assume an ancestor specialized for knucklewalking with a stiffened wrist.

In any case, the rotation of the upper body around its long axis was still anatomically impossible for *Australopithecus afarensis*, and its body proportions were unfavorable for the "jackknife" motion. There was thus no opportunity to use the windup built across the entire body in throwing, as can be seen in a human in Figure 3.

Also, the fingertips, still quite narrow in *Australopithecus afarensis*, surely did not provide nearly as much sensitivity as a good thrower must use in baseball today.

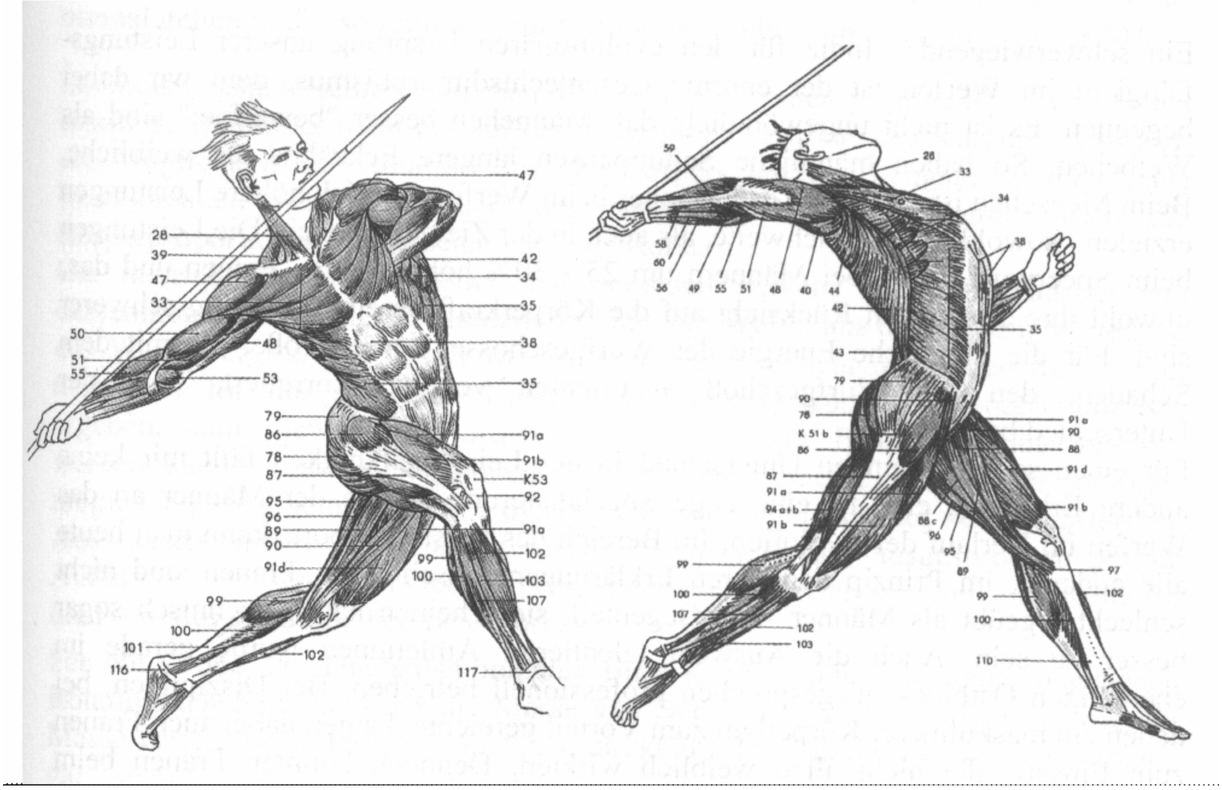


Figure 3: The javelin throw; figure source: Tittel, 1994.

The javelin throw as a track and field discipline represents, according to my approach, a portion of the set of tasks that dominated the adaptations of the hominids in the time around 5.0-1.8 MY ago and also afterwards held a central importance in their survival strategies (well noted: it wasn't spears that were thrown, but stones. The main thing here is the identical, in principle, course of movement.). It does not represent the requirements to their full extent because accuracy plays no great role in javelin throwing in track and field – there is certainly an optimal throwing angle relative to the horizontal, but small deviations from this angle cause only slight losses in range.

The javelin is, like all other throwing disciplines, a pronouncedly whole-body activity that places the highest demands on the movement coordination of the athlete. Equally high are, however, the demands on the physique itself – with the body of a chimpanzee, one simply could not realize such a course of movement. The drawings in Figure 3 show the last phase of the approach and the moment of greatest windup immediately before the powerful, explosive launch of the throwing arm, the so-called "forearm slingshot." "This impressive windup of the body will release itself any moment with the whipping, forward- and upward-directed throwing arm" (Tittel, 1994). On the drawing at right, the right hip is being pulled forward momentarily and thus maximizing the pulling effect on the throwing arm. The forearm slingshot should now immediately follow.

A weighty indicator for the evolutionary origin of our capability in throwing is the enormous sexual dimorphism that we encounter there. It is not unusual for males to be better "armed" than females. Thus, male chimpanzees have longer canines than females. In humans, it is now so that males reach substantially higher performances in throwing – in range as well as in accuracy. Performances in the javelin throw are about 25-30% higher in men than in women, and that even though their spears are already about 200 g heavier in consideration of their physical strength. For the kinetic energy of the projectile – a quantity that is correlated with the damage a projectile is able to cause – the difference is around 60%.

For such a grave difference in capability, no other explanation occurs to me than a narrow specialization for throwing of men only in the course of evolution. In the area of elite sports, we can today rule out all other explanations conceivable in principle. Women are not less practiced than men – on the contrary, they frequently seem to be technically better. Also, the selection of talented female athletes was recently carried out professionally in the former Eastern Bloc. In disciplines for which a male physique presented an advantage, women were also put into action who did not seem all that feminine. Nevertheless, women cannot advance among the men in javelin – quite contrary to the shot-put and the discus throw, in which they have meanwhile reached the same distances (here too, the sports equipment is naturally lighter for the women). That this gap will not allow itself to be closed is due to the fact that men are physically very finely tuned for the requirements of precisely this course of motion, a characteristic that even very masculine-seeming female athletes do not bring along to a complete extent.

Also, the ideal body size and the ideal weight for the javelin throw fit very well with the hypothesis that humans – and in particular, men – are adapted to throwing. In sports, a selection process that is somewhat analogous to natural selection takes place. Of the many available variations of humans, those few always succeed who – among many other characteristics – bring along the best bodily parameters for the sport at hand. If the requirements of a sport differ strongly from the requirements that were selected for in the course of evolution, then the top athletes will differ more from a representative cross-section of the population. Shot-putters are, for instance, quite heavy, and basketball players are unusually tall.
Javelin throwers have normal weights and should be 1.75 to 1.85 m tall (Bauersfeld & Schröter, 1980). This is a range that must not only be normal for modern Europeans and, as we know from skeleton finds, also already for the modern humans that replaced the Neandertals 30-40 K years ago in Europe – early *Homo erectus* was also already this size 1.8 MY ago.

The performance difference between men and women shows clearly that being a good thrower does not only depend on the basic construction of the body – that is, e.g., the possibility for rotation of the upper body around the long axis or high mobility of the wrist and shoulder joints. Physical proportions also play an important role.
Human proportions differ in many respects from those of African apes, in a way that creates an advantage for throwing. In order to throw better, one needs a body that, for the individual rotations on the one hand produces favorable lever ratios so that a proper contribution to the acceleration can then be achieved. On the other hand, the inertial moments for these rotations should be minimal in order to guarantee a dynamic course of motion. From these two requirements results on the one hand the exceptionally gracile build of the human upper body, and on the other hand, they also play a role in the form of the human thorax.

For the size of the inertial moment of a body relative to a given axis of rotation, not just mass is important; much more important is how the mass is distributed. “Points of mass” [centers of gravity] that lie directly on the rotational axis do not add at all to the inertial moment. For points of mass outside the axis of rotation, the contribution increases with the square of the distance to the axis. In order to understand why the human body is proportioned just so and not otherwise, one must look at the requirements of each of the six rotations involved in the acceleration process. I will continue in this without restriction with the generalities of a right-hander.

The rotation of the whole body relative to the left foot is a special case because this rotation is not generated directly by muscle power. Here, much more exclusively beforehand with the approach (javelin) or in a windup motion (baseball), kinetic energy of translation is converted into kinetic energy of rotation. This occurs in that the lower half of the body is slowed down by the standing foot. Since the foot does not move in this, the body neither gains nor loses energy, since work is force times distance and the distance in this case equals zero. The force acting from the ground on the foot thus only leads to a redistribution of kinetic energy. If the body were a stiff board, then the distribution of kinetic energy after this process would look like this: the kinetic energy of a point of mass would equal zero on the ground and would increase proportional to the square of the distance from the floor. This rotation thus leads above all to concentration of the kinetic energy of the approach in the upper body.

As this rotation is not generated by muscle power, the inertial moment and therefore the body’s proportions play for it a subordinate role.

Through the jackknife motion, the motion of the body below the belt is further slowed, while the upper body is placed in a strong rotation. Thus, the kinetic energy is concentrated further on the upper half of the body, and additional kinetic energy is also supplied to the upper body through work performed by the abdominal musculature. The upper body can be moved forward more dynamically by the abdominal muscles the lower its inertial moment relative to the rotational axis in the area of the abdominal muscles is. Points of mass of the upper body that are not necessary for further generation of acceleration should therefore lie as close as possible to this axis.

For this reason, men tend to store fat primarily in belly fat – here it interferes least with throwing (lower down, on the legs, it would interfere with walking); in women, the relationships are somewhat different as a result of sexual selection, but women aren’t very good throwers, either.

Annoying – from the point of view of the jackknife motion – is of course the heavy head, which in its exposed position contributes significantly to the inertial moment. Our developmental line is presumably already too committed to a “Bauplan” [lit.: “blueprint”] to have been able to relocate the brain in the direction of the navel.

Men’s heavy pectoral muscles also add considerably to the inertial moment, but they are indispensable to further acceleration movements. True aggravations, though, from the point of view of the thrower, are the permanently enlarged breasts of women. The fatty tissue stored here represents ballast when throwing and, as we will yet see in the discussion of the natural sexuality of humans, its function presumably lies exactly therein.

The human upper body is generally gracile and stretched out. It thus offers the powerful abdominal musculature a proper lever on the one hand, in order to contribute to acceleration, but on the other hand puts up a relatively low inertial moment against this movement. At the same height, an African ape would be about twice as heavy as a human. The australopithecines were apparently equally compactly built to chimpanzees. This changes first with the transition to *Homo erectus*.

With the rotation of the upper body on its long axis, kinetic energy is again additionally generated as well as further concentrated. The left shoulder is rotated backwards, that is, against the direction of movement, and thus slowed. Kinetic energy is thus carried over from the left half of the upper body to the right half, and above all, to the throwing arm farthest removed from the axis of rotation, and is raised by a contribution that results from the work performed by the trunk musculature in the generation of this rotation. Again, the powerful abdominal and back musculature needs a proper lever to be able to make an appropriate contribution to the acceleration of the projectile.

From this requirement results an upper body that is wider at the shoulders and, at the same time, relatively flat to minimize the inertial moment. In this respect, human – and particularly male – upper bodies differ significantly from those of African apes. Again, the connective tissue of the female breast is, from the view of a thrower, aggravating ballast.

Upon application of the pectoral musculature, “next” (the individual movement elements overlap in time) the throwing arm is rotated forwards, anchored in the right shoulder joint. The shoulder is thus slowed, and so again, kinetic energy is concentrated further in the direction of the projectile and also increased by the work performed by the pectoral muscles. Corresponding things happen in the last two rotations relative to the elbow and the wrist.

In the human throw, the whip effect is used. With a whip, kinetic energy is similarly passed on from the base to the tip. The whole whip is accelerated in a winding up motion (approach) and then stopped at the thick end. Subsequently, a wave runs from inside to outside along the whip, in which region the kinetic energy is then translated from the thicker (heavier) end to the thinner. Because of the decreasing mass, the kinetic energy leads to ever-higher speeds at the end, which ideally ends with the crack of the whip. This indicates that the tip has exceeded the speed of sound.

In addition to the whip effect, whereby energy is only passed along, humans generate further energy through the participating musculature. The procedure is altogether extremely complex and many-layered. The rather superficial description I have delivered here does not do it justice at all and should serve primarily as impetus to deal thoroughly with this line of questioning. This task belongs to a good anatomist – which I most certainly am not.

As such, I can only suppose that the barrel shape of the human torso (in contrast to the tapered form in chimpanzees and australopithecines) represents an adaptation to throwing, in which the demands of the two upper body rotations and the acceleration of the arm from the shoulder (the pectoral musculature that generates this rotation is, after all, anchored in the ribs) were decisive above all.

Even though I am no anatomist, I have no fear as regards the results of a thorough functional anatomical study of the human throw. Six rotations are involved in this throw, for which the inertial moment plays a key role each time. In the inertial moment, yet another geometric variable – the distance of the points of mass from the rotational axis – enters in squared.

Thus, it is very clear that physical proportions play a significant role in throwing. It would therefore hardly be possible for a human to accelerate a 149 g baseball from standing still to 50 m/s (180 km/hr) if its physical proportions were not “cut out for it.” Over an acceleration period of ca. 0.1 sec., an output of 1.9 kW must be transferred to the ball; that’s around 2.5 horsepower!

3.3.2 Anatomical adaptations of the hominids for throwing

We have seen, in the last chapter, that the human high-performance throw places enormous demands on the physique and brain. Of these, the brain had much more “to do” from an evolutionary standpoint in order to reach such a level of performance. Unfortunately, the development of cognitive abilities can hardly be traced through the help of fossils – entirely contrary to the changes in physique.

The anatomical adaptive traits thus carry great importance in the CTSW model. They offer the possibility to reconstruct the chronological course of the throwing adaptations and to construct concrete hypotheses about the underlying driving forces. Assumptions about when the cognitive abilities were developed that humans apply today during throwing are based on knowledge of physical development and the hypothesis that this was all a matter of throwing adaptations from the beginning. Thoughts about the development of these cognitive abilities are thus by nature somewhat more speculative.

The behavior of recent chimpanzees and a comparison of their anatomy with fossil evidence of hominid evolution support the assumption that the characteristics of hominids could have developed as results of increased use of stone projectiles.

A change in behavior in connection with the changed requirements of a fluctuating environment presumably played a role in this. Climatic changes that correlate chronologically with the beginning of hominid evolution led to the jungles of East Africa being pushed back. This could have been the trigger for the development of special adaptations in the developmental line of the hominids, since this line obviously produced individuals that were adapted to life and feeding in the savannah.

Because of the climatic changes, groups of fruit-bearing trees could be reached only over open country, and thus with higher endangerment from predators. If we imagine a group of common chimpanzees crossing open country, it becomes clear that it would be an advantage for them in this situation, given their abilities in handling stones and sticks, to be armed. The habit of carrying weapons on such occasions would be a very sensible expansion of the behavioral repertoire of such animals, since on grassland in an emergency, one finds neither stones nor sticks on short notice.

Such behavior would also be to expected of chimpanzees anyway, as the following examples illustrate:

- It was observed of chimpanzees in the jungles of West Africa that they transported stones or blocks of wood used for cracking nuts over large stretches (Ch. & H. Boesch, 1984).
- At Gombe, primarily male chimpanzees use stone throwing in power displays. In the situation of sharpened competition that occurred in connection with the provisioning carried out, targeted throws against members of the group as well as baboons that also came to the feedings increased significantly (Goodall, 1986).

If our ancestors switched over to carrying weapons with them when crossing open country, then this would have had strong effects on the selection criteria. There would have been much more frequent "armed" conflicts with predators (on the one hand, because our ancestors got into dangerous situations more often in open country, and on the other hand because they were typically already armed). Thus, the abilities to handle weapons also increased in importance for fitness and thus for evolution also; this certainly applied from the beginning particularly to the qualities of a thrower (it was "worth it" to be a better thrower, even when this came at the cost of other adaptive traits).

At the same time, the transport of multiple stones at one time obliged these animals that preferred to rely on throwing to walk upright – if not necessarily to anatomical fixation on bipedality. Walking upright does definitely belong to the movement repertoire of chimpanzees, which are much less fixed in their locomotion than humans. Jane Goodall describes two males that were [each] left with a lame arm after a polio infection and therefore had to travel on two legs on the ground. After some practice, one of the males (Faben) was thoroughly able quite soon to keep pace with the other males in the group during their extended exploratory trips (Goodall, 1991). For the other male, the transition took somewhat longer, but was also eventually successful. Bonobos are even more able to walk upright, since they are less anatomically fixed on knucklewalking. This makes it clear that chimpanzees still have plenty of "room for interpretation" in which their achievements at walking upright can be improved without giving up knucklewalking.

For transport, walking upright certainly has the clear advantage, but in other situations, knucklewalking is doubtless [better]. Particularly when using the teeth to defend against predators, knucklewalking is clearly superior. The final decline of knucklewalking in a pronouncedly dangerous environment thus demands additional explanation above and beyond the pure transport of stones.

If it was, at the same time, a matter of improving the throwing capabilities of a chimplike ape, then knucklewalking caused problems that had nothing to do with getting around. The stiffened wrists that belong among the adaptations of African apes to knucklewalking hindered an effective additional acceleration at the wrist joint. That an increase in the mobility of the wrist could lead to a substantial improvement in throwing performance probably became a burden on knucklewalking and contributed to a one-sided fixation upon bipedality as the terrestrial form of locomotion in the australopithecines. (How advantageous an improvement of additional acceleration from the wrist can be in throwing is illustrated by the development of spear launchers in the Late Paleolithic, which served to lengthen the lever arm for acceleration at the wrist.)

Also, the upright orientation of the upper body, which seems at first glance just to be a consequence of moving on two legs, could in fact have been one of the causes of the transition to bipedality. It offers substantial advantages both in throwing and in the use of sticks and also helps with appearing larger and more imposing.

My interpretation of the transition to bipedality thus rests upon multiple advantages of walking upright for the application of weapons also available to chimpanzees. The superiority of an upright gait for carrying already stood centrally with Owen Lovejoy (Lovejoy, 1989) (although there, it was food being transported). Additionally in the throwing hypothesis, the direct requirements of throwing come into play in the forms of the required mobility of the wrist and the advantages of an upright orientation of the upper body for the use of weapons. These are, however, only the most important of the advantages that the upright gait would have brought with it.

I have already indicated that evolution is an integrative process, in which all advantages and disadvantages of a variation are considered. In order to obtain a transition from knucklewalking to walking upright, only the advantages of walking upright need prevail, and in addition, a loss of importance of knucklewalking could have contributed. Knucklewalking is primarily an advantage in conflicts involving the use of the teeth. A change in behavior to an increased use of weapons – and particularly also a long-distance weapon – could have led directly to a lesser importance of the teeth as a weapon of close combat and thus of knucklewalking, wherefrom yet another driving force for the transition to bipedality results.

When our ancestors had first exhausted the elbowroom that they had for the improvement of the upright gait, then perhaps at the end, giving up knucklewalking completely was not particularly hard. The capability that they had developed meanwhile in walking upright and using weapons, especially in throwing, led to a lesser importance of knucklewalking in moving on the ground as well as in defense, and therefore made it expendable.

The wide pelvis of *Australopithecus afarensis* can also be interpreted as a sensible adaptive trait within the throwing hypothesis. It was relatively poorly suited to walking upright, but instead presented a stable base for the operation of the upper extremities (Brandt, 1995), and thus also was useful for the application of weapons. This applies to targeted throwing as well as to the use of sticks and supports the assumption brought forth above, that the upright posture of the upper body could have been more a matter of a cause than just a consequence of the transition to bipedality. In the course of further development, the wide pelvis could be given up. Evolution led to an ever-stronger emphasis on aimed throwing, whereby improved coordination ability for complex courses of movement and further anatomical adaptations permitted the integration of the whole body into the acceleration process. In the high-performance human throw, the ground takes over the function of the stable platform from which the throw is carried out. The entire body is used to reach the highest possible throwing speed.

The early transition within hominid evolution from knucklewalking to bipedality thus can be explained relatively easily in the CTSW model as an obvious adaptive trait. The high “costs” of the conversion, when compared to the expenditures Nature has made elsewhere for the development of new “weapons systems,” don’t even seem out of place. Thus, the CTSW model demands no more of our early ancestors than recent chimpanzees can achieve and would in fact probably do under similar circumstances. In addition, the CTSW model only needs one basic assumption for this, which is met anyway by the majority of evolutionary models and made obvious by fossils; the assumption is namely that the weapon characteristic was transferred from the teeth to the hands at the beginning of hominid evolution. Thus, the CTSW model is exceptionally parsimonious regarding the explanation of the transition to bipedality, and that speaks in favor of this model.

The transition to bipedality does not present a change in terrestrial locomotion patterns to be considered in isolation within the CTSW model. Much more, it is to be explained in connection with a parallel specialization in the use of defensive weapons, and particularly the improvement of throwing qualities. The significance that I attribute to the mobility of the wrist here automatically calls attention to the hand.

A targeted throw demands, for an increase in throwing performance, an improvement of the precision of the grip. Fossils give evidence that the grip at the time of *Australopithecus afarensis* had already done some of this. The thumb of *Australopithecus afarensis* was certainly shorter than the human one, but nonetheless longer than that of chimpanzees. According to Marzke, it could already be placed opposite the index and middle fingers, such that the so-called three-finger power-and-precision grip was possible (Marzke, 1983).

In the human overhand throw, the throwing technique that permits the most effective acceleration for a targeted throw involves holding the stone with two or four fingers and the thumb. With apes, in comparison, the stone is held between the fingers and the palm (power grip) or between the thumb and the thumb-facing side of the index finger (precision grip).

The power grip of a chimpanzee is poorly suited for getting an effective additional acceleration out of the wrist. There, the hand must speed forwards, and the fingers would necessarily get in the throwing path and divert the stone upon release. As the stone is pressed against the large surface of the palm, limits are also placed on the precision of the transfer of power to the stone. In addition, the stone is located closer to the wrist in the power grip of an ape than with humans, such that the already rather small lever for acceleration from the wrist comes out even smaller. The precision grip of an ape is somewhat better suited for targeted throwing than the power grip, since the thumb and index finger lie to the side of the flight path and do not get in the way of the release. Its weakness, though, lies in the fact that the thumb and index finger also lie to the side of the stone during acceleration. This then tends, because of its inertia, to fall out backwards (be "left behind"), and encounters little resistance in doing so because there are no fingers in that direction. With increasing weight of the stone, this quickly becomes a problem. Therefore, in the course of hominid evolution – possibly from the precision grip of apes – the three-finger power-and-precision grip developed quite early. Every variation that contributed to a lengthening of the thumb or to the ability to place it opposite more fingers was a selective advantage for a thrower.

With its three-finger power-and-precision grip, *Australopithecus afarensis* was quite capable of releasing a stone without knocking it out of its path. At the release, the thumb and middle finger were located to the side of the stone, the index finger behind it. There were thus no fingers to get in the way. During acceleration, the stone also could not slip out backwards because the index finger was now in its way. The stone was also farther away from the wrist than in the chimpanzee power grip, so that a longer lever for the acceleration from the wrist resulted.

The three-finger power-and-precision grip of *Australopithecus afarensis* was thus greatly superior for throwing to both the power grip and the precision grip of chimpanzees. With this grip, an upright upper body anchored on a stable, wide pelvis, and the ability to generate an effective additional acceleration at the wrist, *Australopithecus afarensis* was already a much better thrower than recent chimpanzees.

The grip was further optimized over the course of hominid evolution and flowed into the five-finger power-and-precision grip that already existed with *Homo habilis* and probably with the robust australopithecines ca. 2 MY ago (Aiello & Dean, 1990), and is also typical of modern humans.

Let us remain with *Australopithecus afarensis* for another moment, in order to get our bearings. Until now, it was assumed in the CTSW model, based on the common chimpanzee as ancestral model, that our originally knucklewalking-adapted ancestors changed over to walking upright and altered their grips because they countered increasing predation pressure through the strengthened use of weapons, and in particular through emphasis on throwing. There thus occurred a specialization by an ancestor with generalized defense options upon the use of defensive weapons.

It is now important for the cognotheoretical construction of the CTSW model to make it clear that subsequent observations do not depend on whether the previously encountered assumptions are actually correct. In principle, a reduced model of hominid evolution could begin just with *Australopithecus afarensis* rather than back at the last common ancestor, and it would look exactly like the CTSW model from here on:

We know that for chimpanzees, throwing has a similarly high importance to hitting with sticks and the use of bodily weaponry, in particular the teeth. Precisely in confrontations with dangerous opponents does throwing take on an important role. *Australopithecus afarensis* occupied more dangerous habitats than chimpanzees and was less capable in close combat because of the decreased stability of the erect gait and its shorter canines. At the same time, its physique allowed substantially better achievements in throwing – it can hardly be assumed that it did not use them. I also do not believe that anyone will seriously contradict me on this point.

It is thus to be assumed from this that the australopithecines, just like chimpanzees, employed stone projectiles as weapons. Additionally, it is to be assumed that the upright gait, the pelvic shape, the mobility of the wrist, and the precision grip of the hand made a thrown stone a more dangerous and therefore more important weapon for *Australopithecus afarensis* than is the case with chimpanzees. And this applies independent of whether these characteristics originated as throwing adaptations or not. Presumably, the use of sticks still had a very high meaning for these still extremely chimplike early australopithecines that stood at the beginning of the throwing adaptations. Perhaps even as high a meaning as throwing. There can, however, be hardly any doubt that throwing already took on a much greater importance for them than for recent chimpanzees.

The high importance of stone projectiles for the behavior of the australopithecines can thus be inferred from a direct comparison of *Australopithecus afarensis* with common chimpanzees, without having to refer back to evolutionary scenarios. This creates a relatively stable starting position for continuing considerations and makes them thoroughly independent from the validity of the previously encountered assumptions. Should it turn out one day, for example, that the last common ancestor of humans and chimpanzees was not yet adapted to knucklewalking at all – and many researchers think this more likely – then practically only the explanation offered by the CTSW model for the transition to bipedality will be affected; the plausibility of all subsequent statements – and there will be some yet – will hardly be touched.

Let us continue with the anatomical changes, though, that could be cases of throwing adaptations. A further step in the improvement of throwing abilities would have been an optimization of the acceleration of the upper arm from the shoulder. This step should either have followed the improvement of acceleration at the wrist or taken place in parallel to it. This supposition results from starting with the chimpanzee throw from the forearm and makes the obvious assumption that the closest body parts will be called upon next for the improvement of the throw.

The anatomy of the chest and shoulder would have been affected by this development. Unfortunately, the anatomical circumstances in the area of the chest and shoulder are much too unclear for a non-anatomist like me to judge to what degree changes that took place here could have benefited a thrower. I am also not familiar with any technical literature that deals with this question. It remains only for me to remark that:

- The human shoulder is more mobile than the shoulders of African apes

- The mobility of the human shoulder is important for throwing, since javelin throwers must be careful in strength training not to limit this mobility through one-sided training (Tittel, 1994)
- Human chest and shoulder anatomy must be well suited to throwing, since humans are outstanding throwers and the shoulder takes on a very demanding key function in the throw.

I presume additionally that the demands of throwing present a sufficient explanation for the changes in chest and shoulder anatomy in the course of hominid evolution. It remains, however, for a good anatomist to investigate this question and thus put the throwing hypothesis to the test.

The next step in the improvement of throwing performance is again observable, because the requisite anatomical investigations are already available. It is a matter of the inclusion of the rotation of the upper body about its long axis during the acceleration process. Including this rotation of the upper body in the throwing motion was no simple procedure. Chimpanzees are entirely incapable of such upper body rotations because of their trunk musculature. The same was obviously still true of Lucy (*Australopithecus afarensis*, 3.2 MY old). Unfortunately, only for *Homo erectus* are fossils again available that permit an assessment of the capacity for rotation of the upper body. In *Homo erectus*, it was already present (Brandt, 1995). The rotation of the upper body is not only significant for a more effective throw, but also for an optimized upright gait, and may have developed first with the transition to *Homo erectus* (ca. 2.0-1.8 MY ago) for this purpose. There is, however, an indirect archaeological indication of an older origin of upper body rotation about the long axis.

Stone throwing in the way that I regard as typical already for the early hominids is the aimed, one-handed overhand throw. It is an exceptionally asymmetrical physical activity, which results, in the case of the application of the upper body rotation about the long axis, in an advantage for throwing with the right hand.

This rotation namely occurs around an axis that leads through the center of gravity of the upper body. Since the lungs are located more prominently on the right side of the chest and have a lower density than other organs, the center of gravity of the upper body does not lie in the axis of symmetry but is displaced a little to the left, toward the heart. There thus results a longer acceleration distance, because of the upper body's rotation about the long axis, for a throw with the right hand. That such an increase in this distance was advantageous is also indicated by the broad shoulders that count in humans as male sexual characteristics and signs of strength (chimpanzee males are, at the same weight, five times stronger than men, without any special emphasis in their upper bodies being placed on the width of the shoulders).

If one visualizes how high the demands are on the precision of the precision grip of the hand guiding the stone and the coordination of the overall movement, then it becomes clear that the adaptation to throwing offers an explanation for the origin of right-handedness (see also Chap. 7), provided that at the time during which right-handedness developed, a rotation of the upper body was involved in the acceleration procedure.

I do not mean here that the asymmetry of the upper body presented sufficient grounds to result in the creation of right-handedness. Handedness in itself was much more a convenient adaptation of the brain that eased the mastery of the exceptionally demanding acceleration movement. I will go into this more in my discussion of the development of the brain. The asymmetry of the upper body only acted such that in a population with express handedness, right-handers significantly prevailed. And this again leads to the mentioned archaeological evidence.

Research on the, at 2.5 MY, oldest yet found worked stone tools namely led Nicholas Toth to the belief that the makers of these tools were already right-handed (Toth, 1987). **This leads me further to the assumption that already 2.5 MY ago, at least the male gracile australopithecines were capable of a rotation of the upper body about its long axis, which they employed in increasing the acceleration distance in throwing. Perhaps one day the opportunity will present itself here to test the throwing hypothesis by means of new fossils.**

The adaptations of the physique for throwing were completed with the transition to *Homo erectus*. In connection with the final transition to pure terrestriality, the physical proportions of the hominids of this developmental line changed drastically once more. These changes should not be seen solely as aspects of a now compromise-free adaptation to bipedality, even if *Homo erectus* was probably our first purely ground-living ancestor and could therefore do without adaptations to climbing.

With *Homo erectus*, the legs got longer and heavier and the upper body at the same time became more gracile; thus, the body's center of gravity migrated lower. First through the new distribution of mass that resulted was the effective use of the windup made possible, which is characteristic of the human high-performance throw and which we can observe today, e.g., in javelin. The barrel shape of the human thorax is to be seen in the context that a thrower needs broad shoulders as levers for the rotation of the upper body around its long axis. At the same time, the upper body should counter this rotation with the lowest inertial moment possible. For this reason, the form of the human male upper body emphasizes the shoulders so clearly. From the viewpoint of the throwing hypothesis, it is understandable that no other primate shows even close to such good physical proportions for this kind of throwing technique.

The course of motion was complicated by yet another two rotations at the transition to *Homo erectus*. For one, good throwers take an approach run and use the kinetic energy obtained thereby in that they let their upper bodies rotate over the firmly planted left foot. For the other, a second rotation of the upper body, in which it is thrown forward in a “jackknife” motion, contributes to the acceleration. For the effective use of exactly that jackknife motion, the center of gravity should lie in the region of the abdominal musculature that lets the “jackknife” snap together.

In the human developmental line, the throwing adaptations have been driven very far – this is already apparent just from comparison to the robust australopithecines. We will yet see that defense against predators, covered at the beginning of this chapter, is not enough to explain this development. However, other explanations offer themselves, which I will yet discuss in detail (Chap. 3.4).

3.3.3 Coordination of ballistic movements

I have already indicated the enormous capability of humans in targeted throwing in the introduction to this book. As an example of this, I took the pitch in baseball. Baseball is a modern sport in which modern humans are employed who grew up in a world in which extensive factual knowledge of the natural sciences is available and has found uses in the most diverse areas. The question thus poses itself of whether and to what degree throwing performances profit from this knowledge. Are there opportunities for estimating how strongly modern training methods influence the performance level of an athlete?

Gabriele Wulf indicates that, “motion instructions and corrective advice make up a central component of teaching and learning processes in sports. The instructions usually relate to the spatial-chronological coordination of body movements.” Her investigations show, however, that such advice does more harm than good for highly practiced, automated motions. Subjects who received no instruction averaged much better in the learning of such motions than those who were given advice about the correct sequence of movements. Those subjects did even better, though, who were given advice about what they should accomplish with their motion.

Wulf differentiates in this context between internal and external foci of attention. Concentration on elements of one’s own course of movement (internal focus of attention) disturbs the course of movement, while concentration on the intended effect (external focus of attention) promotes it. This also fits with experiences in baseball. A good thrower has to keep the target (the glove of the catcher) continuously in sight during the throw. He must concentrate on it. One of the most important mistakes in baseball that lead to throwing errors consists in that the thrower turns his head away while throwing and doesn’t envision the target to the end.

> “Apparently, the motor steering of movement is an automatically occurring process that normally is disturbed by conscious influence. How extremely precisely the motor system can make adjustments without the affected [person] becoming aware of it, the American psychologist Franklin Henry demonstrated in the year 1953. His research subjects were supposed to hold a lever that was being turned by a small motor in a vertical position. As it turned out, they reacted on average to changes in pressure of only one twentieth of the value at which they became at all conscious of a change in pressure. This makes it apparent that the attempt at conscious control of movements is more likely counterproductive.” (Wulf, 1998)

If the motor steering of movements is an automatically conducted process, then it is also quite clear that the abilities achieved through evolution for this have a central significance, and cultural achievements are beside the point. If a modern baseball trainer can do nothing better for his men than ask them to keep their eyes on the target, then no more productive cultural assistance is available to them than to an australopithecine (I assume that australopithecines tended on their own to keep their eyes on a lion located within range).

The enormous performance abilities of humans in motor steering that are demonstrated – just to name a few examples – in the circus, in gymnastics, or in figure skating, raise immediate questions about the course of human evolution. All of these movements are certainly products of cultural development. This development, however, obviously left the level of the ability to learn these movements untouched. Much more, it required the preexistence at high levels of this ability in humans.

This enormous capability in motor steering is a result of the development of the human brain and must find its explanation in an evolutionary scenario of becoming human. In the CTSW model of hominid evolution, the adaptations to the steering of targeted throws offer this explanation. The capability of the experimental subjects in the experiment by Franklin Henry cited above was based, for instance, on the highly developed sensitivity of the human hand, whose origins were already discussed in the last chapter and which is substantially an achievement of the human brain. In conventional evolutionary scenarios, the requirements of tool production and walking erect would be held responsible for the exceptional capabilities of humans.

The clarification of this point will depend first upon finding opportunities to quantify the actual requirements and thus make feasible a direct comparison. Such opportunities could arise incidentally during the course of further robot development. Should technological development progress so far that the construction of robots with human proportions and abilities to coordinate motion becomes possible, such robots will surely in fact be built. Since a direct insight into their steering will presumably also be possible, it should then no longer be difficult to compare the demands of the described courses of motion with one another.

I am convinced that the demands on motor steering in the targeted throw place those of walking upright and producing primitive tools deep in shadow. Assigning a group of engineers the task of teaching a humaniform robot to throw with the precision observed in humans without using closed-loop-control- mechanisms in the course of the accelerating motion would be the surest way to make them supporters of the throwing hypothesis.

Observations of a portion of the requirements of throwing has already led William H. Calvin, a biophysically oriented neurophysiologist, to the assumption that throwing had a decisive significance to human evolution. He, too, constructed a hypothesis of human evolution upon this assumption, although the agreements between his hypothesis and the model of hominid evolution presented here consist primarily of this basic assumption and some thoughts about brain development that I have taken from him.

Calvin sees a usable answer in the assumption that the early hominids were already adapted to throwing to many questions connected with the development of human cognitive abilities. The focus of his observations lies on the fact that throwing is a matter of a ballistic movement, that is, a movement that happens so quickly that there is not enough time for the use of feedback loops. The consequence is that the entire course of motion must be prepared in a sort of action protocol before the movement takes place. The movement must thus be planned in advance, down to the smallest detail. The solutions that the brain has developed for the mastery of this task could also, according to Calvin, have found further uses and formed the basis for foresight and planning in human thought.

To that, Calvin:

> [TRANS. NOTE: As always in back-translations of others' work, please consult the original for direct quotes and to guard against misinterpretation.]
>
> "In contrast to other motions, such as walking or picking fruit, a ballistic movement definitely requires an enormous neural machinery for advance planning. This is because ballistic movements are so fast, while the paths for feedback are relatively long. When an ape directs a cherry into its mouth or when I reach for a coffee cup and lead it to my mouth, there is plenty of time for small corrections. The sensors in my arm muscles and joints report the location of the cup to my spinal cord and brain (they do not speak directly with the neighboring muscles, rather only over the detour of the central nervous system); I then compare that with my intentions (cup on the lips, preferably still vertical) and the known conditions (don't let the coffee spill), and correct the path. During the apparently fluid motion, I repeat this correction dozens if not hundreds of times.

> Thus, every single correction takes up a certain amount of time because the report proceeds slowly along the nerves and also requires the central nervous system for a decision. For arm movements, humans need at least 110 milliseconds for the roundtrip from the arm to the brain and back. Movements like hammering and hitting, which are carried out within a fraction of a second, therefore cannot profit from corrections during the procedure (in throwing an arrow, about 119 milliseconds pass before the release). Most error corrections arrive too late to affect anything, since meanwhile the motion is finished. The feedback may perhaps help you to plan the next throw, but as soon as you begin the next throw, you must stick to the plan that you made when you declared yourself 'ready to go.'" … "In organisms that are large (meter-long conductions), and must at the same time be fast, perhaps a waiting queue is necessary that one could think of as a neural counterpart to the roll of an old-fashioned player piano. The roll is a plan for many simultaneous output channels (the 88 keys of the piano) that determine when, how hard, and how long individual keys should be struck.
>
> Our planning queue for a ballistic movement must consider dozens of muscles and activate them at exactly the right time with exactly the right force. When we get ourselves set to go, we work from an exact plan without employing feedback. The action itself is a carefully determined spatial-chronological sequence, comparable to a fireworks finale that is set into motion from half a dozen platforms." …
>
> "Even if it seems that playing a Beethoven sonata is something very different from playing baseball, it could yet very well be that the pianist uses neural machinery that was developed for hammering or throwing; as natural selection certainly has not exercised influence on our ability to perform music very often, we can assume that music is a free-time use of neural mechanisms that possess an important primary function. If the feet can also make use of the same serial buffer that the hand needs for throwing and hammering, then dancing is also such a secondary use." (Calvin, 1995)

It is interesting that I saw myself being led to similar statements even before I was aware of Calvin's work. In an older manuscript on the throwing hypothesis, I allowed myself to be drawn to the following text passage based on my thoughts:

> "The culturally so important musicality of humans presumably builds upon the abilities developed in the course of throwing evolution of the right half of the brain to work with sizes and patterns – musical talent is also located in the right half of the brain. Without the throwing adaptations of his ancestors, Tchaikovsky would hardly have been able to compose Swan Lake. And no one would be able to dance this ballet if the human abilities to coordinate highly complex motion sequences had not been advanced so far in the course of throwing evolution."

Upon closer inspection, the similarity of the two statements turns out to be quite superficial. Here again, it is reflected that Calvin followed a different trail at the time of the development of his throwing hypothesis than I did in mine. Calvin emphasizes that throwing is a matter of ballistic movement, but does not elaborate on its complexity. Otherwise, he would not need to speculate about whether "the feet can also make use of the same serial buffer that the hand needs for throwing and hammering." The human high performance throw is a whole-body activity in which the feet are involved, so throwing adaptations naturally extend to the feet and can provide a basis for dancing. Incidentally noted, the superfluous option also arises on this basis that human talents in this area can be traced back to hammering (tool production), which Calvin always holds open. Throwing, though, is much more demanding and cannot be an emergent characteristic that resulted from adaptations to the production of primitive tools.

I did presume then (when I wrote the text mentioned above) that the course of movement in throwing is ballistic (although this technical term was not yet familiar to me), but I did not know it exactly because at the time I lacked corresponding technical knowledge and data. Therefore, I left this point of view out of my considerations, for one because throwing seemed demanding enough without it.

My approach to the problem resulted from the complexity of the course of motion. My first thoughts were based on lectures about multiple-body system analysis that I had heard. Complex courses of movement and their steering are the object of this field.

As a further difficulty of ballistic movements, Calvin agrees on the precision with which the individual components of the movement must be tuned to one another. The required precision for throwing is so high that the motor neurons that command the muscles are not singly capability of meeting the requirements, since they are nervous by nature, by which I mean that a certain hesitation always underlies the point in time at which a motor neuron fires. The results can be improved, though, through the combining of many motor neurons firing together whose signals

are then somehow averaged. This “law of large numbers” is used, for example, to allow the heart to beat evenly.
Starting from the assumption that the same principle comes into practice in throwing, Calvin undertook the attempt to estimate how much the number of necessary neurons increases with range.

Unfortunately, Calvin’s estimation contains two grave errors (see below). He considers the throw as a single rotation of the forearm with a stiff wrist. The special achievement of humans, however, consists right in coordinating multiple rotations so that for the projectile, as linear as possible a path of acceleration results. Of course, one can limit oneself to investigating a simpler course of motion if minimum requirements can be deduced from it. This, however, does not apply in this particular case. The course of motion studied by Calvin is certainly simpler in itself, but this is not true of the requirements that the steering of this course of motion places on the brain with increasing throwing speed. From his model, in which for the projectile in the course of acceleration not just one change in speed but also a constant change of direction takes place, a “starting window” appears which becomes dramatically smaller with increasingly demanding throwing speeds.
Calvin defines the starting window as the timeframe in which the projectile must be released so that it can reach the target. For his model, Calvin gives for a doubling of the throwing speed a shrinking of the starting window to one eighth and an increase in the number of neurons needed to steer this action by a factor of 64. The number of necessary neurons thus, according to Calvin, rises with the sixth power of the increase in the speed of the throw. In saying so, he places the increase in speed proportional to the throwing distance – in reality, the throwing distance grows with the square of the throwing speed. According to Calvin, therefore, the number of necessary neurons also increases with the sixth power of the range – a truly impressive progression. In order to hit the same target at three times the distance, according to Calvin, 729 times more motor neurons must be employed.

Based upon these estimations, Calvin comes to the conclusion that the growth of the brain that took place is insufficient to explain human superiority in throwing compared to chimpanzees, and develops approaches to solving this self-constructed paradox. He develops the position that regions of the brain not normally involved in the steering of movement also grew in humans and take part in the steering of throws. Thus, countless “sequencers” would be available to the brain that are only used in throwing and otherwise spend their time running through all possible scenarios, upon which the higher cognitive abilities of humans would then be based (Calvin, 1995). As far as I have seen, there are no findings whatsoever in the area of brain research that would support these positions.

The hominids have, in improving throwing – with the inclusion of more and more body parts in the acceleration process – taken very different paths (see Chap. 3.3.2) and were therefore not driven to the solution of the problem constructed by Calvin.
The acceleration process chosen by Calvin as his basis we find realized principally in discus throwing – a discipline with impressive ranges, but in comparison to overhand throwing, miserable accuracy. Here also, the projectile is accelerated along a circular path. Thus, the starting window in discus throwing is not as small as it would have to be in Calvin’s throw from the elbow at the same range, since the angular speed of rotation in discus throwing comes out smaller through the longer lever arm. The lower accuracy in discus throwing shows that we are far from being able to solve the task studied by Calvin.
The actual course of movement in the human overhand throw is substantially more complicated than the one taken as a basis by Calvin. It thus requires much more extensive advance planning with significantly more simultaneous output – the demands on the signal quality of individual outputs, however, do not rise so dramatically with increasing range as Calvin assumes (a factor of 4 would probably be more realistic with a doubling of range than the factor of 64, but the estimate is very difficult and unreliable because of the complexity of the motion. A computer-generated simulation of the course of motion might eventually be able to offer help here).
And even when one takes as a basis the course of motion chosen by Calvin, the estimation is still nowhere near correct, since the range does not increase linearly but rather with the square of the speed, and this has important consequences for the starting window.

It is hard for me to explain how William Calvin could have gone so far wrong in his assumptions. This scientist had already known for ten years before I even began to think about throwing that throwing must be a matter of a high-order adaptive trait of humans. He found himself on the same trail, but was catapulted off the path by a relatively simple consideration, and from there on busied himself with a paradox that doesn’t even exist. What happened?

Calvin writes that the estimation of how quickly the starting window becomes smaller with [increasing] throwing distance presents a very simple task that he solved in the course of an evening on his computer [or calculator]. Led by his scheme of early humans hunting with stone tools, he put together a supposedly suitable scenario for himself. There, he encountered two basic assumptions that, upon closer inspection, turn out to be exceptionally arbitrary and eventually became disastrous for him.

In his scenario, the surprise attack with a stone projectile, with which a rabbit-sized prey animal is taken, plays a central role. With the argument that a noticeable windup-motion would have caused the potential prey to take flight, Calvin consciously excluded "modern" throwing techniques, as seen in baseball, from the investigation. Therein resulted the first arbitrary basic assumption, that is, the assumption that it is sufficient to limit oneself to the investigation of throws that are conducted from the elbow.

Precisely from the comparison of a chimpanzee throw from the forearm with the complicated course of motion in the targeted high-performance throw of modern humans, though, does the supposition become obvious that the further development of the course of movement played an essential role in the improvement of throwing performance. The most important reason for limiting the investigation to a throw made from the forearm thus results, for Calvin, from the underlying hunter scenario. If, namely, the goal of the early hominids was not hunting but defense against predators (CTSW model), then from their point of view, it would doubtless be extremely welcome if the opponent took off [lit.: "made out of the dust"] directly upon seeing the windup motion and thus made the completion of the throw superfluous.

In addition, Calvin's hunter scenario itself does not seem particularly plausible. From the observation that gazelles permit individual baboons to get relatively near them and only flee when a whole group of baboons approaches them in an area where baboons frequently hunt gazelles cooperatively, he concludes that potential prey animals also tolerated the approach of a single hominid up to its throwing range (at the beginning of the throwing adaptations he postulates, that was only 4 meters). More plausible in my view would be to conclude from the behavior of the gazelles that these animals are very capable of reacting to regularly occurring danger situations with appropriate behavioral adaptations. If the early hominids had begun to hunt them with targeted throwing, then they would have learned quickly to stay out of range – which initially wasn't very far anyway – and thus put a quick stop to this hunting technique. This could also be the decisive reason why chimpanzees never switched over to using targeted throws in their hunts. Calvin assumes, on the contrary, that the transition to hunting with targeted stone projectiles was a matter of a blissful “discovery” of our ancestors.

Calvin’s second arbitrary assumption affected the choice of throwing parameters. The release angle or the level of throwing speed had to be provided; the other value then resulted from the condition that rabbit-sized targets ought to be hit. Calvin varied both values here, but still encountered a largely inappropriate limitation. Instead of orienting the choice of the release angle on the target, which is obvious since this is what one is supposed to hit, Calvin oriented himself on the horizontal and studied throws whose directions of release lay less than 10° above horizontal.

And instead of thinking about the already enormous influence in this angular region, with increasing range, of the release angle on the starting window (at a distance of 8 meters, he gives a starting window of 0.99 milliseconds for a throw with 10° in comparison to 0.47 milliseconds for a horizontal throw), he just sweeps this influence under the rug [lit.: “lets this influence fall under the table”] in that he creates an average value across all studied angles. In the end effect, he compares different distances with each other and otherwise works with rounded values that correspond exactly to the relationships in horizontal throws. I now wish further to examine this special case more precisely in order to illustrate what a terrible effect that selection of release angle and its averaging had on Calvin’s evaluation.

In the special case of the horizontal release, the flight time corresponds to the time that the stone needs to fall from the height of the throw to the height of the rabbit. Aside from a small correction term that considers at what height the rabbit is hit, the flight time is thus constant and, in particular, independent of the distance. So that the rabbit can be hit at double the distance, the stone would really have to be thrown with twice the speed with a horizontal release. If we claim the horizontal throw, then Calvin’s evaluations are indeed correct, but how realistic is this claim?

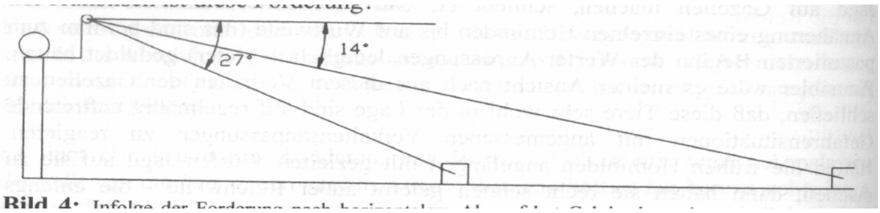


Figure 4: Owing to the claim of horizontal release, Calvin studied the very unrealistic case that a longer throw must simultaneously be much flatter. This has, among others, the consequence that he had to raise the throwing speed greatly (double it) in order to reach the more distant target. By conserving the release angle relative to the direct connecting line between the thrower and the target, the speed would not have to increase nearly so much.

Anyone trying to hit a rabbit will envision this and aim a little higher in consideration of the force of gravity. At a larger distance, the thrower will ordinarily set the throw even higher (relative to the direct connecting line). Gunners behave the same way, since by raising the release angle they can increase the range without raising the velocity (the maximum range is reached for targets of the same height, neglecting air resistance, at 45°). As an extreme case, one can set the angle relative to the direct connecting line as a constant. Through his choice of the (nearly) horizontal release (the horizontal line in Figure 4 stands for the direction of the throw), Calvin has forced his thrower into the feat of hitting a more distant target with a substantially restricted release angle – this is, as I will now show, an adequate explanation for the paradox that Calvin's thrower would require more brain than he actually has available to him.

To make the relationships in throwing clear for oneself in a simple way, one should assume that the heights of the throw and the target are equal, like in darts, where the target [dartboard] is hung at the eye level [lit.: "head height"] of the thrower. The flight path is symmetrical in this case. The flight time depends on the vertical components of the starting speed $v_z(0)$. In the course of the flight, v_z is reduced. In the middle of the flight path, at its highest point, $v_z = 0$. Afterwards, the projectile begins to fall and hits the target with $v_z = -v_z(0)$.

For the ascending and descending legs of the flight path, the projectile needs the same flight time, namely $t/2 = v_z(0)/g$, whereby g is the acceleration of gravity, 9.81 m/s².

The flight time thus amounts to $t = 2v_z(0)/g$.

The target-oriented speed component v_x is not altered by any external forces during the course of the flight (air resistance is neglected here) and therefore remains unchanged. Therefore: $v_x = v_x(0) = \text{const.}$

Range (L) is therefore:

$$L = t \cdot v_x \text{ or } L = 2v_z(0) \cdot v_x/g.$$

Now, humans think less in terms of Cartesian coordinates than direction of the throw and amount of speed of the release. So, we introduce the release angle γ relative to the horizontal plane and the amount of release speed v. Thus, the following relationships ensue:

$$v_z(0) = v \cdot \sin\gamma$$

$$v_x = v_x(0) = v \cdot \cos\gamma$$

$$L = 2v^2 \cdot \sin\gamma \cdot \cos\gamma/g$$

Here one can read directly that with a constant release angle, the range increases with the square of the throwing speed. If one additionally investigates the term sin $\gamma \cdot$ cos γ with extreme values, one will determine that the maximum range results at $\gamma = 45°$.
For doubled range at a constant release angle, one must therefore only raise the speed by a factor of 1.4 – the square root of 2. As a rule, one would even combine a moderate increase in speed with a raised release angle. Even when the target, as with Calvin, lies at a different height than the projectile at release, the relationships are similar as long as the height difference does not become too large compared to the length of the throw. Calvin had to double the throwing speed because he significantly decreased the release angle of a throw over double the distance (Figure 4).

The unfortunate choice of starting conditions also meant that a variation of the release angle of a throw over double the distance led to a variation in range greater by a factor of 4. Here, in principle, the excessive increase in the speed of release cuts to the quick [lit.: "hits to the beech"]. Also, the angular range in which the release (at a given speed) had to take place in order to hit a target of the same size is thus restricted, upon doubling the distance, by this factor of 4. Compare, on the other hand, two throws with constant release angles relative to the thrower-target connecting line, and this angular range only decreases by a factor of 2. This also fits much better with our experiences, since an object twice as far away looks just half as high to us, and not only a quarter as high as at the singular distance.
Now it remains to complete the transition from angular range to starting window. Calvin defined the starting window as the timeframe during acceleration in which the projectile demonstrates a suitable direction for release and must be let go. For him, the projectile is accelerated on a circular path of constant radius. An increase in the throwing speed thus led directly to a proportional increase in the angular velocity of this circular motion. For Calvin, the exaggerated increase in speed cut to the quick [lit.: "hit to the beech"] for the last time here. With a throw over a doubled distance, the allowable angular range would pass by twice as fast because of the doubled throwing speed, and since it was already smaller by a factor of 4, the starting window was reduced by a factor of 8. In a realistic alternative scenario with constant release angles, one gets a release window reduced by only a factor of the square root of 8.

This value must then be squared in order to estimate how strongly the number of necessary neurons climbs. That is how Calvin reached his factor of 64, where I only get 8 out of it. Even with the course of motion taken as a basis by Calvin, the number of necessary neurons grows at maximum with the third power of the range and not with the sixth (maximum because the opportunity to raise the angle of release was forgone).

Now it has not yet been considered that, in my opinion, William Calvin also, based on his first basic assumption described above, used an unsuitable model of the acceleration process. The hominids, after all, did not raise the release speed in throwing compared to their chimplike ancestors by letting their forearms rotate faster and faster. Chimpanzees are very powerful animals, and our ancestors would have been similarly built. The possibility of forming the motion of the forearm much more dynamically thus probably ran into anatomical boundaries very quickly. Presumably, we do not let our forearms rotate faster in throwing than a chimpanzee does in cracking nuts. In order to raise the release speed, other courses of motion therefore had to be integrated into the acceleration. The higher speed of release then ensued as a sum of the components of the individual movements pointing in the direction of the throw. In fact, most of the movements in the human throw actually occur more slowly than the rotation of the forearm. Only the movement of the hand is more dynamic.

The release of the projectile studied by Calvin is, in this scenario, not even particularly tricky. Through appropriate determination of the individual movements, namely, the acceleration trajectory is quite easy to linearize. Since the direction of movement of the projectile therefore barely changes during the decisive timeframe, it is not so extremely important when it is released (it is much more important how the projectile is let go, since it must encounter no diversion). Therefore, a compound throwing movement is, observed from the point of view of the starting window to be kept to, even easier than the single movement studied by Calvin. Thus, one also cannot refer to the throw from the forearm in order to study the minimum requirements of a thrower as Calvin did, because the demands of that are significantly higher than those of the typical human compound motion.

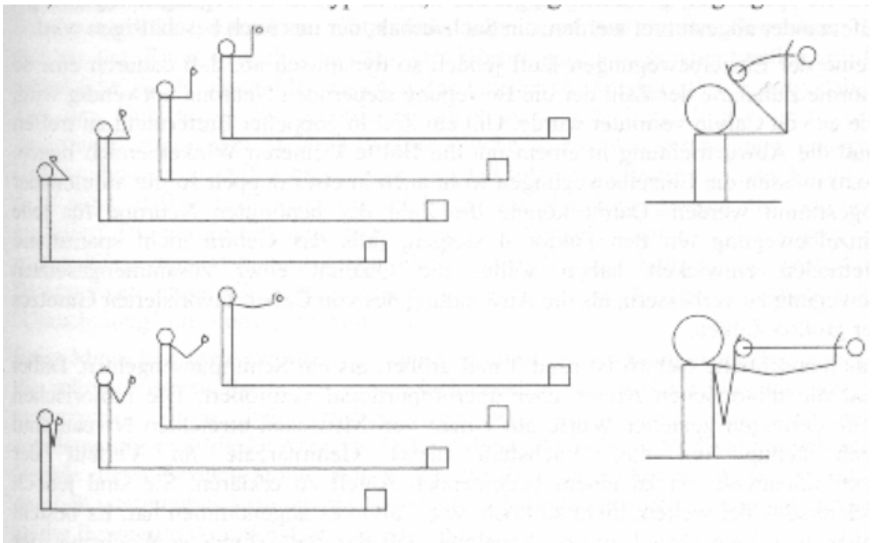


Figure 5: With good coordination of the movements of the arm and forearm, a course of acceleration approaching linear can be achieved quite well (below). For the simplified course of acceleration taken as a basis by Calvin (above), which is in no way typical for humans, the constant alteration of the direction of movement in the course of the acceleration is in contrast characteristic. Of course, the projectile then flies in the wrong direction if one does not let go of it promptly at the right time. And the range of suitable directions of movement is also run through more quickly with increasing throwing speed, so that the starting window shrinks again.

Particularly well suited for a straightening of the acceleration path is the combination of the movements of the arm and forearm, as Figure 5 shows in a simplified way. In each case, the acceleration trajectory is shown on the right. If this is not curved, then the starting window no longer presents a looming problem. With the transition from acceleration by the forearm to the combined acceleration from the forearm and the arm, the starting window actually became larger – despite a higher range.

Of course, one should be aware that the bottom illustration on Figure 5 is severely simplified. Here, only two rotations are balanced upon each other, which are obviously very well suited for generating a linear acceleration motion for the projectile together. Thus, the hand remains passive – which is never true, as the additional acceleration from the wrist is very important in throwing. The special achievement of humans consists in attuning up to six rotations creating the acceleration and release of the projectile to one another so that the projectile flies from them in the correct direction. This depends primarily on creating as straight a path of acceleration as possible for the projectile in order to avoid the problem that Calvin studied, and on generating an energetically optimal acceleration procedure. In all, seven motion complexes must be balanced well with one another, a topic that will yet occupy our attention.

None of the individual motions happens so dynamically, though, that such an enormous increase in the number of neurons needed for steering the motion as Calvin supposed becomes necessary. In order to hit a target at a doubled distance, the release direction must lie within an angular region reduced by half. For that, the individual motions must certainly also be balanced with each other about twice as well. Thus, the number of neurons needed for individual movements could rise by a factor of 4 in the event that the brain has developed no more frugal methods for improving the quality of the assembled motion than the use of the law of large numbers favored by Calvin.

The human brain is around 3 times larger than a chimpanzee brain. At the same time, the motor areas are more than proportionally enlarged. The motor requirements of aimed throwing on the level reached by humans are high enough to explain the growth of these areas of the brain in significant part. They are nonetheless, on the other hand, not nearly so high as Calvin assumed. There thus exists no reason for the assumption that the growth of the motor areas is not enough to explain human capability in throwing.

Calvin also supposes a relationship between the development of language and the human ability to plan a complex course of motion in advance. The ability I emphasize, to balance multiple individual motions well, fits substantially better with this assumption than his multitude of sequencers working in parallel.

As a fully developed thrower, *Homo sapiens* must be capable of balancing seven movement components together and integrating them into a total movement on which very high requirements are placed.

Calvin indicates that humans are obviously capable of thinking up to seven words ahead while speaking (Calvin, 1995). Is that only a coincidence, or was the human capacity here dictated by throwing adaptations, and did it turn out to be fully sufficient for speaking? (intended here is: sufficient for the motor requirements of language. Of course, other aspects come into play in language that required their own adaptations).

This may seem somewhat farfetched at first glance, but one must observe the problem from the point of view of the brain. The brain is a very versatile instrument, and this is not only true of the brain as a whole, but also of the individual sections of the brain.

Actually, only relatively few parts of the brain are specialized for very specific tasks. This is true, for instance, of the motor cortex, from which the commands for moving muscles issue. It is cartographically constructed, so that the movements of individual body parts are released from very specific areas of the motor cortex. The body is thus mapped out in a certain way on the motor cortex. But even with this cartographically constructed part of the brain, the order is not rigid. An area that is assigned to the index finger today can belong to another finger in a week. Investigations on monkeys have shown that intensive practice of, e.g., the thumb leads to an expansion of the area of the brain associated with the movements of the thumb, which then stretches into regions that used to be responsible for other body parts. The same neurons can thus cause the movement of one body part as well as – after corresponding "retraining" – those of a completely different one.

In humans, the premotor cortex of the left half of the brain, which lies in front of the motor cortex, plays a large role in the chronological organization of complex movements. One region in particular, the so-called supplementary motor area (SMA), is brought into connection with this task. Exactly this region presumably must have undergone substantial further development during the course of the throwing adaptations in order to fulfill the high requirements that are now placed on the coordination of movement.

Here, perhaps, the competence developed to steer the course of a complex ballistic movement assembled from seven individual elements (movement schemata). These movement elements, in light of the flexibility typical of the brain, need not necessarily be those that were used for throwing. Presumably, in the course of these individual developments, the brain was first gotten into shape to manage exactly this task, but could also specialize with correspondingly altered learning behavior on the solution of very different problems with identical or lesser degrees of requirement. Exactly thus, we learn to read, write, and drive a car today, although these activities place enormous demands on the brain and our ancestors certainly did not develop any adaptations for the mastery of these tasks.

Broca's area, which plays an important role in speaking, is also a part of the premotor cortex of the left hemisphere. While lesions in the motor cortex lead to paralyses, lesions in the premotor cortex result in disruptions of movement or, if the Broca's area is affected, to a significant language disability, Broca's aphasia (A. & H. Damasio, 1992; Springer & Deutsch, 1995). The Broca's area is, however, not a new development of humans. Monkeys also possess a corresponding area in this place, and injuries that appear there also lead to similar disruptions of vocal communication (Roth, 1996).

The capacity of our ancestors in motor steering, which had already appeared to a meaningful degree in the australopithecines and their ancestors 2-5 MY ago, surpassed by far the level reached by chimpanzees as a result of the throwing adaptations 2 MY ago. This was also particularly true at the beginning of the development of language, which is to be sought somewhere in the last 2 MY. At the beginning, an already well-developed premotor cortex could have taken care of a portion of the requirements of language incidentally. Since language placed additional, demanding tasks on the premotor cortex, its capabilities were surely expanded in the course of language development, particularly in the region of Broca's area – the question is, however, whether the difficulty of the tasks mastered by the premotor cortex was also increased again, or only its overall capacity for the mastery of different tasks as difficult as the human high performance throw. In the first case, demanding further developments would have had to take place; in the second, it would have been sufficient to multiply existing structures – one of the easiest exercises in living Nature.

Roth points to a hypothesis of the development of human language that shows interesting parallels (Roth, 1996):

> "The American neurobiologist T. Deacon recently proposed a hypothesis on the development of human language. According to it, this process was completed in multiple steps. The first step consisted in the big increase of the prefrontal cortex in humans (at least since *Homo erectus*, which appeared for the first time around 1.8 MY ago). The functions of the prefrontal cortex lie, among others, in the chronological organization of behavior. This includes action planning, following up on actions, expectations, learning strategies, focus of attention, combinatory analysis, the analysis of symbolic signs, and in particular, the recognition of the significance context of results. These functions of the prefrontal cortex, present in the common ancestors of apes and humans, were put into the service of verbal language, of which the chronologically flexible organization (i.e., grammar, syntax) is the major feature, in the course of human evolution. In humans, the prefrontal cortex took over more and more of the control of vocalization, which is otherwise steered from centers in the

> limbic system and brainstem. This process does not represent a truly qualitative innovation, but rather a reorganization, a recombination of preexisting abilities (e.g., those of the prefrontal cortex).
>
> The second major occurrence in the development of human language abilities was the *remodeling of the larynx*. Modern *Homo sapiens* stands out in comparison to other primates through a relatively low level of the larynx in relation to the tongue and to the soft palate. This permits an expansion of the possibilities for sound production, in particular in regard to the production of vowels. According to the theory of some authors (e.g., Lieberman), this remodeling was first completed by modern *Homo sapiens* (Cro Magnon Man) and was not present in Neandertals, who disappeared around 30,000 years ago and were "replaced" by Cro Magnons. This interpretation is controversial, though. Deacon's argument in this context goes: Even with a small vocal range, consonants can be produced well, if slowly. Additionally, this kind of language sounds can be supported semantically through nonverbal communicative signals. The decisive step in the evolution of human language, namely the enlargement of the isocortex, took place before the final conversion of the larynx, according to Deacon."

The throwing hypothesis delivers a concrete reason why the prefrontal cortex was enlarged significantly in *Homo erectus* at the latest. After all, at least two of the three rotations by which the human course of motion in throwing is more complicated than in ballistic movements observed in primates were first anatomically possible with the transition to *Homo erectus*. If the development of human language actually occurred according to the scheme developed by Deacon, then a pioneering role for the throwing adaptations is, from the point of view of the CTSW model, highly probable.

Very interesting, though, are Deacon's thoughts on the potential significance of nonverbal communicative signals before the descent of the larynx. Together with a further observation, they suggest a bridge between the throwing adaptations and language development. Humans are not only capable of learning a spoken language, they can make themselves understood equally efficiently with a sign language. This is, from the view of the throwing hypothesis, extremely noteworthy for two reasons at once.

First, the requirements of sign language are covered much better with the requirements on a thrower – in both cases, complex ballistic motions must be coordinated in which a decisive role falls to the hand. A thrower would thus also bring with him the physical requirements for sign language in full. For a thrower, the development of a sign language would thus have been much more obvious than the development of a spoken language that demanded additional extensive adaptations of the vocal apparatus.

Second, we know today that the Broca's area (motor speech center) very important in language is also exceptionally active in sign language (Roth, 1994). This suggests the thought that this was developed further, on the basis of preceding throwing adaptations, for use in a sign language, which at the beginning was merely accompanied by oral vocalizations. Only in the course of time would it then have come to a shift of focus from the hands to the voice, which was accompanied by corresponding adaptations of the vocal apparatus. Today, we use the spoken word primarily and underline our expressions with mimicry and gestures. Against the background of the scenario clear from the throwing hypothesis, this is very close to the ideas that Deacon developed.

Should the human ability to communicate have taken this route, then major consequences for the evaluation of the human evolutionary course result. That is, one can no longer assume that conclusions about the level of performance in the area of communication at a given time can be drawn from investigations of the vocal apparatus of our ancestors.

Why our ancestors developed language at all is a very interesting question, with which we will yet concern ourselves. And this question is not a consequence of the throwing hypothesis; it presents itself anyway. If we are equally capable of exchanging information through use of sign language and thus could have avoided many adaptive changes that were developed only in the service of language ability, then the question forces itself upon us why our ancestors did not limit themselves to this more economical communication system. After all, it already is apparent from the observation that people with speaking and hearing disabilities are quite capable of making themselves understood through their remaining abilities that evolution has achieved more in the development of language than is necessary for the basic exchange of information. The remodeling of the larynx in humans, for instance, obviously serves only for its ability in verbal communication, which in this case was bought at the price that we can now choke ourselves. This entails, particularly for children, nontrivial dangers.

The motor cortex (primary motor cortex) and the premotor cortex (secondary motor cortex), along with the Broca's center and the supplementary motor areas, are parts of the frontal lobe, a region of the brain that is said to have an important role in the human ability to see and plan ahead (Calvin, 1995; Roth, 1994). Also, in the development of this ability, Calvin presumes a pioneering role of the throwing adaptations. It is also known that the motor system is not only active in the carrying out of movements; the same brain areas are often also active when we only imagine a movement, an activity that is of elementary significance to planning in advance.

Of course I can only agree with Calvin here, since it is, after all, primarily the enormous complexity of the course of motion that must be completely planned in advance for throwing to which I attempt to point. Additionally, however, I propose that other throwing adaptations that do not directly affect the carrying out of the throw play a major role in the human capacity for foresight (see Chap. 3.3.4).

3.3.4 Judging distances

Modern cognition researchers – psychologists as well as neuroscientists – emphasize the close relationship between perception and recognition. The London neurobiologist Semir M. Zeki writes, for instance:

> "We know today that seeing can no more be separated from understanding than recognition of the visual environment from consciousness. Actually, consciousness is a self-added – emergent – characteristic of every complicated neural organ, to which the brain developed in the course of its ancestral history, so that its bearer recognizes the environment in which it must stand its ground ever more precisely. Thus, research on the visual system leads us unwaveringly to the core of all scientific effort: the striving of humanity toward understanding itself and its true nature." (Zeki, 1992).

Even if such an expansive speculation about the origin of consciousness might appear somewhat rash – alone because a treatment of consciousness must start from an unequivocal definition of the term – this citation makes it clear how high modern cognition researchers place the significance of perception to the level of the higher cognitive achievements of humans. According to Zeki, a deep-reaching reconsideration has happened in the last decades – not least because of the use of ever more finely honed research methods. As late as the mid-seventies, we assumed that seeing and understanding were separate functions that ought to take place in different places on the brain's cortex – an idea that today can be considered refuted.

Today, visual perception presents itself as an exceptionally demanding accomplishment of the brain, which is based on an express division of labor. Specialized areas of the brain analyze incoming information in parallel according to different criteria, and the results of these analyses are called upon in order to construct a representation of the environment in the brain. The interpretation of visual information, thus the attempt to "understand" it, is therefore an integral part of perception and a prerequisite for the fact that we "see" at all. Thereto, Zeki (Zeki, 1992):

> "The visual stimuli that reach the brain in the form of nerve impulses do not represent a clearly defined code that need only be deciphered. For instance, the wavelength of the light reflected from a surface changes with the lighting, and still the brain is able to assign this surface a constant color. The picture that the gesticulating hand of a speaker throws upon our retina changes at every moment; nonetheless, the brain unswervingly recognizes a hand there. And it also does not ordinarily allow itself to

> be confused about the actual size of an object, although its image on the retina becomes ever smaller with increasing distance.
>
> The task of the brain is thus to filter out the constants and objective features from the constantly fluctuating data flow of the observed object. Perception is inseparably tied to interpretation. In order to determine what it sees, the brain cannot content itself with analyzing the images on the retina; rather, it must reconstruct the visual outside world from them. For this, a highly complicated neural mechanism has developed that is so unimaginably efficient that it took a century of brain research before anyone even acquired a notion of the multitude of its components."

From this modern view of visual perception, enormous consequences for the understanding of human evolution result.

Explaining the high level of human recognition ability is one of the most important component tasks that must be handled in the framework of an evolutionary model. If recognition must be interpreted as a portion of perception, though, then this line of questioning should be reformulated. In order to track down this highly developed recognition ability, it is now obvious to ask why perception had to be significantly improved in the course of human developmental history, and which aspects of perception were improved.

If this, however, should truly be the direction in which one must search to track down the high level of human recognition ability, then we have thus far looked in the wrong place. In current explanations for the origin of human recognition ability, a significant improvement in perception is not provided at all. Therefore, the approaches that postulate cultural development as the driving force here are still too deeply rooted in the since-falsified dualistic thinking that explained seeing and understanding as two strictly separate functions of the human brain. They take as their subject solely understanding, which, for instance, must supposedly have developed further in order to make the manufacture of tools possible.

In the case of the CTSW model of hominid evolution, the relationships are very different. The determination of target distance presents the central problem in the determination of throwing parameters here.

With the increase in distance, a lengthening of the flight time also goes along. Thus, the projectile is subject to gravitation longer and is more strongly diverted. In order to counteract this, one must know the actual distance. For this, the binocular vision of the primates is insufficient by far to determine distances around 60 m – a thoroughly realistic range for a practiced male *Homo sapiens* and therefore surely also for a *Homo erectus* – with the precision that is necessary for the person to throw with the aim that we observe today. William Calvin mentions this problem briefly in his book, "The Symphony of Thought" (Calvin, 1995). He determines that even a strike in baseball from the 9 m line demands more than binocular vision can achieve. Calvin, however, favors as a suggested solution the assumption that the brain here again uses his obviously beloved "law of large numbers" in order to take care of the problem. Binocular vision would this remain the basis for determining distances, only the determination would have to occur many times in parallel in order to average them and achieve a more exact result.

This does not explain, however, why humans are, for instance, able to drive a car with only one eye. Here too, the evaluation of distances over a broad field also plays a large role, but binocular vision is dependably excluded. In addition, it has been demonstrated experimentally that humans are not able to complete such tasks based on binocular vision. Calvin's explanatory approach here is thus clearly false.

The determination of distances, which is strongly emphasized in the CTSW model, is a component aspect of the ability of humans to perceive their environment spatially. Spatial perception is again an exceptionally demanding achievement of the brain, in which one can easily imagine that its improvement could have led to a marked increase in recognition ability.

Spatial perception is from the start a nontrivial exercise, since the visual stimuli from the three-dimensional environment are represented on the two-dimensional retina. In this representation, a dimension of the environment – spatial depth – is naturally lost. The task of reconstructing this aspect of the environment from the two-dimensional retinal image places an enormous demand upon the brain. In this context, cognitive researchers are aware of a multitude of "procedures" that are called upon for the reconstruction of the third dimension (Rock, 1985):

- Animals that are able to fixate on an object with both eyes have access to the assistance of convergence. The lines of sight of the two eyes converge on the fixated object and thus create a convergence angle relative to each other. This angle is a measure of distance.
- A similar such measure of distance is accommodation, the adaptation of the lenses in close-range vision by which a sharp picture is generated.

- A relative measure of the distance of objects is provided by disparity. This also depends, like convergence, on binocular vision. Here it is not a matter of fixation on the object, but of how different objects at different distances are perceived from two different lines of sight (the lines of sight of the two eyes) in their positions relative to one another.
- A similarly relative measure for the distance to objects is motion parallax, which results from motion of the observer. In order to keep its eye on a nearby object despite changing position, a moving observer must alter its line of sight more strongly than for a more distant one.
- Further information for spatial perception is delivered by factors of representation, among which perspective, shadows, covering by objects lying in front, and the known size of objects are included. Perspective again allows a relative determination of distances; only the known size of observed objects, though, offers along with convergence and accommodation a usable basis for absolute determination of distances.

Experience teaches that the human brain takes into account all presented procedures at the same time in order to produce a three-dimensional representation of the visually observed environment. Among the quality criteria of this representation is, of course, the accuracy with which the absolute distance of the observed objects is determined. This task throws up great difficulties with increasing distance of the objects.

The "standard method" of the primates – the reconstruction of distance from the two-dimensional retinal image through use of binocular vision – is based on the different lines of sight from which both eyes consider a fixed point. Since both visual axes converge on the fixed point, one thus speaks here of the "convergence" that is called upon for the determination of the distance. How large the angle α between these lines of sight is depends upon the distance L of the envisioned object and upon distance between the eyes d. The latter is on the order of 6 cm. For small angles α, such as result for $L > 1$m, $\alpha \approx d/L$ in radians or $\alpha \approx 180d/L\pi$ in degrees.

For the accuracy of the determination of distance, it is important how large the actual variation in angle α ($\delta\alpha$), which is due to a variation in distance L (δL), is. The smaller the quantity $\delta\alpha/\delta L$, the worse the results of an estimation of distance. From the above relationship $\alpha \approx d/L$ results:

$$\delta\alpha/\delta L \approx -d/L^2.$$

The accuracy of determinations of distance with binocular vision is inversely proportional to the square of the distance. In other words, it decreases quickly with increasing distance. It behaves similarly in the second "direct" measuring procedure for distances that is available to humans, the accommodation of the lens (i.e., the adaptation of the thickness of the lens to the distance, which is required for sharp vision). It is therefore not amazing that the determination of distances based on convergence and accommodation alone (these are classed together as "oculomotor factors") fails at distances beyond three meters – as has been shown experimentally (Rock, 1985).

A certain amount of help in the task of judging larger distances correctly is surely offered by the above presented processes for "relative" determinations of distance. Disparity, motion parallax, and perspective can be called upon in order to determine the distances of faraway objects based on nearby objects whose distances in the close range of three meters were "measured" with the oculomotor factors. At the same time, however, not only the distance is extrapolated, but also the measurement errors. The relative error of close-range estimation is thus retained. Additionally, yet another error term for the estimation of relative distance comes into play, which may itself become larger with increasing relative distance. It is thus foreseeable that the use of these procedures for relative determination of distances under high requirements on the precision and the increasing size of the absolute distances to be determined would reach its limits. In the end, only the use of the third procedure for the determination of absolute distance offers a way out, the application of the known sizes of observed objects. I suggest, therefore, that the enormous capacity of the human brain in the area of spatial perception rests upon the significant degree of dependence on memory in determining the actual sizes of distant objects. We remember how large individual objects are and build our reconstruction of the visual environment upon these memories.

Distances can be determined from a comparison of the known size of the objects with the size of the visual angle (the angle that the object fills as seen from the eye). And it can be shown experimentally that humans also call upon this process in determining distances. This gives us, together with the other representational factors, the ability to reconstruct a two-dimensional representation in the third dimension, an ability that we apply constantly when watching television or looking at pictures. Binocular vision is useless here, since the pictures themselves are already two-dimensional.

That humans are aware of the actual size of observed objects under normal circumstances within a radius of several hundred meters is long since known. This achievement of the perception system is termed size constancy.

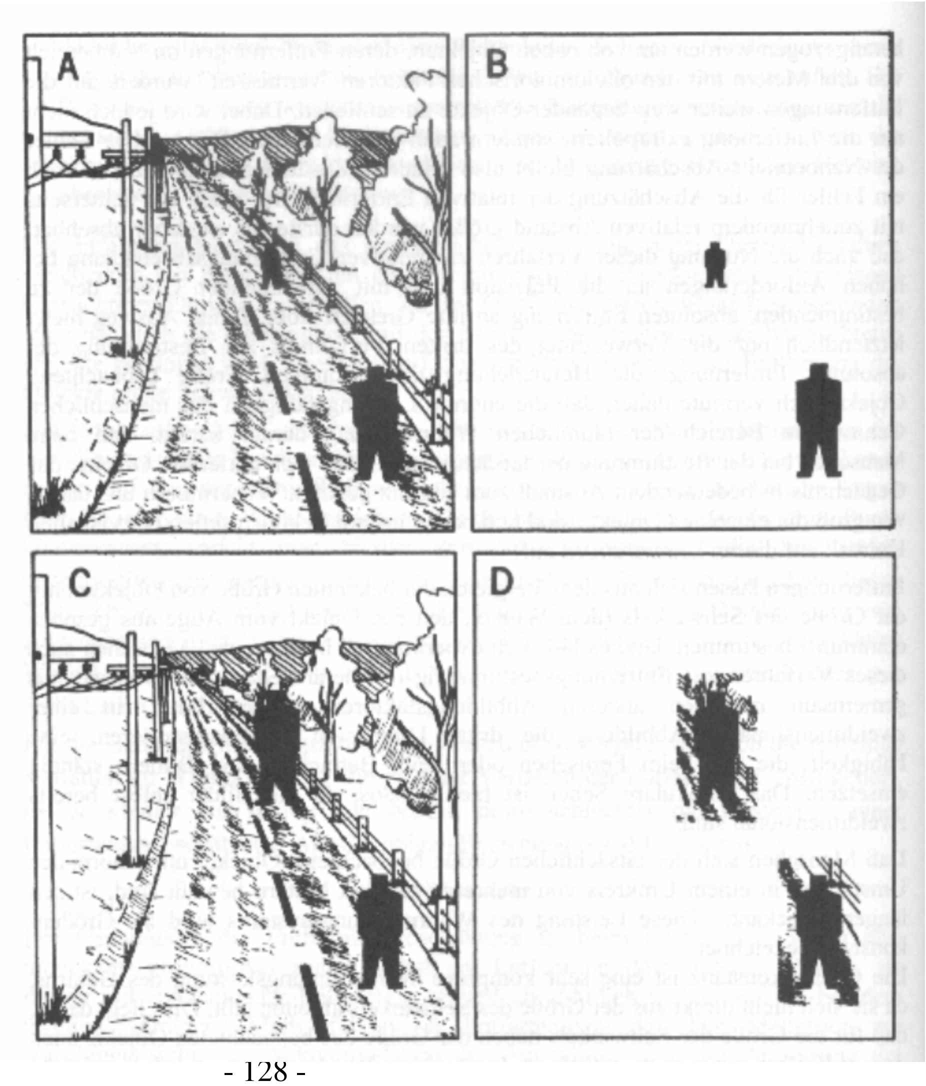
Size constancy is a very complex perceptive achievement of the brain that cannot be derived directly from the size of the visual angle. This is because in addition to the size of the observed object, its distance is also responsible for the size of the visual angle. At twice the distance, the same object is perceived with only half the visual angle.

As an explanation for the phenomenon of size constancy, it is primarily proposed that the size of objects can be determined with knowledge of the visual angle from the perceived distance according to the formula

perceived size = perceived distance * visual angle.

This, however, presumes knowledge of the distance.

Figure 6: Reconstruction of the third dimension from a two-dimensional representation (source: Eibl-Eibesfeldt, 1995). Although all of the drawing elements of which Figure A is assembled lie in a plane ca. 30 cm from the observer, humans recognize a three-dimensional landscape in them and prefer this interpretation. Meanwhile, the observer is certainly knowledgeable and aware of the actual distance of all of the elements of the



drawing, since a distance of 30 cm is dependably identified with binocular vision and is available as information to the brain. This information is nonetheless suppressed in interpretation of the content of the picture, since the size relationships of the pictured elements allow a sensible three-dimensional interpretation. Thus, the observer speaks of the hill all the way in the back and thereby taps with a finger on the drawing lying before him. Consequently, the upper figure on picture C appears overlarge, although the representations of both figures on this picture are the same size. Even on picture D, on which only a few elements of the drawing are available for the reconstruction of the third dimension, binocular vision has not yet taken the final victory, and the "back" figure appears somewhat larger.

Since the "perceived distance" for distances over three meters can no longer be determined through the oculomotor factors, this equation points for such distances to two unknowns and is therefore unsolvable. Both unknowns must be interpolated from other data at larger distances; it must be that one of the two sizes can be determined based on past experiences – i.e., from memory. Since perceived size is connected through this equation to perceived distance, size constancy and the ability to evaluate distances are only two sides of the same coin. If size constancy occurs, if the size of the observed object is known to the brain, then this equation can be applied to determine its distance. If, on the other hand, the brain possesses information about the distance, then the size can be deduced from the equation.

Size and distance are therefore either perceived correctly at the same time or interpreted falsely at the same time. Everyday experiences can primarily help with the determination of the size of the observed object. While distances change according to situation, the sizes of observed objects are generally independent of the situation. If such sizes are known to the brain, then they can be called upon in order to determine one of the unknowns of the above equation and thus make the equation solvable.

The occurrence of size constancy in humans at distances of several hundred meters is indicative that humans are able to construct a spatial representation of the environment in their brains that substantially corresponds to the actual relationships in this vicinity. This is an exceptionally remarkable and, no doubt, also an exceptionally "expensive" achievement of our brain. In addition, it is surely a natural achievement that we have gained in the course of our evolution. After all, perception is an autonomous achievement of our brain that substantially avoids conscious control and has in general remained untouched by cultural development.

Thus, from an evolutionary theoretical view, the question directly presents itself why our ancestors needed such a high and expensive level of performance in the area of spatial perception, and when it was developed. In the CTSW model of hominid evolution, the high level of performance in humans in the area of spatial vision is interpreted as a throwing adaptation and made responsible for the high level of human recognition abilities. The decisive aspect of spatial perception, upon which it depended, was the correct evaluation of distances within range, i.e., with a radius of over 60 meters. Size constancy could have resulted incidentally therein, as the "other side of the coin." I would sooner suppose, though, that size constancy in humans developed into an accomplishment predominantly determined by memory, which then became the most important source of information for the derivation of larger distances.

It is thus also not surprising that size constancy appears in a radius that exceeds the range of throwers by a lot. If the distance is inferred from a size estimated from the basis of experience, then the determined value cannot be better than the underlying estimation – on the contrary, additional errors come into play in the inference. High demands on the quality of distance estimations thus place even higher demands on the quality of the underlying size estimations. In addition, it can be expected anyway that a perception system that must produce spatial representations that agree very well with reality in the area of range will also create a passable spatial image of the environment within a given radius.

Incorporating the known size of observed objects in determining distances brings enormous advantages, since the accuracy of this measurement procedure is no longer limited by the – in comparison to the distances determined by a thrower, very small – distance between the eyes, as is the case with convergence. But, this procedure is characterized by an unbelievably high level of expenditure. The capabilities of the procedure depend primarily on a reliable estimation of the actual size of observed objects. This is again based on identification of the objects with the most possible accuracy and on the availability of appropriate data in the memory. It thus requires an exceptionally effective memory for sizes and shapes, which would be associated with significant "costs" for the brain.

In order to get an estimation of distance based on the known size of objects, the brain must solve the following component tasks:

1. The actual size and shape of an observed object must be assessed.
2. The influence of the orientation of the observed object relative to the observer's visual angle must be eliminated.

3. The size of the visual angle must be determined and placed in relationship to the (twice) corrected estimate of the actual size. From this, an evaluation of distance results.

Humans are not, however, limited to estimating the distances of individual objects, but produce in their brains a three-dimensional scenario of the environment in which the distances to the individual objects are reproduced in such a wide radius and with such precision that the demands of a good thrower are fulfilled. The points 1-3 are thus not just resolved for an observed object, but are rather applied to as many objects as there are in the field of vision. All resulting distance determinations then present only one of the many components that are called upon in order to generate an accurate three-dimensional scenario of the environment within the brain. These special components offer, however, the advantage that the scenario can be "gauged" with a few estimated values in the realm of larger distances. Therefore, and because of the high costs to which they are tied, I propose that these components first came into use on a large scale in the course of human evolution – as throwing adaptations. The other procedures that are available for use in the spatial reconstruction of the visual environment and make further information available I have already enumerated. Of them, primarily the other representation factors would have increased substantially in importance over the course of human evolution, which again would also have been associated with substantial "extra costs" for the brain.

From the total relationship, corrections or fine-tuning of the sizes of objects estimated in Point 1 would surely follow. In particular, the brain must recognize contradictions in the scenario sketch and resolve them through variation of the assumed size parameters. This procedure demands an enormous investment of work and very special abilities of the brain.

In order to master Point 1, the objects must be identified, after which estimates of size and shape can be called up from memory. These estimates become more reliable the more precisely the objects can be identified and the better the memory for shapes and sizes is developed and "fed." Of course, an organism that relies on this kind of estimations develops a very especially keen interest in new objects unknown to it.

Overall, in my opinion, Point 1 places high demands on analytical thought and the memory of sizes and shapes. The ability to find shapes again in different scenarios also plays a large role. This point would also demand a lengthy learning process before it could be mastered.

The capacity to identify objects precisely offers humans substantial assistance again in learning language. When children learn to talk, they are told primarily what individual objects are called.

The means by which they identify these objects are left substantially to the analytical abilities of their brains. Also impressive is the fact that humans are able to differentiate many tens of thousands of written symbols, as is done by educated Chinese. Chimpanzees manage, with years of practice, at best a few hundred symbols – Kanzi, the most accomplished (pygmy) chimpanzee in this area thus far, makes it to one thousand symbols.

Point 2 requires the ability to imagine how a three-dimensional object would look from a different perspective; this is an aspect of geometric thought. The high level of human achievement in this area is traditionally traced back to the production of tools. In the CTSW model of hominid evolution, geometric thought is necessary in order to reconstruct a very demanding spatial representation of the visual environment in the brain (next to "Point 2," the increased use of the representational factors "superposition" and "perspective" presumably also plays a role in the high level of human geometric thought).

Point 3 probably places the least demands among the three points, and I will not discuss it further.

In the combination of individually recognized objects – or, more precisely, their schemata – into a scenario of the visible surroundings, the brain surely incorporates many other criteria to reach an accurate scenario. As objects with the same shape can present observable differences in size, it is to be expected that a multitude of indicators of the actual size of the observed object would also be considered. The more one knows about an object, the more precisely one can identify it. Next to the shape itself, its movements, for instance, are also analyzed. In poorly made pirate movies, for example, long shots of the model ships used often look ridiculously implausible because they jump much too hectically on the waves. Large ships have large inertial moments and therefore roll in a more leisurely manner on the waves. A practiced human brain is obviously familiar with these relationships, so the model is effortlessly exposed.

When contradictions are recognized in the scenario, they are resolved in that individual schemata are fit into the total scenario with the least effort necessary to make it appear correct. Occasional illusions will also result from this, such as the overlarge man in Figure 6C.

In his book, "The Stream That Flows Uphill," William Calvin writes, in his storytelling style (Calvin, 1994):

> "She *(a presumably fictitious storyteller)* naturally encountered difficulties when she tried to drive home to the others that many things attributed to the mind – individuality, free will, thought, intentions, responsibility, motive – are very simple to explain in that the brain possesses an overdeveloped ability to combine schemata into scenarios, to compare different scenarios with each other, and to pass judgments of quality in order finally to trigger the blocked muscles of the body to carry out the best scenario."

Of course Calvin's scenario shimmers through here, according to which the coordination of the course of movement in throwing demands lots of parallel sequencers that can be used at the times when no throwing is taking place to run through different alternative scenarios in parallel. This scenario rests on the unsteady foundation of the assessment discussed in the previous chapter. Nonetheless, throwing could have had a decisive importance for the development of the "overdeveloped ability of the brain to connect schemata into scenarios." Although [it did so] in a very different way, and in front of the background that throwers must put together a more precise scenario of their visually perceivable environment than their ancestors.

Combining schemata into complex scenarios with as few contradictions as possible is precisely what we must achieve in seeing. An improvement in visual performance could therefore have come to have a key role in the development of higher cognitive functions in humans. Irvin Rock, one of the pioneers of modern perception research, already presented this thesis (Rock, 1985). The brain's procedure for the reconstruction of the visual environment reminds me structurally of the development of scientific model ideas – and this expressly includes the appearance of "illusions."

That we should have, of all things, visual perception to thank for our most prominent mental characteristics seems at first glance to be irreconcilable with our experiences. We are aware of our significant mental superiority over other animals. How, then, could the superior human recognition ability come from an achievement that is of more importance to other animals? After all, we are more likely to think of eagles or falcons when it comes to who has the best eyes – not of humans. And also lions, as well as their prey, must surely be able to estimate distances. The one in order to hunt better; the other in order to avoid becoming prey. I will elaborate briefly on this example in order to illustrate the characteristic adaptive traits of humans and to make clear that seeing is not the same as seeing. What we perceive is not simply our environment and the same to all animals because they all live in the same environment. Our perception leads to an expensive representation of the environment in our brain, and this is only as “good” and “expensive” as is needed in individual species.

For a falcon, it is a matter of perceiving its small prey animals from a great distance. It therefore primarily needs eyes with very high resolution – the exact size and distance of the prey animal, on the other hand, play a lesser role. Corresponding estimates can be corrected in the course of the approach flight, just as deviations from crosswind are corrected. Even if the falcon should err in its original estimation of the actual size and distance by a large margin, the attack does not have to fail because of this. With the approach to the prey animal, the estimation of distance becomes ever simpler and more reliable, so that initial incorrect estimates can be corrected in plenty of time before reaching the prey, in “cost-effective” ways. Thus, enough time remains for it to adapt its own behavior to the actual relationships.

Falcons are therefore certainly superior to us in one particular aspect – visual acuity – of visual perception; the price that they must pay for it is not extremely high from the standpoint of the brain. High visual acuity can be achieved though a correspondingly high density of receptors in the eyes – i.e., with “conventional” methods. It is, on the other hand, hardly to be expected that very expensive spatial perception is similarly well expressed in falcons as in humans – since falcons have no need for it, the “costs” of an accordingly effective perception system would result in lowered fitness.

In lions, the relationships are similar; they, too, can correct initial distance and size estimates in the course of the attack and are not overly reliant upon their accuracy.

In their prey animals, it would at first glance appear to be different. Fleeing a hunter too early means wasting energy and time. Fleeing too late could be deadly. Once they have let a hunter come too near, it could be too late for corrections. There is, however, a very simple solution to their problem. They can limit themselves to watching the size of the visual angle without “thinking” about to what extent it results from the distance of the lion and to what extent from its size. It is all the same to an antelope whether it sees a small lion at one distance or one twice as big at twice the distance – the larger lion is also generally the more dangerous one, and it is entirely appropriate to keep a larger distance from it. It is a very different matter, though, if one would like to fend off this lion with stones. Here, it makes a huge difference whether one is faced with a small lion 10 meters away or a large one at 20 meters’ distance.

The estimation of distances by a thrower is, in the case of humans, a matter of determining absolute distance of a target from the thrower at distances on the order of 60 m. This assessment, as we have seen, places enormous demands on visual perception and provides a conceivable explanation for why humans, as postulated by Semir M. Zeki at the beginning of this chapter, needed in the course of their development to recognize their environment ever more accurately – much more accurately than their cousins, the chimpanzees.

A thrower that has specialized on the use of a visually steered distance weapon needs a significantly more precise reconstruction of his visual exterior world than a chimpanzee, which only needs precise estimates of distance for as far as it can jump. (Climbing and therewith in particular jumping from one tree to the next place requirements upon the determination of distances that lie behind the possibilities of binocular vision. It is therefore to be assumed that chimpanzees and other monkeys call upon additional processes for estimating distances. Hominids, however, have presumably improved these processes greatly.) It is thus to be expected within the framework of the CTSW model of hominid evolution that we are significantly superior to chimpanzees in the arena of spatial perception.

This "expectation" is a case of a concrete, falsifiable prediction of the CTSW model. Should there be significant differences between the visual perception abilities of humans and chimpanzees, then it should also be possible to demonstrate this. It would be the task of animal psychologists to develop series of tests for chimpanzees in order to investigate their capabilities in the areas of size constancy and distance assessment and to compare these with those of humans.

Another way to demonstrate that spatial perception was substantially improved in the course of hominid evolution as a throwing adaptation results from the fact that in the course of human evolution, primarily men were optimized for throwing. This can already be seen in that men reach 30% higher ranges in javelin throwing than women.

Range, the issue in javelin throwing, primarily places high demands on physique. The individual components of the motion must "only" be chronologically well attuned to each other. The maximum range for a throw is reached with a release angle of 45° (with consideration of air resistance, the optimal angle comes out somewhat smaller), whereby slight deviations from the ideal angle only result in small effects on the range. The release direction need therefore neither be determined nor generated especially accurately. **In the mastery of these tasks, however, in particular in the assessment of distances, men should still be superior. This, too, is a falsifiable prediction of the CTSW model.**

Doreen Kimura investigated achievement differences between the female and male brains of *Homo sapiens*. Her results (Kimura, 1992) are exceptionally informative from the point of view of the CTSW model (see Figure 7). Those among the problems she presented on which men were superior read like a list of homework for a thrower:

- Since improved spatial perception counts among the throwing adaptations and is a case of a construction task of the brain, throwers should also be able to master tasks of spatial imagination especially well.
- That a thrower must be good in targeted throwing surely needs no further explanation.
- The location of simple shapes within a multitude of overlying structures is a valuable ability for a thrower; it surely eases the identification of objects whose size is known to him and can be applied in the determination of distance.
- In mathematical deduction, the improved ability to recognize relationships comes to bear and is used for checking the overall scenario.

Problems in whose solution women have the advantage:	**Problems in whose solution men have the advantage:**
Tests of so-called perception speed, in which image pairs are to be recognized rapidly – here, the counterpart of the house pictured at left is to be found: [picture of houses] Tasks such as remembering whether individual items were shifted or removed from an ensemble: [key example] Tests of fluency of ideas and words, in which the test subjects are told to list things like objects of the same color or words with the same initial letter: [L words] Tests of fine motor coordination – such as the insertion of pegs in the holes on a board: [picture of pegboard] Arithmetic: [arithmetic problems]	Certain tasks in spatial imagination and mental rotation, such as imagining rotating this three-dimensional object: [pictures of rotating blocks] or to determine in which position the holes in a folded page will lie after unfolding it: [pictures of hole task] Activities that require the application of aim-oriented motor abilities, such as for instance the throwing and catching of objects: [picture of playing darts] Finding simple shapes, like the one drawn at left, in a multitude of overlying structures: [picture of abstract line drawings] Mathematic deduction: [story problem: "If only 60 percent of all seedlings take, how many must one plant in order to retain 660 trees?"]

Figure 7: Tasks on which Doreen Kimura identified performance differences between the sexes. (Source: Kimura, 1992

It is not, however, only interesting which problems are better solved by men than by women, rather also the degree of superiority. Kimura found the biggest differences between the sexes with particular tests of aim and the mental rotation of objects; the latter is exactly the aspect of geometric thinking that is necessary for "Point 2" (see above). In both cases, then, it is a matter of express throwing adaptations. This is reminiscent of the out-of-place superiority of men in the javelin throw and demonstrates the exceptionally high priority that throwing adaptations had in the course of human evolution. Not just physically, but also mentally, men are primarily specialized throwers.

My interpretation, that the majority of the mental achievements determined by Doreen Kimura in which men average better than women act in the service of improved performances in aimed throwing – and therein especially distance assessment – is apparently supported by the research results of Frank McKenna of Reading University. Unfortunately, I only know of his activities through a report in the magazine "Der Spiegel," in which McKenna's work was torn apart for socio-politically understandable but cognotheoretically unimportant reasons (Der Spiegel, 22/1997).

McKenna's actual intent was obviously to investigate differences in driving behavior between men and women. In his series of tests, he supposedly came to the result I set out as a basis of the CTSW model, that men can judge distances significantly better than women.

Targeted throwing is a task that separates into two component tasks. The first component task consists in determining the throwing parameters (e.g., direction and speed at release), the second in generating these parameters. Both tasks are equally important, since the errors occurring in them accumulate and result in inaccuracy of the throw.

Since humans are exceptional throwers, they are obviously capable of mastering these two tasks exceptionally. The adaptive traits for the mastery of these two tasks are composed of physical adaptations that are documented in fossils and of the adaptive traits of the brain for the coordination of complex ballistic movements discussed in the last chapter.

When and in what order the physical adaptations took place can in part be read quite clearly from the anatomical changes of the hominids. It is a different story [lit.: "it behaves itself differently"] with the other adaptive traits. The determination of throwing parameters and the coordination of complex ballistic movements could only be solved through expansion of the capabilities of the brain. The certainly very extensive adaptations to the mastery of these tasks therefore have left behind hardly any clear fossil traces. They would have contributed substantially, though, to the growth of the brain that can be demonstrated from fossils; however, this singular, integral characteristic of the brain is far from enough to test concrete statements about evolution. The question of when which adaptive traits of the brain developed therefore essentially leaves a lot of room for speculation, which I would like to point out before I develop concrete notions about it.

In the framework of the CTSW model, it is obvious to orient oneself upon the course of physical development, which may give a clue as to when the corresponding cognitive adaptations would have taken place – inasmuch as the observed physical changes were truly cases of throwing adaptations from the start. This method does offer the best chances of constructing a concrete timeline of mental development and is also suited – at least a little – to test the CTSW model. Should, that is, a significant increase in performance of the body in throwing that should theoretically be accompanied by a significant increase in the performance of the brain have taken place without a significant increase in brain volume, then the CTSW model would be somewhat shaken.

The anatomical adaptations to an activity that included a complex ballistic course of motion could only take place if simultaneously – at least in principle – the ability was developed to coordinate this course of motion. Otherwise, the anatomical changes would have led to no evolutionary advantage and would therefore not have prevailed.

This says little, though, about how precisely the complex course of movement could be coordinated at a particular point in time. As I hold the adaptive traits of the brain for throwing to be substantially more demanding than those of the body, I presume that they also required more time. The development of these mental abilities therefore presumably continued to take place when the physical adaptations had already been completed. We can rule out, on the other hand, that the mental adaptations could have preceded the physical ones.

The development of the ability to determine suitable starting conditions for the throw thus presumably happened parallel to the development of the ability to coordinate complex ballistic movements. There would have been little sense, namely, in continuing to improve the implementation of the throw at high cost if the throwing parameters could not be determined with corresponding accuracy. (If the angle of release can only be determined with 5° accuracy, there is little sense in generating the determined throw at high cost with only 0.7° of deviation.)

If we place these thoughts in relation to the fossils, the suspicion arises that the throwing adaptations could have played a prominent role in the increase of the brain volumes of our ancestors. At the time of *Australopithecus afarensis*, the complexity of the course of motion in throwing did not yet exceed the level that we observe in the ballistic movements carried out by chimpanzees. Also the range would hardly have exceeded the distances that chimpanzees, as heavy, acrobatic climbers, must be able to assess precisely anyhow. This fits with the brain volume of this hominid, which was still within the range of variation of chimpanzees.

The integration of the upper body rotation about its long axis into the course of motion, which I propose at latest in a population of gracile australopithecines ca. 2.5 MY ago, first raised the complexity of the course of motion in principle above the level that is also mastered by chimpanzees. It fits with this that *Homo habilis*, which presumably came out of this development, is the first hominid in which significant brain growth can be registered. To what degree improved judgment of distances contributed to the growth of the brain, though, can hardly be evaluated.

With the integration of two further rotations, the degree of difficulty of the throwing motion rose again significantly with the transition to *Homo erectus*, and the range and therefore the distances to be judged grew strongly. This was accompanied by a substantial growth in brain volume, which also continued after the completion of the physical adaptations.

As the physical adaptations to throwing were substantially completed with the appearance of *Homo erectus*, it is to be expected within the CTSW model of hominid evolution that early *Homo erectus* already possessed a significant portion of the accompanying brain achievements. For the further mental development of humans, decisive switches had thus already been thrown by barely 2 MY ago, about which we can gain no insight from observations of our nearest living relatives – the chimpanzees. In addition, the mental throwing adaptations should have needed more time than the physical ones and could therefore also be important in substantial part for the continued, significant brain growth in the course of the *erectus*-phase.

3.4 Importance of throwing to hominid survival strategies

In the previous chapters, I have tried to trace back a whole series of anatomical and cognitive characteristics of hominids and humans to throwing adaptations. Such extensive adaptations to a single activity, stretching over at least 3 MY, demand a reason. They only make sense for evolutionary biological considerations if this activity had a consistent, very high importance for the reproductive success of the hominids.

In this chapter, I will present why throwing could have had such a high priority for hominid evolution over such a long period of time. I will again begin with the suitability of throwing stones for fending off predators. I have already explained that our ancestors had to deal with exceptionally low fertility. Chimpanzees are, in relation to this, downright extreme "outliers." One can interpret extremely low fertility as an elite performance – an animal species brings it about to avoid extinction with a minimum of offspring. It is characteristic of elite performances that they can ordinarily only be produced when everything comes together optimally. In athletes, elite performances require, e.g., talent, practice, good form that day, and good circumstances. Equally, the extremely low reproductive rates of apes require, in comparison to other animals, an actually well-developed brain (talent), high parental investment (practice and security for the children), and a predator-poor habitat (good circumstances).

If one of these requirements does not apply, then the appearance of an elite performance, such as is the low fertility of apes among primates, can really no longer be counted on. The abandonment of the relatively secure trees for longer periods of time, as we observe of chimpanzees, already represents an exceptional achievement for an ape that has retained its extremely low fertility. Presumably, the intensive use of weapons and large groups with a pronouncedly defensive social structure were requirements for this achievement. The advancement of the early hominids into the savannahs in turn puts this achievement clearly in the shadows, and this was made possible – according to the CTSW model – primarily through extensive adaptations to the use of weapons, in particular stone projectiles. The capacity in the use of weapons, therefore, should have exercised enormous influence on their fitness. Even expressly "costly" adaptations, such as the transition to bipedality, were thus also justified.

This defense against predators does not suffice, however, to explain why the human developmental line took the throwing adaptations so far. The robust australopithecines did not go so far, you see, although they occupied the most open habitats among the australopithecines and therefore – as far as endangerment through hunting predators is concerned – the most dangerous ones.

How should one imagine the defense against predators through use of stones? After all, the savannahs into which the australopithecines advanced were the habitats of very dangerous predators, among which were numbered hyenas as well as lions. How should a quite small, at less than 1.5 m tall, male hominid prevent one or even several cooperating lions from taking a substantially smaller female or a juvenile of their group?

The answer presumably lies in part in the inborn behavioral repertoire of the predators. The success of a fast, targeted attack by, e.g., a lion could hardly be – purely physically considered – prevented by throwing stones. Predators only carry out such attacks, however, when the potential prey tries to evade the attempted attack. Animals that stand up to the attacker usually also present a potential danger to it. They are therefore instinctively approached with caution. Representative of the accustomed opponents of the predators in such confrontations are the horn- or hoof-bearing occupants of the savannahs. If one or more cooperating predators have managed to corner such an animal, the ensuing attack proceeds with extreme caution. Hasty attacks can very easily lead to fatal injuries of the attacker. Since the hunt is bound to a daily repeated danger for the predators, their behavior is lain out to hold the risk as low as possible during each individual hunt.

The hesitation of predators to charge directly a potential victim that holds its ground offered the hominids with their special adaptation the opportunity to hold their devourers off from an attack. Exactly in that phase during which the predator had to decide whether and how it should attack the potentially dangerous (because standing to fight) animal, the hominids had the opportunity, because of the availability of a distance weapon, to convince their opponent of their own defenses.

The strength that proceeded from the hominids and that the predators already felt from a substantial distance must have made the hominids downright terrible and unpredictable to them, since experience teaches a predator that an opponent normally becomes more dangerous the closer one gets to it. The hominids, for their side, must have placed great value upon appearing as well-defended as possible and thus preventing an actual conflict in close combat. In principle, earlier lion tamers [“predator tamers”] proceeded similarly, as they held their “beasts” at arm’s length through use of whips.

It was also the hominids' first objective to impress the predators. A fast, mindless flight would have made no sense under such circumstances, since it would have provoked an attack in the first place. The australopithecines presumably extricated themselves from dangerous situations through an orderly, slow retreat and were, with their wide pelves that were well suited for throwing but rather poorly [suited] for running, correctly equipped.

The defense of the australopithecines was surely structurally nothing but a grand, supported very effectively by throwing stones, usually communally carried out, power display by the males. Structurally similar behavior can be observed today in the confrontations of neighboring chimpanzee populations, with the two decisive differences that in the latter case the opponent has access to the same materials and that for australopithecines, stone projectiles had a much higher importance. If the australopithecines descended from a chimplike ancestor, they would surely have had available a similar behavioral repertoire for the intimidation of dangerous opponents. Through use of stones – especially effective in open country – they gained decisively in the credibility of their displays and could injure their opponents quite seriously in case they did not keep the proper distance.

Perhaps there were strategies by whose use, for instance, a pride of lions could have hunted australopithecines with relatively low risk. A quick, cooperative assault might have yielded the lions sure prey with low risk of injury.

Perhaps the development of such an unusual strategy simply wasn't worth it, as in light of their low population density and reproduction rate, the hominids offered little incentive to develop special hunting techniques – all the more because these hunting techniques demanded that the predators do exactly the opposite of what had proven itself for millions of years and was still best for all other prey animals. I would not lay my hand in the fire, however, for the claim that the australopithecines yielded as defenseless prey as soon as it was possible to get past the flying stones in approaching them. That they show extensive adaptations to throwing stones naturally does not mean that they had no other defensive options open to them.

I have already addressed that the optimal procedure may have consisted of preventing close combat situations with thrown stones when possible, but having someone or other in the group carry a cudgel for emergencies. How important this cudgel was would have depended primarily on the efficiency of the defense with stone projectiles. We should not imagine the australopithecines, despite their small body size, as too defenseless. Chimpanzee males of the same body weight are five times stronger than men, and the muscle marks on fossil bones make the presumption easy that australopithecines were similarly competent in this respect. They were also similarly compactly built. Thus, they would have had defensive options even without throwing stones, although these would have brought higher risks of injury with them. The opportunity to lower these risks significantly suffices entirely as a reason for the development of extensive throwing adaptations by an animal with exceptionally low fertility.

The australopithecines thus occupied a niche in which the throwing of stones presented by far the most effective means of predator defense and so made survival in the savannahs possible for them. This was true for all australopithecines, from which one can gather that the level that the robust australopithecines had reached in their throwing adaptations was entirely sufficient from defense against predators.

That the gracile australopithecines went farther indicates that throwing had found a further, more demanding use among them. The recovery of the first worked stone tools (ca. 2.5 MY ago), which served to cut up cadavers, indicated that this use was a matter of the acquisition of carrion. The australopithecines were downright predestined to conquer a scavenger niche for themselves. After all, their task consisted "only" of driving off carnivores, and they had specialized on just that in the preceding millions of years. For a transition to hunting, on the other hand, the throwing adaptations offered no suitable basis as long as no spears were at hand.

From the perspective of a thrower, the decisive difference between hunting and acquiring carrion consisted in that in hunting, one must first get hold of the animal to be stoned. One thus stood before the task of approaching the animal within throwing distance and damaging it so severely with one hit that it was no longer capable of flight. One would have gotten little out of it if the hit animal, weakened by its injury, became easy prey to a lion several kilometers away. In scavenging, though, one must instead keep the pelted opponents at arm's length; if they take off [lit.: "make out of the dust"] after one hit, so much the better.

The showplace of the development to scavengers may have been the gallery forests along rivers and lakeshores in the East African Rift Valley. Blumenschine and Cavallo have conducted investigations into carrion as a possible new food source for the early hominids and have proposed the gallery forests as suitable habitats (Blumenschine & Cavallo, 1992). Next to kills by leopards and saber-tooth cats, which in their opinion accrued throughout the year, they lead during the dry season to the cadavers of starved and drowned animals as suitable carrion.

Although the underlying task in scavenging and in fending off predators is very similar, the requirements for scavenging are substantially higher. One must visualize for oneself that it is not the same thing to make it clear to a predator that one is not suitable prey as it is to drive it away from a cadaver.

Hunger is much less tied to aggression for a predator than is conflict over carrion. In hunting, the goal is taking prey with minimal risk of injury and expenditure of energy. Meanwhile, potential prey always defends itself in any way possible. Conflict over carrion, on the other hand, is a conflict among competitors over limited resources, which leads to a basic rank order among the meat eaters, which in turn helps determine how much food is potentially available to an animal. A higher rank permits relatively risk-free access to the carrion. Conflict over carrion (actually over the rank at the carrion) therefore only takes place occasionally; once the rank order has been clarified, then a threat by a higher-ranking individual usually suffices to gain it access to the carrion. Thus, rank has much greater importance for a meat eater than a single piece of prey, and it is fought for very aggressively and with a higher tolerance for risk on the part of the predator. It has already been observed that lions have been attacked and fatally injured by hyenas over carrion. I am, however, aware of no case in which hyenas would have undertaken an actual hunt for healthy lions.

Blumenschine and Cavallo have drawn a less dangerous picture of the life of the hominids as scavengers. In habitats that correspond to those in which, in their opinion, early hominids began consuming carrion, namely the gallery forests mentioned already, they believe they have found a seasonal ecological niche into which the hominids advanced without encountering any competition worth mentioning or exposing themselves to great danger.

This is to be countered by the fact that such an ecological niche, in a world occupied by specialized meat-eaters, has something odd about it. I do not wish to deny, by any means, that this niche exists today, but if it was occupied by the early hominids, then presumably it was first vacated by humans a few thousand years ago with the appearance of farming and a pastoral economy, since we know from recent hunter-gatherer groups from southern Africa that they, too, by no means disdain carrion.

To this extent, it is not surprising that this niche has not yet been reoccupied by carnivores in the ensuing era marked by human expansion. This, however, says nothing about the relationships that reigned before the hominids conquered this niche. Blumenschine and Cavallo themselves point to the extinctions of two species of hyenas and the African saber-tooth cats, that could be related to the encroachment of the hominids into the scavenger niche (Blumenschine & Cavallo, 1992).

The previous specialization on stone throwing made the australopithecines attacking in groups 2.5 MY ago into exceptionally combat-ready animals. Gracile australopithecines could switch at any time – in their habitats favorable for it – to scavenging. Perhaps a prior incorporation of the upper body rotation around the long axis in the acceleration procedure first made this advancement into the scavenger niche possible.

Life as scavengers again sharpened the selection pressure in favor of further improved throwing qualities. The competition typical of chimpanzee societies over reproductive success within one's own group drove the males to excel in conflicts with predators; the greed for meat did the remainder. Thus, every advance in fighting ability was applied in challenging ever-more dangerous opponents. In consequence, *Homo habilis* rose in the pecking order of predators, to which it actually didn't belong at all (I count *Homo habilis* among the australopithecines; see Chapter 3.6). As a side effect, it disappeared from their menus.

An important role in this process, in whose course one hominid branch definitively stepped out from the long shadows of the predators, probably fell to the leopards. Appearing in the same regions at the same time as *Homo habilis*, these animals distinguish themselves in that they are not especially large and therefore can definitely be seriously injured with thrown stones. As loners, they were thoroughly controllable for an aggressively attacking group of stone-throwing australopithecines. They also certainly counted – because of their ability to climb well and as nocturnal thieves – among the predators most dangerous to australopithecines. They could ambush the australopithecines at night in their sleeping trees, where stones were probably not at hand for their defense and, as visually controlled distance weapons, would not have done them much good in the dark anyway. In addition, leopards have the habit of bringing their prey into trees for security from scavengers. Of course, the cadavers they deposited in trees were by no means protected from australopithecines; on the contrary, they were quasi-reserved for them.

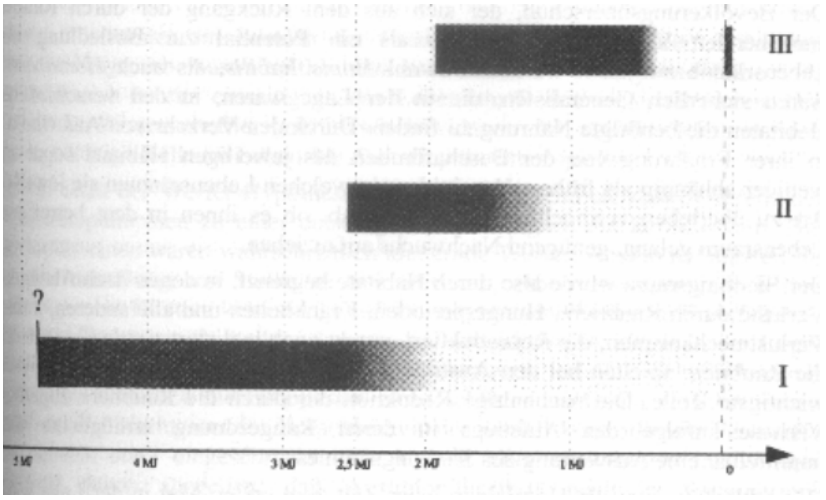
As of a result of its consumption of carrion, *Homo habilis* regularly became involved in conflicts, especially with leopards, which for the latter carried a substantial risk of injury. A leopard with a broken jaw or leg bone is inescapably condemned to death from hunger. It is therefore hardly surprising that over time, leopards tended toward instinctive avoidance of *Homo habilis*. Presumably, evolution also favored leopards, which basically do not defend their prey very heavily. This would explain why leopards today are shy animals and are easily chased off their prey, even by baboons and chimpanzees (Blumenschine & Cavallo, 1992), while a few million years ago they still obviously hunted australopithecines, as finds in South African caves prove (Johanson & Shreeve, 1990).

The increasing avoidance of scavenging hominids by predators led ironically to selective pressures that enforced the throwing adaptations even more strongly. *Homo habilis* had reached, in its confrontations with predators, ecological dominance, and had to pay for that with intensive intraspecific conflicts through which, from then on, the excess population was pruned. This is by no means a unique process in the animal world. So, for instance, fully-grown brown bears possess practically no natural enemies. This has led to adult males becoming the most common cause of death for juvenile bears. To what adaptations such a situation leads, however, is different from species to species. In the case of bears, the juveniles are exceptional climbers, because they can most easily find safety from adult males up a tree.

For our ancestors, the relationships were different. They were pronouncedly social primates with – I assume – a chimplike group organization. Because of this, the birth surplus primarily led to an intensification of confrontations between the groups. Just like in chimpanzees – only more often – it therefore came in border regions to attacks on strange females and juveniles, to alternating power displays by the males, and to attacks on strange males encountered singly or in the minority. On all these occasions, all of the abilities were now used that the australopithecines had developed in the preceding millions of years. Thus, throwing abilities came into use by ca. 2 MY ago in conflicts between groups of throwers. With that, range again gained decisively in importance, and vulnerability to injury by thrown stones became a problem. Things came to a landslide shift in selection criteria and therefore to the development of *Homo erectus*. The extensive adaptations of *Homo erectus* to throwing on the one hand, and on the other hand to the lowest possible vulnerability to injury by stone projectiles, make it a “key witness” [lit.: “turn ‘queen’s evidence’”] for the throwing hypothesis (see Chapter 4.1).

Overall, a 3-step model arises for the development of human capacity in the area of throwing (Figure 8). The three steps of this model are the most important areas of application. The intensity of the gray shading in Figure 8 marks the importance of the individual areas of application for the evolution of the human ancestral line. Step I is the application of stone projectiles in fending off predators. This activity in itself still finds occasional use in the present. Step II is the application of stone projectiles in scavenging. This activity was generally important until the Late Paleolithic and, for some groups, certainly beyond. Step III is the application of throwing in intraspecific confrontations.

The beginning of the next-higher step was automatically tied to the weakening of the importance of the lower step for evolution, since a thrower that became equal to higher demands would hardly be subject to selection in the accomplishment of simpler tasks. Above all, fending off predators quickly became one of the easier exercises, since the predators' shyness of the throwers increased after the beginning of scavenging.



- - - - - - - - Transition to the Late Paleolithic

I: Fending off predators

II: Scavenging

III: Intraspecific confrontations

Figure 8: Applications of throwing and their importance for evolution

In intraspecific confrontations, throwing played an important role at least in the *erectus* phase. At the end of this phase, there were surely some changes in the way in which these confrontations were conducted; however, I propose that the thrown stone still counted among the most important attack weapons afterwards. Through the development of throwing spears in the Late Paleolithic, yet another increase came in the importance of throwing to the conduct of war; I do not believe, however, that this carried substantial evolutionary consequences with it.

Actually, a fourth step should be introduced that considers the application of spears in hunting. This use cannot have played a decisive role in the development of throwing abilities, though, as is often assumed in connection with hunting hypotheses of hominid evolution. The decisive physical adaptations of the hominids to throwing were already completed by 1.8 MY ago. The development of the brain had presumably already reached its current state by 100,000 years ago. As finds of spear points show, however, well-developed throwing spears first arrived with the Late Paleolithic (Knecht, 1994).

3.5 Expansion out of Africa

The population surplus that resulted from the recession of losses to predators can be understood as a potential for the occupation of new habitats. *Homo habilis* and *Homo erectus* were surely generalists capable of finding the necessary food in the most diverse habitats. Through their consumption of carrion, they were actually even less dependent for food on the nature of a particular habitat than earlier hominids. In which habitats they could then survive as species depended on whether they were able to manage to rear enough offspring in the affected habitat. The space they could colonize was thus limited to habitats in which – after subtracting all losses to predators, famines, illness, and other external loss mechanisms – reproduction could just be realized. And predators presumably played the most important role in this balance for australopithecines. Thus, the permanent reduction in losses due to predators because of the rise in their rank directly allowed an expansion of their occupiable space.

That explains why the hominids were able then for the first time to expand out of Africa. The transition to *Homo erectus* and its habitat expansion across the borders of Africa were presumably introduced through the same processes and went hand in hand.

This means that late *Homo habilis*, in comparison to *Homo erectus*, is the better candidate for leaving Africa. Since for the settlement of new habitats, as yet unoccupied by hominids, a few thousand years were surely enough, as later for *Homo sapiens* in the settlement of the Americas. It thus happened much faster than the transition to *Homo erectus*, which resulted as a reaction to the same changes but represented a process that required at least tens of thousands of years.

New finds in China apparently prove this inference of the throwing hypothesis correct. Obviously, later representatives of *Homo habilis* had already crossed the borders of Africa barely two million years ago (Wanpo et al., 1995). The oldest hominid fossils outside of Africa were previously ca. 1.8 MY-old finds of *Homo erectus* and were discovered on the one hand at Mojokerto on Java (Swisher et al., 1994) and on the other hand in Dmanisi in the Caucasus (Gabunia & Vekua, 1995). The oldest African *Homo erectus* fossils from Koobi Fora are equally old.

3.6 Consequences of the primate model and the thrower hypothesis for the image of the early hominids

Among the most strongly discussed points in the area of paleoanthropology belongs the question of whether australopithecines were still partially tree-living (arboreal) or had already adapted one-sidedly to life on the ground. The majority of scientists now assume that climbing still played a very important role in the life of the australopithecines.

From the perspective of the throwing hypothesis, it is improbable that australopithecines had already come to a one-sided adaptation to bipedality. The australopithecines were probably climbing throwers. On the ground, they used an upright gait to transport stones, but by no means did they abandon their climbing adaptations because of this. Since stones carried along represent a limited resource in emergencies, their defensive strategy could not usually be based exclusively on fending off enemies. Relative security was only reached when the group could pull back to a protective tree. At night, the utility of the stone, a visually controlled distance weapon, was strongly limited in any case. We can thus assume within the framework of the throwing hypothesis that australopithecines still spent the night in tree nests, just as recent chimpanzees do. For gracile australopithecines, food available in the trees additionally played a large role. From the perspective of the throwing hypothesis, it is quite plausible that the australopithecines could still climb well and also did so abundantly.

Since the specialization on throwing for defense against predators is viewed within the throwing hypothesis as sufficient explanation for the transition to walking upright, there exists no cause whatsoever to assume decisive behavioral alterations in the direction of a food-sharing society. We have also already seen that the mental development of our ancestors by no means requires the assumption of grave changes in the social structure of the early hominids. Thus, a very simple explanation exists for the modesty of the signs of cultural development in the course of hominid evolution and their non-reflection of increasing brain volumes: the growth of the brain was not driven by cultural progress (in either the social or the craft areas), and the modest signs of cultural development paint a realistic picture of a genuinely modest development in the course of hominid evolution.

Fending off predators, which in the CTSW model is held responsible for the most important anatomical changes in the course of australopithecine evolution, was surely taken on primarily by the males. Even among baboons, a clear division of labor can be observed, whereby the males very clearly bear the risks of the defense of the group. It is quite correct to assume the same of the hominids (at least until the appearance of *Homo erectus*). On the one hand, the security of the females was even more important because of their lower fertility compared to baboons. On the other hand, the males, who stayed in their natal groups, had more reason to take on risks on behalf of the group's members, to whom they were closely related. And they had better chances, in a multi-male group, to parlay image gains from predator defense into reproductive success.

In light of the predictable, clear division of labor in fending off dangerous predators in open country, a substantially stronger emphasis on the necessary throwing characteristics in australopithecine males is to be assumed. The females would not have been driven to such a high degree to give up proven chimpanzee adaptations in favor of improved throwing performance. And if the group structure of the australopithecines corresponded extensively to that of modern *Pan troglodytes* – for the gracile australopithecines, I make this assumption – then much longer walking stretches over open country also resulted for the patrolling males than for the females. While chimpanzee males move around the entire territory of the group and carry out regular patrols in the border regions, they are at most accompanied by females that are in estrus. The females normally limit themselves to a partial area of the group's territory and cover significantly shorter stretches.

By slight variation of this scheme, one can imagine how gracile australopithecines behaved. The females tried to spend time in the most heavily forested part of the group's territory, which offered them food and protection against predators, and only crossed open country in the company of males. The males, on the other hand, had to be much more terrestrial than the females and put more emphasis on throwing characteristics.

That means that the "primitive" characteristics were retained as long as was at all possible. The females retained their apelike proportions, although the males had already developed "modern" proportions. The australopithecines were as primitive as possible and as modern as necessary. This indicates the costs of the conversion.

The single and decisive advantage was readiness to fight and relative security on the ground in open country. Disadvantages appeared in the search for food in the trees and in hunting monkeys. It would have been uncomfortable for the males not to be able to follow the females everywhere, since in contrast to the chimpanzees, australopithecine females were presumably better climbers than the males (I am sure, however, that the males found a fitting solution to this "problem" – after all, a thrower need by no means actually get a female in his hands in order to get respect). The different adaptations of the two sexes could also have led to relevant differences in the food consumed by each.

Overall, the males would have been significantly better fighters and more terrestrial – and for an australopithecine, that means larger and more modern in physique (*Homo erectus*, with his height of 1.80 m, was the first uncompromisingly adapted to throwing) – than the females. This presumably offers sufficient explanation for the marked sexual dimorphism of the australopithecines, all the more because Stern and Susman proposed, to explain the characteristics of the postcranial skeleton of *Australopithecus afarensis*, that the more gracile females would have been decisively less terrestrial than the more robust males (Henke & Rothe, 1994).

One should free oneself from the anthropocentric perspective that all developments in the direction of humanity were progress. In many respects, the chimpanzee is superior to humans. It is less specialized in its locomotion and therefore more adaptable than humans.

The transition to walking erect was a conversion advantageous for the occupation of open habitats, but it weakened the australopithecines in conflicts over typical chimpanzee habitats; these mostly remained reserved for our conservative *Pan* cousins.

Larger brains also cause enormous costs, and the growth of the brain was therefore not pursued by the robust australopithecines. For their lifestyle, the brain that they had was enough. A further enlargement would have brought more disadvantages – primarily in energetic endurance and because of the longer childhood required for learning – than advantages. Because of this, selection acted conservatively here and against further brain enlargement.

Since sexual behavior is not the main factor influencing the degree of sexual dimorphism, it is unnecessary to assume, based solely on their marked sexual dimorphism, a group organization for the gracile australopithecines that diverged in essence from that of chimpanzees. That the strong adaptation of the females to life in the trees was partially responsible for the marked sexual dimorphism of the gracile australopithecines made itself noticeable at the transition to *Homo erectus*. *Homo erectus* was the first to switch to pure terrestriality. Since the females were more strongly adapted to arboreality before, the dramatic changes now took place with them. That the size difference between the sexes was reduced to a chimplike level serves as evidence for my assumption that the hominids in the human developmental line truly had a chimplike group structure.

Their specialization for stone throwing made it possible for the australopithecines to use ever-drier habitats. This does not, however, mean that they rejected the moister habitats that their ancestors had used before they expanded their activities onto the savannah.

As good climbers, the australopithecines were surely able to feed themselves in original chimpanzee habitats in their accustomed manner (probably with the exception that their climbing skills were no longer adequate to hunt monkeys in the treetops). In the settling of forested habitats, though, their original chimpanzee cousins stood in the australopithecines' way.

Who among these close relatives prevailed in the occupation of a territory presumably depended, in light of their social organization, primarily on the readiness of individual groups to fight. Precisely this had increased in the australopithecines, though, and this probably worked to their advantage for a good piece into the woods.

The observations of wild chimpanzees at Gombe have indicated clearly enough that chimpanzees have an enormous respect for thrown stones. Only in large, connected forest regions would the chimpanzees of the time have been safely superior to the australopithecines, which had difficulties under such circumstances in the use of projectiles (because of the trees standing in the way) as well as in the acquisition of suitable stones.

Whether there were still forests in East Africa 2.5 MY ago that were large enough to permit chimpanzees to survive next to the australopithecines is an open question. In any case, the quite narrow gallery forests along lakeshores and rivers were taken over by australopithecines from the start and were probably especially valued by them, since they offered both more customary food and more protection than the drier surroundings.

For both *Australopithecus afarensis* and *Australopithecus africanus*, the gallery forests were a component of the habitats taken in by each species and represented one extreme of the demands on the traits of these hominids. The other extreme was dictated by the driest of the habitats used by the australopithecines at the same time. *Australopithecus afarensis* and probably also *Australopithecus africanus* represent the concept of being fit for both extremes, which was given up, however, when the distance between them became too great with the occupation of ever-drier habitats.

Consequently – according to the present state of the science, presumably in East Africa – a radial speciation took place. In place of a generalist, two specialists appeared, a robust *Australopithecus* as a specialist for drier habitats with extra-thick tooth enamel, corresponding jaws, and perhaps also an altered social organization; and *Homo habilis* as a specialist for tree-richer biomes. The latter were probably even moister on average than the habitats occupied by *Australopithecus afarensis*; at least the characteristics of the teeth and a comparison of Lucy (*Australopithecus afarensis*) with OH62, a *Homo habilis* female, support this.

Since for the females, the survival strategies and selection criteria usual for australopithecines remained the same with the origin of *Homo habilis*, their climbing characteristics were more strongly emphasized in light of the tree-rich habitat (they were separated from the drier ones after the speciation by their robust cousins). They therefore became, as regards their physical proportions, the most "primitive" of all australopithecines (and this just before the dramatic transition of this developmental line to *Homo erectus*, which renounced climbing completely!).

When a group of investigators under the leadership of Donald Johanson found the skeleton of "Lucy's Child," an adult, almost 2 MY-old *Homo habilis* female that was catalogued under the number OH62, people were so surprised by the characteristics of the postcranial skeleton that she is even today not recognized as *Homo habilis* by some experts. Others see a *Homo habilis* in her, but have removed this [species] – not least because of her – from the human ancestral line in favor of *Homo rudolfensis*. Lucy's Child was, if possible, even more "primitive" than Lucy – the 1.4 MY older *Australopithecus afarensis* female whose 40%-complete skeleton was found in 1974 in the Afar Triangle of Ethiopia.

Both females were exceptionally small. For Lucy, 105 cm are given; Lucy's Child was of similar stature, presumably actually even smaller, although that skeleton is in much poorer condition and accurate estimates are difficult. It is notable that the ratio of the length of the humerus to the length of the femur in OH62 was even higher than in Lucy. This ratio is called upon as a measure for the modernity of hominid skeletons. In chimpanzees, it amounts to 100%, in humans, 70%. Lucy fell, with 85%, in between, as expected; but the much more advanced on the path to humanity – at least chronologically – creature, christened "Lucy's Child," fell unexpectedly outside the developmental trend with its humerus-femur index of 95% (Johanson & Shreeve, 1990).

"Lucy's Child" was an australopithecine female whose habitat was limited by the preceding speciation to relatively moist and tree-rich areas – and seen thus, shows exactly the adaptations that are to be expected. The aforementioned results of investigations of the labyrinth of a female *Homo habilis*, which showed even stronger adaptive features for arboreality than the labyrinths of all other studies australopithecines, also fit.

The unusual thing was not the development of the *Homo habilis* females, but that of the males. As a reaction to the speciation and accompanying habitat restrictions, the australopithecine features really should have weakened in them, in favor of the original chimpanzee features. With the thickness of the tooth enamel, which clearly declined, this was in fact the case. The physique and the brain, however, were even more strongly optimized for throwing because they resulted from new selection criteria consequent to a fundamental behavioral change.
For the *Homo habilis* males, which had gotten involved in scavenging, the throwing characteristics appeared especially clearly; they became, therefore, the most "modern" representatives of their genus (meant here are of course the australopithecines).
Homo habilis thus showed presumably the highest sexual dimorphism of all hominids. The refusal of some scientists to let such marked sexual dimorphism exist immediately before the appearance of *Homo erectus* in the human ancestral chain led to arguments for dividing the fossil material attributed to *Homo habilis* and ascribing it to two species (Henke & Rothe, 1994). From the perspective of the throwing hypothesis, the thus additionally introduced *Homo rudolfensis* can presumably be discarded.

4 Evolution in the Marks of War

4.1 *Homo erectus* – marked by stone

The skeletal morphology of *Homo erectus* reflects extensive adaptations to the conduct of confrontations involving the use of stone projectiles. The thrown stone is a blunt impulse weapon that primarily leads to broken bones. Exceptionally informative in this context is the cranium of *Homo erectus* (Figure 9) (Henke & Rothe, 1994):

- Since the front of the skull faces the opponent in a conflict and is therefore endangered primarily, it was covered with enormous armor. The lower jaw became much more robust and thus less vulnerable to fracture. The impact-sensitive eyes were protected from hits by stones through significantly strengthened, prominent brow ridges. These brow ridges served simultaneously as protection for the brain that lay behind.
- The sloping forehead ensured that oncoming stones that got past the brow ridges only reached the skull at an obtuse angle, and were therefore deflected. This led to a lessening of the energy transferred to the skull.
- The strength of the walls of the neurocranium was meaningfully increased (doubled in comparison to *Homo habilis*), such that the probability of skull fractures was decreased. The largest danger naturally came from stones hitting the neurocranium perpendicularly (maximal energy transfer upon impact). As the stones in fights between throwers surely were not normally thrown at very close range, they reached their targets not from straight ahead, but somewhat from above. In the region in which stones coming from the side would more probably hit perpendicularly, the skull of *Homo erectus* was additionally strengthened with lengthened parietal bones, which reached farther backwards.
- In an unexpected attack from behind, effective hits could be achieved before the combatants were aware of the danger and could limit the damage through raising their arms or dodging. Also, in the middle of confusing melees or in flight, projectiles coming from behind were especially dangerous because they mostly remained unnoticed and thus offered no opportunities to take countermeasures. For these reasons, next to the face, the back of the head also needed reliable protection, all the more because stones here hit the cranial vault directly. Consequently, the neurocranium of *Homo erectus* presents the strongest bone thickness in the back (Aiello & Dean, 1990).

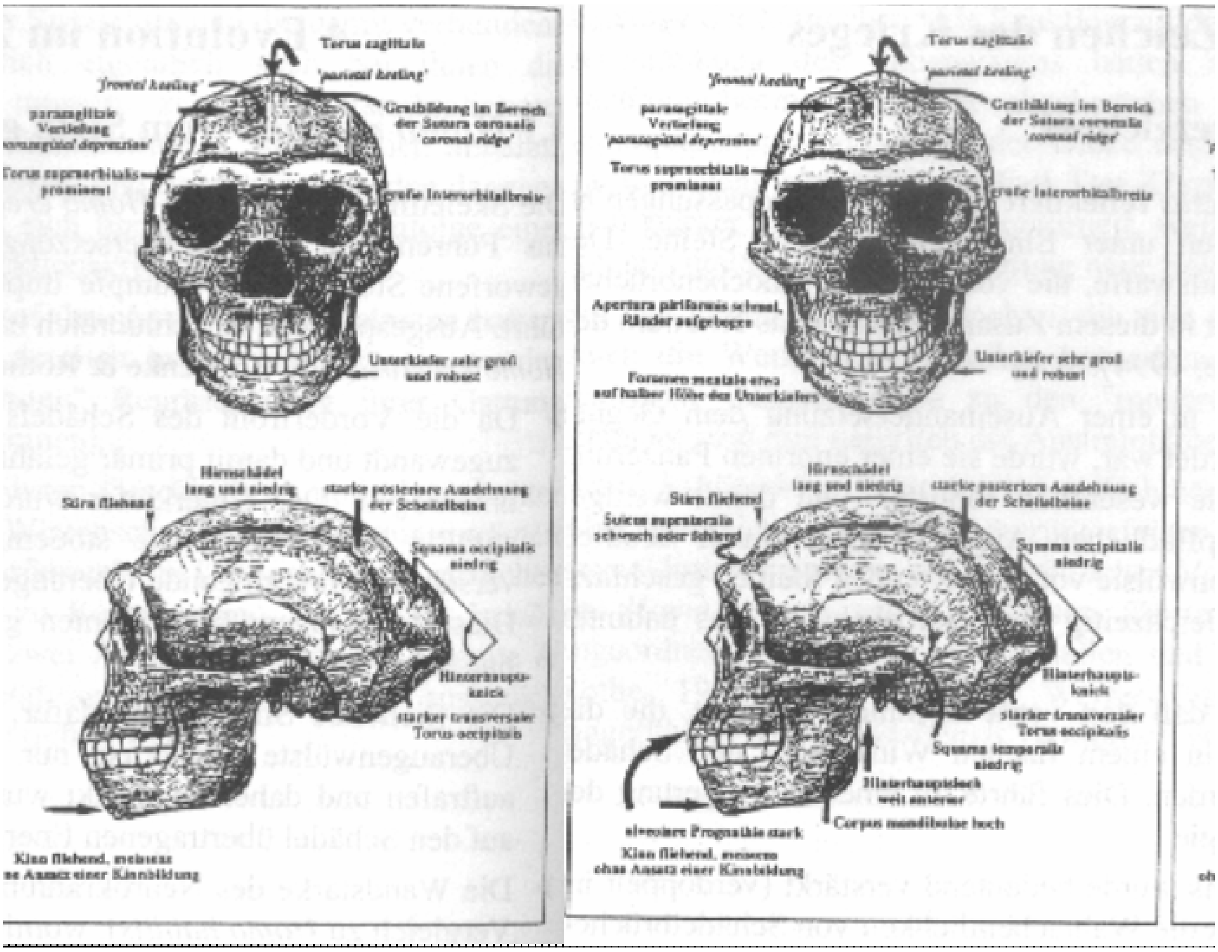


Figure 9: Morphological hallmarks of *Homo erectus* according to Henke & Rothe (left) and those that can be directly explained as adaptations for lowering the risk of injury by stone projectiles (right). (after Henke & Rothe, 1994, modified)

[Translations of German-only labels within the figure:

"große Interorbitalbreite" = large interorbital distance
"Apertura piriformis schmal, Ränder aufgebogen" = narrow piriform aperture, edges bent up
"Foramen mentale etwa auf halber Höhe des Unterkiefers" = mental foramen at about half the height of the mandible
"Unterkiefer sehr groß und robust" = mandible very large and robust
"Sulcus supratoralis schwach oder fehlend" = supratoral sulcus weak or missing
"Stirn fliehend" = receding forehead
"Hirnschädel lang und niedrig" = neurocranium long and low
"starke posteriore Ausdehnung der Scheitelbeine" = strong posterior expansion of the parietal bones
"Squama occipitalis niedrig" = low occipital squama
"Hinterhauptsknick" = main occipital angle
"alveolare Prognathie stark" = strong alveolar prognathism
"Kinn fliehend, meistens ohne Ansatz einer Kinnbildung" = receding chin, usually without a true chin

“Corpus mandibulae hoch” = high mandibular corpus
“Hinterhauptsloch weit anterior” = foramen magnum far anterior
“Squama temporalis niedrig” = low temporal squama
“starker transversaler Torus occipitalis” = strong transverse occipital torus]

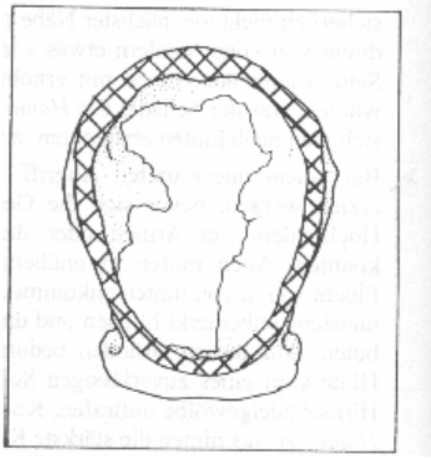


Figure 10: Horizontal cross-section through a *Homo erectus* skull for illustration of the unusual thickness of the skull bones. (after Weidenreich (1943) from Aiello & Dean, 1990, modified.)

The long cylindrical bones of the extremities were also greatly endangered and were enormously strengthened in *Homo erectus*, compared to *Homo habilis*.

In order to explain the enormous robusticity of different parts of the *Homo erectus* body, multiple independent assumptions have thus far been needed. Thus, there are hypotheses that try to explain the robusticity of the skull in part through chewing loads, and other hypotheses that explain the robusticity of the long bones with the demands of locomotion. The CTSW model manages here with one explanation and is thus more parsimonious.
How much the skull shape of *Homo erectus* points to the use of stone projectiles becomes clear when one considers which shape would have made sense in confrontations with clubs (after all, cavemen are popularly presented with huge clubs, especially in caricatures). In a fight involving the use of clubs, a hit can come from any direction and almost always hits the head perpendicularly. In particular, direct blows from above are common. For a confrontation with clubs, the skull should be equally protected from all directions. It should be, where possible, spherical and thick. The oblong skull of *Homo erectus* with its flat cranial roof was, in contrast, as vulnerable to hits from above as a skull that thick can be.

The shape of the *Homo erectus* skull shows clearly primitive features. Marked, protruding brow ridges are thoroughly characteristic of African apes; however, they require explanation [when present] with a substantially enlarged brain. Even in *Australopithecus afarensis* and *Homo habilis*, a raised forehead and a substantial weakening of the brow ridges appeared in parallel with the growth of the brain. In connection with the enlarged brain, it was obvious to combine functionally protection of the eyes – one of the original tasks of the brow ridges – and of the brain. A high forehead could both make room for a larger brain and take on protection of the sensitive eyes. It is a similar situation with the second task of the brow ridges, the reception and transmission of chewing pressures. Franzen says: “The brow ridge is stronger as a bridge construction the wider the arch to be spanned and the stronger the conducted chewing pressure are, and the more the direction of the chewing pressure deviates from that of the pressure-accepting frontal bones. … First because of the strong development of the brain, particularly the forebrain of anatomically modern humans, did the frontal bone reach a steeper, increasingly parallel orientation to the direction of chewing pressure and with it a more mechanically favorable position. Thus, the construction of the brow ridge becomes superfluous and is reduced according with the principle of economy” (Franzen, 1977). The chewing pressures, however, had long since – because of reduced prognathism – already begun to decrease, and also the brain did not just start to grow with modern humans. For *Homo erectus*, with its face already substantially shortened in comparison to apes and its equally substantially enlarged brain, a relatively high forehead would therefore have been quite obvious (as long as one does not consider the throwing adaptations). This concept is first realized, however, by *Homo sapiens*, although a corresponding development had already appeared in the course of the evolution of the gracile australopithecines. This development was taken back with *Homo erectus*, just as though its brain had needed the doubled protection through forehead ridges and thickened neurocranial walls, whereby the former were very massively realized and the latter showed a doubling of the wall strength in comparison to the gracile australopithecines.

The reactivation of old patterns is a process observed repeatedly in evolutionary history and obviously represents a handy medium for evolution. A parallel development of the features introduced above in extensively isolated component populations of *Homo erectus* with similar selection conditions is therefore not to be discounted [lit.: “not to banish from the hand”]. This is interesting inasmuch as the indications multiply that *Homo erectus* may not have been one species only, but rather an entire series of species that developed in parallel across its huge range, which encompassed the better part of the “Old World” (I would, though, prefer to speak of substantially reproductively isolated branches of the same species, since a maximum of 1.8 MY of isolated development presumably were not enough to lead to a demarcation at the species level).

The robusticity of the long bones of *Homo erectus* is also a very obvious reaction to intraspecies confrontations involving the use of stones, and therefore easily conceivable as a parallel development.

There were, however, more and from our point of view even more “important” changes at the transition to *Homo erectus*. After all, **we** have no overly thick skulls, so these could hardly have had too high of an importance to the development of humans – right? (I hope I was able to formulate and present that last sentence such that there is no doubt that it was meant sarcastically.)

The transition to *Homo erectus* came with a substantial enlargement of the brain, and it was likely the first hominid that had completely adapted itself to walking erect. It apparently gave up climbing adaptations in order to optimize the upright gait without any compromise.
The emphasis on terrestrial locomotion by *Homo erectus* can be read from the altered physical proportions. *Homo erectus* was the first uncompromisingly bipedal hominid with proportions that were similar to those of *Homo sapiens*. The labyrinth was also typically human for the first time with *Homo erectus*, in men as well as women.
This certainly points to further weighty changes in behavior. Obviously, the hominids of this line went over to pure terrestriality at the time of the transition to *Homo erectus*.

Before the background of a shift in the meaning of different selective pressures on the development of this line, the CTSW model provides enough explanatory approaches and a new way of viewing this process. The reduction in endangerment by predators and the accompanying increase in endangerment by conspecifics offer, taken by themselves, enough reason for extensive behavioral changes and also for physical transitions. There is, therefore, no justification whatsoever for assuming fundamental changes in the social construction of the groups at that time – an assumption that one frequently encounters – in the CTSW model.

Again, we presumably have here – as with the transition to walking erect – to deal with a series of aspects that drove development in the same direction. This is also not surprising, since fundamental changes in physique always have effects on a whole palette of characteristics, and first the summary effect that cuts to the quick [lit.: “hitting to the beech”] of total fitness decides whether such a change takes place at all.

At the time of the transition to *Homo erectus*, the hominids could certainly afford, on the one hand, to do without the protection of the trees at night as well, since the danger from predators had declined. On the other hand, perhaps it was no longer advisable, in light of the increased danger from conspecifics, to be surprised by them up a tree. A behavioral change by the women could also have accelerated the switch to pure terrestriality.

As the fourth and perhaps most important aspect, there is also the fact that the new physical proportions not only served to improve the upright gait once more, but also completed the physical adaptations to throwing.

The longer and heavier legs of *Homo erectus* did not only improve the upright gait. They serve humans as a counterweight that permits the use of a windup built over the entire body in throwing. *Homo erectus* also already shows the barrel-shaped construction of the thorax, in contrast to the funnel-shaped thoraces of apes and early australopithecines. Perhaps, though, there were intermediate shapes among evolved australopithecines in connection with the incorporation of the upper body rotation around the long axis in the throwing motion that I assume of an earlier time. Fossils can thus far provide, to the best of my knowledge, no information about that.

The capability in throwing was also significantly increased again at the transition to *Homo erectus*. This was, on the one hand, obvious from the background of increasing intraspecific conflicts. In these conflicts, throwers stood against other throwers; both sides had access to the same distance weapon. Range and accuracy thus increased significantly in importance compared to confrontations with carnivores over carrion. On the other hand, throwing adaptations happened at the expense of climbing ability and made favorable the one-sided specialization to life on the ground and the upright gait. This is, as mentioned, only one aspect that must be attended to in this context; however, I propose that it was the most important one.

Supported by the shyness that predators had developed toward them, the hominids presumably also switched over, in the course of the transition from *Homo habilis* to *Homo erectus* (or shortly before), to spending the night in groups on the ground (these behavioral changes could have contributed decisively to the one-sided adaptation to bipedality, but they could also have been a consequence of this adaptation). On the ground, the entire group surely gathered together to overnight together and thus minimize the risk to each individual.

Predators that might risk an attack under cover of darkness were presumably driven off with stones and sticks, whereby at night not only the otherwise usually handy throwing stones were used but also large pieces that were able to cause more damage at close range. The efficiency of distance throws was, of course, limited at night by poor visibility. It is nonetheless entirely conceivable that for evolved throwers, communal defense against nocturnal predators on the ground offered more protection than a retreat into the trees.

How high the danger from, e.g., leopards was at night then is hard to estimate. Possibly, the hominids were avoided by them during the day and hunted by them at night. Recent "man-eaters," which really only appear very rarely, also hide during the day but at night even (without consideration for fire, which is supposed to have provided such great protection against nocturnal predators in the course of human development) enter villages in order to get their victims. Since leopards are primarily active at night and can climb well, they have presented a serious danger to hominids since time immemorial. A community camping place on the ground, possibly surrounded by thickets that could not be crossed noiselessly and thus served as natural "alarm systems," and a large stock of stones presented under these conditions an interesting alternative model for predator avoidance for evolved throwers.

Here, they did not have to flee and thus increase the confidence of the predators, but could instead appear as aggressive and ready to fight as during the day. Under these circumstances, it is to be expected that the predators, with their experiences of the throwers gained over carrion during the day, also avoided confrontation at night.

Baboons also congregate for the night. And they don't do this to share food, but to find collective protection from nocturnal predators in a relatively safe place. Spending the night on the ground could thus have been a new behavioral strategy for limiting losses to predators that first paid off after their entry into the scavenger niche, and thus could not be introduced earlier. In this case, this new strategy would have contributed to the loss of importance of climbing and thus also to one-sided adaptation to terrestriality.

In this scenario, I see a usable and sufficient explanation for the famous stone circle of Olduvai. These collections of stones were interpreted partly as a gathering place and indications of a marked food-sharing society in the hominids of 2 MY ago. It was also presumed that these stones were somehow connected with the first dwellings. On the other side, it was called into doubt that these stone collections were even artificially created (Johanson & Shreeve, 1990). If these stone circles are to be traced back to hominids, then the natural explanation for the use of stones by early hominids, namely, as projectiles, is in my opinion preferable to all others.

It is also conceivable that spending the night in trees had to be given up because the danger arose of being surprised in the trees by enemy neighbors in the morning. The morning, well prepared, surprise attack of an enemy group is a charming scenario for the transitional time from *Homo habilis* to *Homo erectus*. The attackers would choose a full moon night for such an ambush, which because of good visual conditions allowed them to march, relatively safe from nocturnal predators, into the territory of the opponent. They would track down the sleeping trees of the opponent. They would carry over stones in sheer quantity, while the sleeping opponent took no countermeasures whatsoever. And in the early morning, when the opposing group got up to leave the trees, with good visibility, they would carry out a crushing surprise attack without giving the victims a chance to line up or to arm themselves with stones. Groups sleeping on the ground would also have been much better armed against such morning raids by conspecifics. They were in good formation and had a good quantity of projectiles available. They also surely sought out terrain well suited for defense as sleeping sites. Thus, in the CTSW model, a second scenario seems at hand that could explain the transition to sleeping on the ground and the stone circles at Olduvai.

The scenario of the organized morning surprise attack by strange conspecifics I classify today as a variety of the most dangerous anthropocentric pitfalls with which I dealt during the working out of the CTSW model.

With the construction of a new model of hominid evolution, it is always also primarily a case of explaining the singular cognitive capacities of humans. And it is always humans who are trying to find suitable explanations, and they do it with some sense of superiority over animals and on top of a rich cultural background. In the few millennia of human development that we can survey today in the framework of written history, warlike conflicts have played an enormous role. Strategic thought was at a premium; it was glorified and is yet today felt to be the absolute top achievement of the human brain – one need only think of the enormous prestige that chess enjoys in this respect.

Because of this, nothing is easier for a model of hominid evolution that places a high importance on intraspecific conflicts for the course human development in the last 1.8 MY than the assumption of a central importance of strategic thought to the development of the human brain. And just this assumption, in my opinion, is a case of a dangerous anthropocentric trap. Perhaps I find this mental pitfall particularly dangerous only because I fell in myself and had great difficulties freeing myself from it. For a long time, I interpreted the last 1.8 MY of human development primarily as a sort of bloody chess game that drove brain development onward. Therein, I saw the best explanation for the growth of the brain observed in this timeframe. And the development of language could also be explained thus, since communication has a high value for strategic planning. As we have not yet collected enough information at this point to show the way out of this pitfall, or even to unmask it, I will first of all limit myself to warning against it. Why strategic thought played, in my opinion, no role in human brain evolution I will present later in detail.

This does not now mean that intraspecific confrontations played no role in the growth of the brain – quite the opposite. In it, though, strategic thought did not stand in the foreground, but rather throwing.

It also certainly does not mean that intraspecies confrontations played no role in the transition to pure terrestriality. I have already pointed out that the completion of the physical throwing adaptations at the transition to *Homo erectus* should have led to a limitation of climbing abilities and thus surely – possibly decisively – contributed to the transition to pure terrestriality. In view of the growing intraspecific conflicts, though, the ground would also have been the better place to be during the day. Fleeing up a tree would have made no sense in conflicts with conspecifics. On the contrary – the trees became traps. Up a tree, one finds no stones. Throwing stones brought along or deposited in advance was hindered, since freedom of movement is limited in a tree. The same goes for attempts to dodge thrown stones. Since trees don't grow all the way up into the heavens, they also offered no opportunity for flight – at least not for an ape that had already had to make substantial concessions to the demands of bipedal locomotion in the preceding millions of years. As they were always dealing with conspecifics, their pursuers could climb just as well anyway and follow them into the tree, if they didn't prefer to limit themselves to throwing. In order to flee, one would have had to get back to the ground first, and exactly there was one awaited.

Rescue from conspecifics was thus not to be found in trees, but in rapid, enduring flight on the ground. Quick and enduring runners had the advantage in being able to get away from enemy overpowering through flight. A conceivable consequence in this context would also be the replacement of the pelt with skin thickly covered in sweat pores (I do not, however, wish to commit to the idea that this actually already occurred with early *Homo erectus*; I will yet come to speak of an alternative scenario).

If the head hair was not only retained but in fact increased at the time, even though the growing brain was presenting problems with cooling through its enormous energy usage just then, this can be explained in that the protection of hair was more necessary for the head than ever before. While the long bones of the extremities were protected from direct impacts of stones through the muscles surrounding them, only the scalp and hair lay between the skull bones and potential bashing points, and under the skull bones [lay] the brain, whose protection from injuries naturally had the highest priority. Under these circumstances, every head hair was needed to limit damage to the impact-sensitive brain. Humans today demonstrate the hairiest heads of all the primates; if the hair is not cut, it reaches on average a length of one meter.

Of course, bare skin and long head hair need not have developed simultaneously. Perhaps early *Homo erectus* retained the pelt, but also developed the long head hair as additional protection for the brain.

Scavenging and the conduct of war were surely "men's work," and this would also have precipitated men being much better throwers than women. This does not mean, though, that the changes in the transition to *Homo erectus* passed the females by – on the contrary, the changes in the females in consequence of the new selective conditions were even more dramatic than those in the males.

In the australopithecine females, climbing characteristics were always more strongly emphasized than in the males. With the transition to pure terrestriality, the females thus changed dramatically. And the question presents itself whether this was not entirely in their interest, and to what degree this could have accelerated the transition.

The behavior of chimpanzees shows us clearly enough that females could have been favored targets in intraspecies conflicts. It is thus quite easily conceivable that it was better for them, in the face of increasing territorial conflicts, to avoid the trees.

On the other hand, it could also be that they had a concrete chance to move about on the ground in an easy-going way because of the decreasing danger from predators, and that they used this chance. Defense against predators was by far no longer as dangerous as it had been at the beginning of australopithecine evolution, since the predators meanwhile showed proper respect to the evolved throwers. Perhaps the females thus got the chance to cover larger stretches on the ground without protection from males – even in open country – on the search for food. If they changed their behavior accordingly in order to gain advantages in their search for food on the ground, then the selection criteria on them would consequently have shifted toward stronger emphasis on throwing qualities, and this again could have accelerated substantially the transition of the entire developmental line to pure terrestriality.

The whole thing becomes even more complicated when one also considers the children. On the one hand, children could have begun much earlier to prepare for their throwing careers through intensive practice if they spent time on the ground with their mothers more often and longer. Thus, the transition of the females to pure terrestriality could even have been a prerequisite for further improvement of throwing abilities, which again was an advantage in territorial conflicts. On the other hand, this transition of the females to pure terrestriality could also have been a prerequisite for doing without fur, since this may previously have been needed so that the little ones could hold tight to their mothers in the trees.

Whether the females thus left the trees by their “own will” or under pressure from warlike conflicts, throwing adaptations were also consequently more strongly emphasized in them, at the expense of climbing adaptations. Their adaptive pattern became equivalent overall to that of the males; they also became terrestrial throwers, even if the throwing adaptations were not so uncompromisingly assimilated as in the males. This was because the application with the highest demands on the thrower, namely, the conduct of war, remained a purely male thing in any case; women up into the present have been left primarily with the role of victim – a role that they share with female common chimpanzees. Since women were equally terrestrial throwers from then on, the extreme sexual dimorphism disappeared with the transition to *Homo erectus*. The body size difference between the sexes in *Homo erectus* corresponded to that of *Homo sapiens* and *Pan troglodytes*, which can be taken as a further indication that their social structure did in fact correspond to that of the chimpanzees.

Supported by the shyness of predators, *Homo erectus* women could thus presumably occupy themselves with the search for food throughout the whole territory without male protection, just like *Pan troglodytes* females. Since this is hardly so easily conceivable of the australopithecines, it is quite possible that the social structure of the australopithecines deviated somewhat from that of chimpanzees, and that *Homo erectus* first returned to a chimplike group structure. I propose, however, that at least the gracile australopithecines, in their relatively forested territories, still got along quite well with the multi-male group structure of the common chimpanzee. This group structure offers some room for adaptations that are necessary for life in the savannah. Thus, chimpanzees as well as baboons use the so-called fission-fusion principle. The members of a group can appear, according to the demands of the present situation, in a closed band as well as in small groups – down to single animals. The division into small groups primarily offers advantages in the utilization of widely scattered food. If, on the other hand, there is occasionally enough food for everyone in one place, then it is advisable for all to congregate there. Also, in situations of danger, a larger group naturally offers more protection. The use of this fission-fusion principle should have been obvious for the australopithecines.

How the smallest conceivable partial group of australopithecines looked presumably depended on whether there were enough forest islands in their territory in which females could set about the search for food alone with their children and without male protection, as is usual for chimpanzees. For the robust australopithecines in their drier habitats, there were presumably fewer of these forest islands, so that among them the females would have gone about more seldom, if at all, without male protection. When baboons spread out across the land, then in every small group there is always an adult male, the pasha. Whether a similar group structure would have been sensible for robust australopithecines is difficult to say. A single adult male may have been insufficient to protect a “family.” Throwers are especially strong fighters primarily in groups. A single thrower uses up his stockpile of projectiles very quickly and is then relatively defenseless.

Since the requirements of the social structure of australopithecines were strongly influenced by their special adaptation, we do not have access today to a primate model that would permit us reliable conclusions about the organization of the australopithecines. This is particularly true for the robust australopithecines, which were especially strongly specialized and thus also differed especially strongly from their chimpanzee cousins.

This behaves differently for *Homo erectus*, since for it the danger from predators decreased greatly, such that similar requirements were placed on it as on chimpanzees. In the CTSW model of hominid evolution, the shyness of predators to people during the daytime obviously cannot be traced back to fire or some other cultural innovation for which no one knows when it was introduced. Human dominance is based much more on the use of thrown stones in confrontations over carrion and can be followed back in time to around 2 MY ago. Thus, it is to be expected that *Homo erectus* women could move through the landscape without male protection just as well as *Homo sapiens* women in recent hunter-gatherer groups, to whom even today no more advanced weapons are typically available.

The above scenarios, which could explain the dramatic changes of our ancestors at the transition to *Homo erectus*, all fit into an overall scheme:

Spending time on the ground was, at the time of the transition from *Homo habilis* to *Homo erectus*, by far no longer so dangerous, since the predators had responded to generations of high losses in confrontations over carrion by switching to instinctive avoidance of the aggressive stone throwers. Meanwhile, the intraspecific conflicts of our ancestors at the cusp of *Homo erectus* presumably led to them becoming conclusively terrestrial. With decreasing danger from predators and simultaneously increasing danger from conspecifics, the climbing thrower quickly stepped into the background and the uncompromising thrower, which was now also a warrior, entered the stage – *Australopithecus* was replaced by *Homo*. The physical proportions and the body size are thus to be seen on the one hand as final adaptations to bipedality, and on the other hand as [final adaptations] to stone throwing. The significant enlargement of the brain at the transition to *Homo erectus* had already indicated the direction in which intraspecific confrontations would drive further development. In contrast to physique, in which the optimal size and proportions for throwing were quickly reached, there was no comparable optimum for the brain. Its performance increases were in principle unbounded – an increase in brain capacity could continuously effect further increases in performance at planning and steering throws, a condition that resulted in a long-lasting "arms race" in the area of brain evolution.

Just 2 MY ago, a revaluation of selective criteria took place in a short time that could hardly be imagined to be more far-reaching.

Of course, I present with mixed feelings these arguments for making a delineation at the generic level at this point. We have here another case in which the use of the vocabulary of a Systema Naturae for the description of an evolutionary scenario is insufficient. In the human developmental line, nothing occurred 2.0-1.8 MY ago that would justify a differentiation of ancestors and descendants at the species, let alone genus, level, as long as one remains true to the logical construction of an evolutionary scenario.

If one nonetheless insists on describing the occurrence with the vocabulary of the Systema Naturae, then one is required to draw an arbitrary border somewhere, and with use of retrospect, one does find a suitable place for it. From the point of view of the CTSW model of hominid evolution, decisive boundaries for the future development of the human developmental line were placed ca. 2.0-1.8 MY ago, with the raised importance of intraspecific confrontations. Such a placement of boundaries seems meaningful enough to undertake a delineation on the generic level, if at all, at this point. This only seems plausible to us, however, because we ourselves stand at the end of this development and know to where it led. This knowledge, however, has not lost anything in an evolutionary scenario concerned with what happened 2 MY ago for reasons important at that time.

The achievements of *Homo habilis* presented downright classic conditions for an adaptive radiation. A generalist able to expand its nutritional base and its habitat so dramatically (into East Asia) because of new advanced developments should then in short order found multiple, more strongly specialized developmental lines.

The fossil record seems, however, to speak another language – at least it has long been interpreted otherwise. *Homo habilis* was certainly quite dramatically replaced by *Homo erectus*, but that [species] showed an almost unbelievable constancy of its characteristic features across its entire huge habitat and over a period of nearly 1.5 MY, although its brain volume did grow from ca. 800 cc to ca. 1200 cc. This is even more astonishing when one takes into consideration the intensive intraspecific conflicts. *Homo erectus* was presumably expressly territorial. It was anything but a nomadic hunter that followed large herds over long distances. Genetic exchange probably took place primarily through women changing groups, who certainly did not set out alone on long travels but rather at most switched to the neighboring group after making secret contact with a man of that group. The exchange of genes over long distances was thus probably very weakly expressed. In light of its immense range, *Homo erectus* really ought to have split up into multiple branches.

For its unusual developmental pattern, however, there is an easy explanation. Precisely those characteristics that are given as characteristic for *Homo erectus*, I hold for the clearest evidence for the throwing hypothesis. They can be interpreted as adaptations to intraspecific conflicts involving preferential use of stone projectiles.

These confrontations are to be seen as consequences of the scavenging of *Homo habilis* and the common inheritance of all *Homo erectus* populations, and they also present a suitable explanation for the rapid growth of the brain. Aforesaid physical characteristics are additional obvious adaptations of the hominid physique to the new requirements. For this reason, these characteristics are not suitable for determining kin relationships among the individual populations of *Homo erectus*. They can easily be the result of parallel evolution. And this is not only true for the origin of *Homo erectus* or of the [plural] species (as already mentioned several times, I would personally prefer to speak of local, reproductively isolated populations) that would occupy its place in the future, but for the entire length of its appearance.

Characteristics that can be interpreted as obvious adaptations for confrontations involving the use of stones should in future be bracketed out in order to determine, from the features left over, kinships and regional adaptations of *Homo erectus* populations. I assume that *Homo erectus* will then be split up into multiple species, and the expected pattern of adaptive radiation will come into view. That the finds attributed to *Homo erectus* could represent more than one species has been expressed many times anyway (Henke & Rothe, 1994). And most recently, the indications are multiplying that *Homo erectus* was not just one species, but rather at least two, the African *Homo ergaster* and the true, Asian *Homo erectus* (Tattersall, 1997). It would not astonish me if this were only the beginning of the development at whose end as many as a dozen human species will be named for different regions and time sections of the last 2 MY. I expect the greatest multitude for the time 70,000 years ago, shortly before the triumph of *Homo sapiens*, which brought this plurality to an abrupt end.

An interesting question is to what extent the enlarged range of *Homo habilis* promoted renunciation of climbing adaptations and the transition to *Homo erectus*.

I assume that the altered selective conditions resulting from increasing territorial conflicts would have led to the development of *Homo erectus* in the original range of *Homo habilis* in any case.

It is, however, possible that it no longer came to this because the transfer to new settlement areas went faster.

In Africa, *Homo habilis* was not the only thrower. The robust australopithecines first died out ca. one million years ago and possibly represented the better model for dry habitats within Africa up until then. They could thus have been a hindrance to the settlement of this type of habitat within Africa.

The settlement of such open habitats would surely have contributed to the transition of *Homo habilis* to full adaptation to bipedality, since climbing plays a limited role in such habitats, at least for nutrition. The robust australopithecines presumably never left Africa. Therefore, it may have been possible for *Homo habilis* to advance out of Africa into the sort of habitat that remained reserved to the robust australopithecines in Africa. In such habitats, the transition to *Homo erectus* may then have gone faster (a development in the direction of robust australopithecines would, after entry into the scavenging niche, surely have made no sense). An enormous advantage in the area of war, arising through the transition to *Homo erectus*, may then have led to the replacement of all remaining populations of *Homo habilis*.

We will yet see that I hold an enormous advantage in the area of war responsible for the surpassing success of *Homo sapiens* (more precisely put, the descendants of a small group that belonged to *Homo sapiens*) almost two million years later. Something similar may have happened often – at least locally –in the last 2 MY; this seems obvious because of the human-specific, high importance of warlike conflicts.

This is – and I especially want to point this out – extensive speculation. Here slumber interesting lines of questioning, which become current should the CTSW model otherwise prove its worth. An interesting alternative approach consists in that the transition to *Homo erectus* could have occurred in parallel, in a variation of the multiregional model of the development of *Homo sapiens*, although I would not place genetic exchange between populations over great distances as a basis. That the multiregional model has proven false for *Homo sapiens* says nothing about *Homo erectus*. This is a much better candidate for the multiregional model, since its most prominent characteristics were obviously dictated for millions of years by selection conditions equally active everywhere. Very impressive in comparison to that is the substantial variability that *Homo sapiens sapiens* has developed in the last 0.07 MY.

We touch here upon a philosophically very ticklish aspect of human evolution. The question here is how far the development of humans was “inevitable,” “foreseeable,” or “coincidental.” Detail questions that are relatively unimportant to an evolutionary scenario and invite lively speculation are associated here with philosophical terms grown out of cultural evolution, which count as central, pivotal points of rival paradigms. Now, I have had to correct my own paradigm many times during work on this book and have no fear of touching it. I will thus present my speculations.

From the towering importance to which intraspecific confrontations in the evolution of humans are entitled, some assumptions about the basic course of human evolution can be derived:

- Deep-seated animosity and the availability of a distance weapon surely hindered the exchange of genes between the groups. We will yet see that this had major influence on the development of human sexuality. On the other hand, the range covered by the genus *Homo* underwent a tremendous expansion from the start. Consequently, it presumably came repeatedly to the creation of local subspecies.
- The appearance of multiple reproductively isolated populations (an indispensable prerequisite for the formation of multiple different species) could only be preliminary in character. One of the hypothetical isolated populations would inevitably achieve a developmental advance and, depending on the situation, either crowd out the others or exterminate them in the truest sense of the word.
- Depending on the conditions of the habitat at the time, the selective pressure due to intraspecific conflicts was differentially strong. In habitats with difficult living conditions, the birth excess was slimmer, and thus also the importance of intraspecific conflicts to the evolutionary process.
- In light of *Homo erectus*'s very extensive area of occupation, stretching over many different habitats, it is to be expected that a series of developmental centers with particularly favorable living conditions always existed. The characteristics whose development was forced in such centers primarily raised the fighting efficiency of the corresponding populations. They were thus not only regionally but also globally significant and were surely exported to the peripheral zones of slower development.

This export could occur in two ways. On the one hand through normal, ongoing, symmetrical gene flow through exchange of women by neighboring groups; on the other hand, through waves of conquest. With the latter, it was less a matter of crosses with the "natives" than of their suppression. All fathers and a preponderance of the mothers of the following generation belonged to the presently conquering group. In extreme cases, no offspring at all of the "natives" made it into the next generation – this presumably happened with the expansion of our ancestors 70,000 – 30,000 years ago on a global scale. With further waves of conquest in the last 2 MY, a regional or even continental scale is to be reckoned with. I presume, however, that there was only ever one replacement wave as radical as that of *Homo sapiens*. It was presumably – as we will yet see – the result of grave behavioral changes. For other changes of such moment, the CTSW model in its present form offers no room.

It is frequently assumed that difficult environmental conditions drove the development of humans – ice-age climatic fluctuations are to have delivered the decisive impetus for the development of our cognitive abilities.

I would therefore like to point out that the CTSW model does not assume the centers of human development in the regions of highest environmental demands, but on the contrary, in the regions with the lowest demands and the highest birth surplus. Such were presumably to be found right in Africa, the original homeland of the hominids. Repeated waves of expansion that had their origins in Africa are therefore unsurprising.

The complete adaptation of *Homo erectus* to throwing represents a core statement of my hypothesis. From this arises an opportunity to falsify the stone thrower hypothesis. Modern experiences from the field of engineering sciences give us – at least in principle – a means in hand to test whether the physical proportions of *Homo erectus* or those of *Homo sapiens* present a more optimal solution to the task of making as good a thrower as possible out of an ape.

With the methods of multiple-body system analysis, one can make a model of the human body and investigate whether a further improvement of throwing performance is possible through altered physical proportions. If not, then the human proportions represent at least a local optimum for the solution of this task, and that is exactly what evolution is able to achieve and what I expect from such a calculation.

To be exact, I would reject every differently-indicating result of such an investigation, since in sports it is now shown clearly enough that men with ordinary proportions make the best throwers. Should a simulation indicate other results, I would first look for errors in the simulation (seen thus, there is no "real" chance to falsify the throwing hypothesis here; it would then be that it contains an error of which I presently haven't the slightest inkling but which one would discover through the collection of further data). Nonetheless, such an investigation would be very informative for several reasons.

It would be very interesting to see what physical proportions a thrower using only a portion of the course of motion we find in humans should have. Starting with chimpanzees, one should be able to make predictions about the physique of the australopithecines – primarily the males.

The use of multiple body system analysis to test the throwing hypothesis represents a challenge to [do] thorough, scientific work. The task must be carried out with much circumspection in the model construction on the one hand and in the choice of a suitable reductive function [lit.: "punitive function"] for the optimization calculations on the other hand. Yet I am convinced that, next to the confirmation of my hypothesis that I hope for, large gains in the understanding of our anatomy – and that of the australopithecines – will grow from the determinations of the calculation of the forces and moments produced in the body during throwing. Perhaps here, for example, a deeper understanding of the anatomy of the human shoulder could be gained.

Another prediction of the CTSW model can, on the other hand, doubtless be tested with the methods of modern engineering science – the prediction that the skull shape of *Homo erectus* substantially decreased the probability of injury by stone projectiles in the course of a confrontation.

4.2 Training a thrower

Stone throwing has, according to my hypothesis, played a central role in the survival strategies of the hominids for no less than four million years. This should be reflected in the ontogeny (individual development) of humans. In this time, the games of children, as in all mammals with strongly developed play instincts, were also an important preparation for the mastery of the tasks appearing in adult life. Consequently, tendencies should be visible in the play behavior of children that reflect the origins of humankind, since each lesson takes place based on a phylogenetically acquired learning mechanism (Grammer, 1995).

Since throwing in itself surely represented the most important hominid skill and into the bargain a skill that, next to physical and mental adaptations, also required thorough practice, everything that has to do with throwing or aiming should seem like fun to children, and not just to them. The list of games that meet these requirements is long. All ball games, for example, hinge on placing the ball somewhere, be it in a space, a goal, a net, a hole, or on the body of an opponent. One need only think of the joy that a strike in bowling can cause.

The scenario that comes closest to our origins is of course offered by the snowball fight, in which one can observe all conceivable stone-thrower strategies, without the members of the participating groups meeting for long discussions about them. Snowball fights reflect the nature of conflicts at the time of *Homo erectus*. They include the laying in of reserves with piled up stocks of projectiles, rapid flight in the case of inferiority, [and] dodging incoming projectiles, or at least protecting especially sensitive body parts through turning of the pelvis or a forearm held in front of the head. Additionally, the origins of our grip are impressively demonstrated in snowball fights. The hands, whose form was optimized in order to direct handy throwing stones, serve here as forms with which objects (snowballs) are produced with a geometry that fits exactly to the hands.

These games are, of course, a singled-out aspect of human behavior and not of much value as evidence for an evolutionary hypothesis. I mention them here only because the CTSW model would not be very plausible if such games were not popular today. The following cognotheoretical observations offer somewhat more:

- Babies have an inborn protective reflex. Already at two weeks, they interpret a stationary but enlarging black spot on a projection screen as an object that is moving directly toward them, and they try to protect themselves from the hit: “As a defensive action, it lifts an arm for its face, turns aside, and blinks. An asymmetrically expanding spot causes no defensive reaction; it is interpreted as passing by” (Eibl-Eibesfeldt, 1995).

- Doreen Kimura and Diane Lunn have determined that three-year-old boys can already throw with better aim than girls, independent of quantity of practice (Kimura, 1992).
- Small children go through a phase in which they throw everything away from themselves, and this activity can also have as its result, aside from the devastation of the child’s room, an enormous satisfaction to the agitated child. It belongs among the tasks of childrearing today to break children of such habits. In modern large societies, throwing is not only no longer adaptive, but to a large extent counterproductive. All humans submit to societal demands; uninhibited power displays are damaging against this background because they could destabilize the society.
- Small children don’t box. The typical aggressive behavior for small children is in fact hitting, but they do it through carrying out a throwing motion, only that at the moment in which the stone should actually be released, the person to be hit is struck.

Boxing, though, is a more effective hitting technique, since in this case one not only can transfer the impulse contained in the arm but also can use the substantially heavier body as a supporting mass. Additionally, the opponent is warned early by an extensive windup motion and can introduce defensive measures. One can of course object that the guiding of a club is responsible for the hitting techniques of small children. That is contradicted, however, in that the strikes are carried out with an open hand; the palm is oriented toward the opponent – that is the hand position in throwing.

Irenäus Eibl-Eibesfeldt presents in his works interesting illustrations of primitive peoples, wherein what he calls the “hitting threat” is also documented among children of different peoples – it is clearly not a case of hitting but of a throwing motion in the direction of the threatened person. One can differentiate these movements quite well from each other once one has sharpened the eye for it.

In throwing, one often goes into the windup-cross position in order to enlarge the acceleration stretch. Therein, the forward body parts are stretched and opened; it is hardly to be assumed that “hitting threats” that show such a body position originate with a behavior appearing in close combat, since in close combat one must be intent on defense and minimizes the frontal face of the body as much as possible. In popular language usage, the connections are rendered better, since one would call the gesture named "hitting threat" by Eibl-Eibesfeldt a "throwing away hand motion."

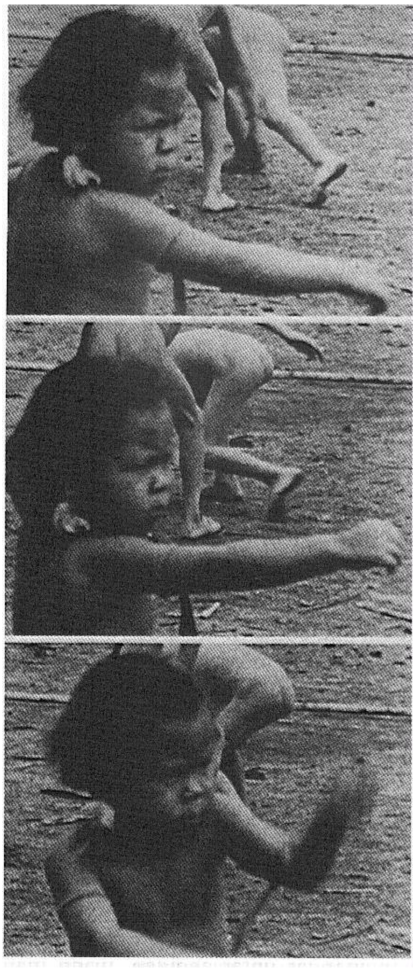
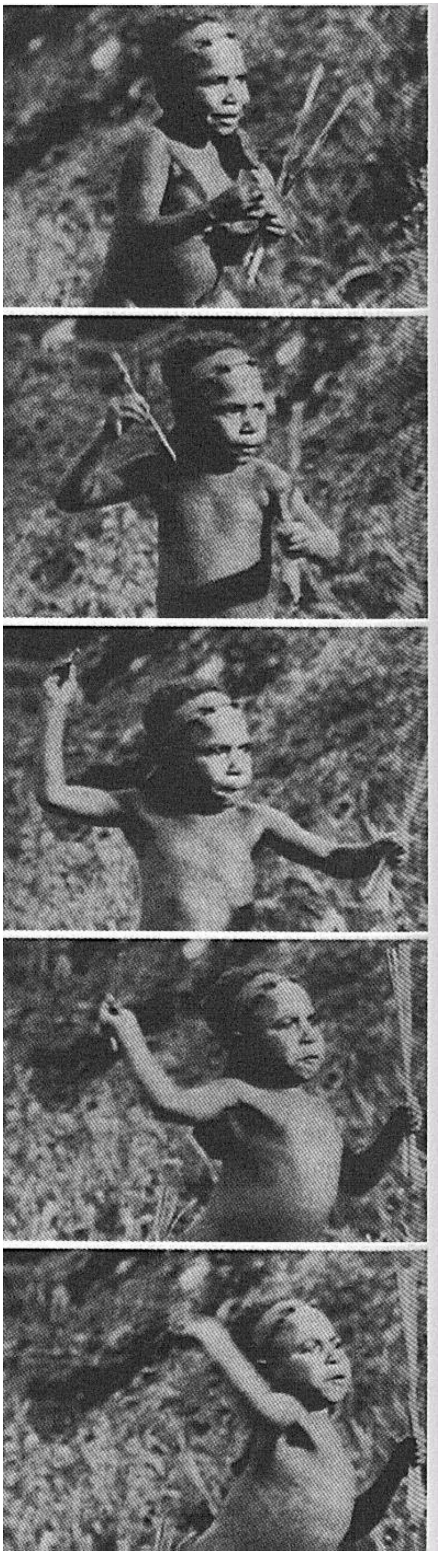


Figure 11 (left): A hitting threat, carried out by the left hand

Figure 12 (right): Eipo boy playing with grass arrows, whereby it is a clear case of a throwing motion (pictures from Eibl-Eibesfeldt, 1995)



To this interpretation, Eibl-Eibesfeldt's commentary to the following picture also fits. He writes: "Children hit and threaten each other with objects, also. Cudgels that could injure the opponent, though, are mostly used just for threats. One also throws them in the direction of the other, but then badly aimed, in an obvious effort to prevent damage" (Eibl-Eibesfeldt, 1995).

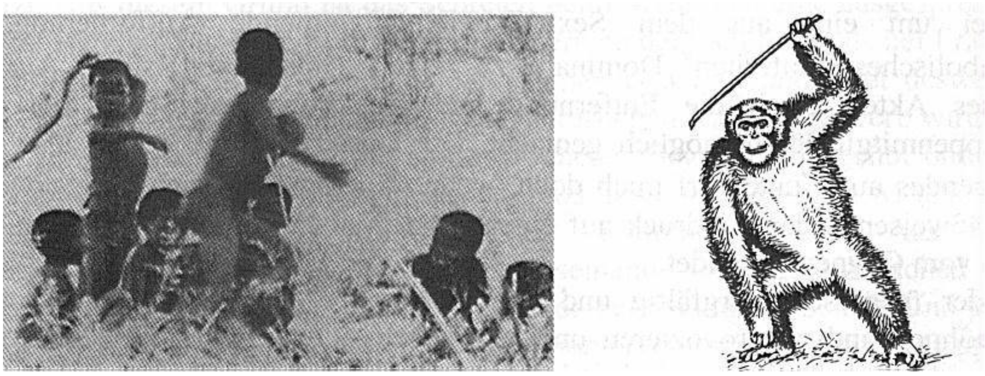


Figure 13: Contrast of “hitting threats” by human and chimpanzee, after Eibl-Eibesfeldt. Although the similarity is apparent, I believe that one thoroughly recognizes that the boy has raised his arm for a throw and the chimpanzee for a strike.

Many conflicts involving the use of stones in humans surely had the character of power displays. This is exactly like the chimpanzees, and is particularly always to be expected when two similarly strong groups have taken up positions opposite each other.

The groups presumably posted themselves just outside throwing range and presented some kind of spectacle in order to humiliate and provoke the other side. Individual young men could thus prove their courage – and thus seek to stand out within their own groups – in that they charged forward briefly and threw a stone at the opponents. The risk of such an action was, in light of the distance at the edge of the range, thoroughly calculable, and it was not at all improbable to hit someone from the other group, since with the charge a whole row of opponents came into throwing range.

Such advances were suited to animate the opponents to throw, also. Should they forget themselves and sling across a multitude of stones in reply, that could result in a tactical advantage through the reduction of the opposing munitions stockpile. The risk for the ones thrown at was low especially when they promptly began to retreat, or were very skilled at dodging. And even in the case of a single hit, the danger of a life-threatening injury was low at extreme throwing ranges, more so because the head was surely protected by a raised arm.

On the other side, the opponents really should not allow themselves to waste their stones at extreme throwing distances. If one still wanted to lead them to this, then one would have to manage some things. Another possibility for leading them to throw consisted in provoking them with unmistakable gestures. Herein could lie the original function of the widespread, provocative display of the buttocks by humans. Mooning is suitable in many respects for the provocation of an opponent armed with stones. This sign is easily identified from large distances and the mockery it entails is obvious. It is a case of an invitation originating from the sexual area, of showing dominance through symbolic "mating." At the same time, carrying out this act is made impossible through the distance and the threatening stones of one's own group members. Mooning thus expresses roughly the following: "go ahead, subjugate me if you can." At the same time, the one showing his buttocks gives the impression of being unprepared for an attack, since he has turned away from his opponent.

Children practice all methods for ridiculing and provoking an opponent very conscientiously and happily, and they gladly seek out opponents for this that are vastly superior to them, but from whom they can assume that they could block a serious attack promptly through appeasing behavior. A child that provokes someone to an attack with a gesture or with slanderous words, only to withdraw immediately through flight, is a very normal, constantly repeated picture. This play pattern first makes sense when the behavior practiced therein can be applied sensibly to "real life." Why, though, should one provoke a real attack by a dangerous opponent on the one hand, but on the other hand withdraw from it? The opportunity to disarm an opponent with a calculated risk to one's own person presents, from the point of view of the throwing hypothesis, a sensible application for this course of action.

If a child is then actually hit and the situation becomes too threatening, it starts to cry, whereupon the behavior of its playmates immediately switches from aggression to devotion. Crying prompts assistance in humans and simultaneously serves as a sign of submission, with which further attacks in conflicts with fellow group members can be prevented. It thus has a similar function to, for instance, the presentation of the jugular vein in wolves. The lower-ranking wolf thus clearly puts himself at the mercy of the higher-ranking one, and in a way in which deception is hardly possible. This then makes it possible for the higher-ranking one to approach the lower-ranking one with little risk to itself and to be appeased. Here, the functionality of crying becomes clear. The natural armament of humans is the visually controlled stone projectile. Tears in the eyes hinder clear perception of the surroundings and are a handicap in throwing. The one who submits becomes unequivocally more helpless and puts himself at the mercy of the higher-ranking person in such a way that deception is truly difficult. Seen thus, the saying is true that tears don't lie. Sobbing has a similar effect. The uncontrollable shaking that runs through the body presents a substantial handicap in the carrying out of a complex, finely determined whole-body movement – it thus hinders throwing and decreases significantly the fighting ability of the sobbing person.

Aside from stones, the voice was also applied in driving away competitors over food, and surely earlier against predators also. For this reason, screaming is a markedly aggressive action for humans, and the voice of men is so clearly deeper than that of women. A deep voice is associated with a large body and therefore instills respect. As an important tool for the natural acquisition of food, screaming is practiced by human children with exceptional enthusiasm, and is often suppressed when possible by modern parents as an aggressive, uncivilized act. That driving off predators from carrion and power displays in the course of confrontations between groups represent related activities was already addressed. And so, it is only obvious to find screaming again as a part of power displays of groups of *Homo sapiens sapiens* – raucously shouting soccer fans are a good example. (The flying beer cans and bottles appearing in this context could be chalked up as further indications for the throwing hypothesis.)

A very sensible human adaptation is the change of voice; it is presumably a part of the feat [lit.: “the splits”] that our ancestors had to complete in order to achieve stable social associations while they developed into the most aggressive of all primates.

Of course, children must learn their future “craft” and practice for it thoroughly, in particular when the first serious situation could very easily end fatally. This means for boys in particular that they should throw and scream a lot and otherwise – even during “school time” within the group – behave aggressively. This is only tolerable for adult group members, though, if they really do not experience the children as threatening.

The delay in growth before puberty, which lasts longer in boys than in girls, and the change of voice in which the timbre of boys’ voices sinks by an entire octave, can thus be interpreted as typical throwing adaptations. The timbre of girls’ voices sinks in the course of puberty as well, but not nearly as much as in boys.

Puberty itself became the most difficult developmental stage for boys in the course of hominid evolution. Before puberty, they enjoyed free horseplay and could behave as wildly as they wished, which they used in order to learn their future “craft” thoroughly. Afterwards, they had to fit themselves into the rank order of the adult men and had to count on bad consequences from higher-ranking [males] for the same behavior within the group. Before, they had the physiques and voices of children, which were not taken seriously by adult males as competitors; afterwards, they had to join the men's society and bring along the physical requirements for that. In puberty, this metamorphosis had to take place under the eyes of the mistrustful men, such that the boy was first seen by the other men as a serious competitor as late and as well equipped as possible.

In puberty, boys shoot up in height. They also develop the broad shoulders important for throwing. So that the men are not called to the scene too quickly by these developments, they often come with the transitional development of a girlish breast, which makes the boys' status somewhat ambiguous. The course of the change of voice is also a sensible adaptation. During the change of voice, one simply cannot take the boys seriously, since such a cracking voice does not seem threatening. At the end, however, stands the fully developed, deeper man-voice.

It is often pointed out that boys are made very insecure by the quick transitions of puberty. The girlish breasts, the change of voice, the awkward body whose movements are hard to coordinate, cause them trouble. This is also probably adaptive for a thrower. The boys must revise their self-images sharply downward, since upon entry into men's society, they must first be submissive. In many societies, there are interesting cultural parallels to this process. Boys are humiliated through initiation rituals in their introduction to the men's society, in order to drive out their childish overconfidence. Modern armies also avail themselves of similar methods. They "break" the recruits, in order subsequently to form them into soldiers of a strongly hierarchically constructed fighting force.

Our psyche is adapted to play the role of a markedly dangerous opponent against predators – even when we are no longer aware of our strength because of the domestication that took place. This is, for instance, impressively demonstrated by "whistling in the dark" [lit.: "whistling in the woods"]. If a defenseless animal feels threatened in confusing territory, then it will do anything not to be noticed. It will hold still and use all its senses to determine whether an enemy is really nearby. An exceptionally well-defended animal, like for example a poisonous snake, will in contrast be intent upon being noticed. For it, a confrontation that could always lead to injuries is most threatening primarily when another animal comes too close without noticing it. Anyone that recognizes it promptly acts without further prompting to avoid coming too near. Fight-ready animals are therefore often exceptionally striking. They bring attention to themselves through warning colors or noises – for a defenseless animal, such a thing only comes into question when it can deceive its opponents through mimicry, such as flies that imitate wasps in appearance.

That humans can calm themselves in a situation perceived as threatening by announcing their positions aloud (through the proverbial “whistling in the dark”) clearly indicates the dangerousness of humans and is typically understood as such by other animals whose ancestors had to put up with the evolution of humans. Perhaps the reason for an aggravation with which many humans – primarily men – are troubled is also to be found here. Snoring ensures that sleeping humans are promptly perceived, so that nocturnal predators can avoid a potentially dangerous confrontation from the start. In light of the widespread nature of snoring, which can also come with health disadvantages, it is to be expected that it originally had a function. That primarily the fighting-ready men put out a warning is obvious.

4.3 Evolution and war

The transition to *Homo erectus* marks within the CTSW model not just an elemental change in the weighting of selection criteria effective in evolution. From here on, statements pile up which fundamentally contradict current views about human evolution. This seems contradictory at first glance, inasmuch as the CTSW model originally grew up around the throwing hypothesis. As this comes to grips with the throwing adaptations, one should expect the greatest influence upon the understanding of human evolution for that timeframe in which the throwing adaptations were developed, i.e., for the time before *Homo erectus*. The transition to *Homo erectus* already marks the conclusion (at least physically) of the adaptations to throwing.

Just that early *Homo erectus*, however, presents itself very differently in the CTSW model, as a product of a multiple-MY throwing evolution, than in current evolutionary scenarios. Therein lies for further considerations a new, clearly altered ancestor model. Thus, the introduction of this new ancestor model – and this insight surprised me, too – is justified, without having to refer back to the throwing hypothesis. It is again time to take our bearings within the CTSW model of hominid evolution.

Because of its anatomical similarity to modern humans, early *Homo erectus* offers the opportunity to evaluate the extent of its throwing abilities based on a comparison with *Homo sapiens*. Since the differences in physique are very slight, we are also only dealing with a very slight difference in physical capabilities. Because of the muscle marks on *Homo erectus* fossils, it is to be expected that these were even more athletic than modern humans. To what extent that helped directly with throwing is difficult to say, though, since in throwing bodily strength does not play an overwhelming role; the decisive factor is not strength, but speed.

Since early *Homo erectus* left behind no archaeological traces to indicate a meaningful cultural development and substantially improved opportunities for the use of resources (in the first several hundred thousand years, it limited itself to the chopping devices of the primitive Olduwan technology), it is to be expected that for them, the effective use of the body was still a very high priority.

We tend to presume that our ancestors were less capable in all possible areas than we are. However, our ancestors had to get by in much more difficult conditions as long as they did not have access to manifold cultural assistance. A high level of physical fitness is much more the rule in wild animals than in modern *Homo sapiens*. This species seems just as limited in its physical capacities as some of the animals it has domesticated. As a “wild man,” *Homo erectus* was surely typically in very good physical condition.

We have also already seen that humans can hardly profit from modern knowledge in throwing, since the steering of movement occurs autonomously, so that conscious influence does more harm than good. And we can finally assume that *Homo erectus* practiced throwing from childhood on. Just as at the time of the australopithecines, it is namely hardly conceivable that precisely that primate that had available the best prerequisites for throwing would have turned away from this proven primate strategy. There are also no archaeological indications of any sort of more effective weapons.

Thus, though, it is also to be expected in light of *Homo erectus*’s physique that the thrown stone represented an important weapon, whereby they were capable of performances similar to those of specialized modern elite athletes. This would still be true in the event that the previously presented explanations for the development of the human physique in the CTSW model are false. In light of the increasing ability to fling 800 g stones at opponents at speeds up to 120 km/hr (in javelin, one must release an equally heavy spear at 126 km/hr in order to reach a top performance of 92 m), it is to be expected that *Homo erectus*, given an amount of cooperation that can be observed among chimpanzees, was already able to dominate every predator. Thus, the assumption is also obvious that it was hardly hunted by predators anymore.

The well-founded assumption that the stone projectile was its most important weapon, the assumed low predation pressure, the shape of its skull, and its enormous robusticity are again sufficient grounds for the assumption of intensive intraspecific confrontations involving the use of stones.

These confrontations, the close relationship to *Pan troglodytes*, and a similarly large sexual dimorphism again make a chimpanzee-like group structure obvious for early *Homo erectus*. Thus, we again have a relatively secure starting position for further considerations, similar to the case of *Australopithecus afarensis*. This relatively secure starting position ca. 1.8 MY ago is also bitterly needed for considering the further development of humans. The time from then to the Late Paleolithic, which came with a steep increase in archaeological inheritances, namely offers especially much room for speculations:

- In the course of the last 1.8 MY, there were no more fundamental changes in physique that could give clues to the current state of evolutionary development.

- In this time, the brain grew substantially in volume and certainly also became much more capable – from the fossils, though, of course nothing but the volume can really be seen that might announce the state of this development at a given time. And the volume is not an especially great help – the brain of *Homo sapiens* can vary between 1000 and 2000 cc without having clear effects on achievements studied thus far.
- In the last 1.8 MY, it must also have come to the development of language. Here, fossils can certainly deliver an indication of the present state of development, but I have already stated that this may not be sufficient to evaluate the state of human communication abilities, since a sign language could have preceded spoken language.
- The importance of the ability to communicate lies primarily in the opportunities that it offers for cultural development. When and to what degree this appeared is important for judging the development of human development, which again had major influence on biological evolution. Difficulties appear here not only in that we have few indications of the chronological course of cultural evolution. Very touchy is primarily the question of in which ways cultural and biological evolution influenced one another. Confusion also reigns over conceivable "goals" of cultural evolution.

Perhaps even weightier is that it is especially difficult to avoid the pitfalls of anthropocentrism when considering the last 1.8 MY of human evolution. *Homo erectus* is quite clearly identifiable as human in its physique. Many strategies are known to us from contemporary observations for how one can survive successfully under use of this physique. It has always been tempting to hold the introduction of such strategies responsible for the course of hominid evolution. Corresponding hypotheses could be supported by the experiences of the public and easily found acceptance. These hypotheses were based, however, only on human behavior, and this is exceptionally versatile and subject to constant change.

This change today takes place exclusively through cultural development and at a downright breathtaking tempo compared to the relationships in other animals, so that the origins of a behavior are quickly lost to the past. Which behaviors were introduced when remains substantially left to fantasy. Assumptions about this are hardly suitable to serve as a basis for an evolutionary scenario, but are always called upon for lack of sturdier data. This would not be so bad if it were not a matter of our ancestry. Within a scientific discussion, speculations are very appropriate if for lack of known facts there cannot yet be a reliable answer to a line of questioning. Speculations can lead to new research approaches whose results enrich our limited knowledge somewhat. One may not take the presently favored speculations too seriously, however – this is a lot to demand of a line of questioning that directly affects our understanding of ourselves.

Despite these methodological difficulties, I have decided to treat the last 1.8 MY of human evolution in the CTSW model as well, but I warn expressly against turning my statements into dogma (actually, the warning goes for all conceptions that deal in detail with this timeframe, independent of whether they come from me or from someone else). Of course, I have done my best and also had an informative ancestor model in the new picture of early *Homo erectus*, which, it seems to me, can help to get away from many unknowns. Nonetheless, the room for interpretation is significant and the burden of prejudices that one carries around is very high.

I have already laid out thoroughly why I have decided upon *Pan troglodytes* as an ancestor model for hominid evolution. How good the selected primate model is, though, primarily proves itself in the course of hypothesis construction. The characteristics of *Homo erectus* corroborate, from the point of view of the CTSW model, that the group structure of our ancestors resembled that of *Pan troglodytes*. They also support a long-discussed hypothesis about the development of the human brain and behavior, whose contemporary supporters start from a chimplike group structure. They thus give an important indication of the principles of the course of the last 1.8 MY of human development.

Richard Alexander belongs among the scientists who place a very high importance of warlike group conflicts as the basis of human evolution. He had already drawn up, without knowledge of the interpretation proposed in the CTSW model of the adaptive traits of *Homo erectus*, an interesting scenario for the development of the human psyche (Alexander, 1989). Under the term “psyche,” he understands practically the sum of all tendencies and mental abilities through which humans stand out from other animals. Following a tradition that goes back to Darwin, Alexander sees in the confrontations between competing human groups the decisive driving force for the mental and social special developments of humans. As prerequisites for such a development, next to a multi-male group structure like that of *Pan troglodytes*, he names ecological dominance. The term “ecological dominance” is actually superfluous in the CTSW model, since it just encompasses the lessening of losses due to predators and the expansion of the nutritional base to include carrion.

The exceptional robusticity of *Homo erectus* and the shape of its skull are clear evidence for selection-determining, intraspecific conflicts involving the use of stones. They document that the conditions postulated by Richard Alexander for the development of the human psyche were there by 1.8 MY ago at the latest.

Although in the CTSW model, a high importance for warlike confrontations to hominid evolution is clear, I would like to indicate expressly here that cognitive development is not traced back solely to the conduct of war. Next to very demanding adaptations to throwing already in the australopithecine phase, raised requirements on the brain of social behavior within the groups must also be taken as a basis (such would surely have occurred above all as a result of the development of language) in order to be able to explain the capabilities completely. This aspect will yet occupy us in the following. Additionally, according to the CTSW model, the cognitive features that were developed further in the course of intraspecific conflicts were also primarily a matter of throwing adaptations. I have already indicated that, in my opinion, the assumption that strategic thought played a major role in this is a matter of an anthropocentric fallacy.

Jane Goodall was aware that her observations of the group conflicts of free-living chimpanzees presented an important contribution to the discussion of human development. She writes on this (Goodall, 1993):

[TRANS. NOTE: As with all of Kirschmann's long excerpts from English-language works, please consult the original for precision in quoting and to confirm nuances.]

> "Chimpanzees also stand on the cusp of another exclusively human behavior – the conduct of war. The wars of humans, defined as *organized armed conflicts between groups*, have had over the course of time a deep-reaching influence on our history. Wherever humans live, they have at some time made some kind of war. It therefore seems probable that there were already primitive forms of war in our earliest ancestors, and that this sort of conflict played a role in human evolution. War, it has been proposed, could have exerted considerable selective pressure in the development of intelligence and increasingly differentiated cooperation. This process is to have escalated – since the greater the intelligence, ability to cooperate, and courage of a group, the more that demands of its enemies. Darwin was among the first who

expressed the view that war could have exerted a mighty influence on the development of the human brain. Others have assumed that the conduct of war could have been responsible for the deep chasm between the human brain and our nearest living relatives, the apes: hominids with inferior brains could not win wars and were exterminated.

Thus, it is fascinating as well as shocking when one discovers that chimpanzees show hostile, aggressive, territorial behavior that is not dissimilar to certain forms of primitive human war. Some tribes, for example, undertake assaults in which they 'scatter as in hunting, (they) approach the enemy through the thicket as though stalking game', writes Renke Eibl-Eibesfeldt, a behavioral researcher who has studied aggression by peoples of the entire world. Long before differentiated war-making had developed in our own species, our pre-human ancestors must have shown preadaptations similar or equal to those observed among chimpanzees today, such as life in groups, cooperative territoriality, the ability to hunt jointly, and the use of weapons. Another necessary preadaptation would have had to be the inborn fear or hate of strangers, which was sometimes expressed in aggressive attacks. But attacking adult individuals of one's own species is always a dangerous undertaking; that's why it has been necessary in historical times for human societies to train warriors by means of culture, for example in that people glorified their role, condemned cowardice, rewarded bravery and skill on the battlefield, and highlighted the value of practicing 'manly' sports in childhood. Chimpanzees, however, above all young adult males, obviously find conflict between groups stimulating despite the danger. If young male pre-humans *also* saw some appeal in clashes of this type, that could have provided a firm biological basis for the glorification of warriors and wars.

Among humans, the members of one group often see themselves as completely different from the members of another group and thus treat group members and nonmembers differently. Nonmembers are actually sometimes considered 'dehumanized' and nearly beings of another species. When that happens, the people are freed from inhibitions and societal sanctions that are in effect within their own group, and can behave toward the non-group members in a way that would not be tolerated among their own people. This leads, among others, to the monstrosities of war. Chimpanzees show equally different behavior toward group members and non-

> group members. Their feeling for group identity is strong, and they know exactly who 'belongs' and who doesn't: nonmembers can be attacked so heavily that they succumb to their injuries. And that is not simply the 'fear of strangers' – the members of the Kahama society were well known to the Kasakela attackers and were still brutally assaulted. Because they had split off, they had apparently given up their 'right' to be treated as members of the same society. In addition, some attack patterns directed toward non-group members have never been observed in confrontations between members of the same society – the twisting of limbs, the tearing out of strips of skin, the drinking of blood. Thus, the victims are in every respect 'dechimpified,' since these behaviors are usually seen when a chimpanzee tries to kill an adult prey animal – an animal of another species.
>
> Chimpanzees have obviously reached a stage, due to unusually hostile and violent acts of aggression against non-group members, where they stand at the cusp of human achievement in destruction, cruelty, and systematic conflicts between groups."

To these statements of Jane Goodall, one must make a few corrections from a sociobiological perspective. At least in the realm of animal behavior, the sociobiological approach has since prevailed. The paradigm of sociobiology states that (animal) behavior developed in the course of evolution such that the fitness of individuals is maximized. Thus, sociobiology makes the demand that behavior is also interpreted as a biological characteristic of organisms that can only be correctly understood upon consideration of evolution.

From a sociobiological view, competition between conspecifics, up to and including war, is nothing unusual. Conspecifics occupy the same ecological niche and thus naturally compete directly with one another. In order to be successful in reproduction, it often primarily means prevailing over members of one's own species and especially of one's own sex. Selfishness is the norm, and not just at the level of the individual, but – in a figurative sense – even perhaps at the level of the gene, as Dawkins brought to expression with his very popular "selfish gene." Unusual from the point of view of sociobiology is thus not competition between conspecifics, but rather cooperation. To explain this, sociobiology has two mechanisms available in the form of reciprocal altruism and kin selection, which have proven very powerful for the explanation of animal behavior. The socialization of animals is also traced back to these mechanisms. In both cases, cooperative behavior of an individual eventually proves advantageous for its own fitness, and is therefore selfish when seen from the standpoint of the gene. And it is often not least conflicts with conspecifics over commonly claimed resources that make it “worthwhile” to band together in groups.

From a sociobiological perspective, which Richard Alexander also takes as a basis, the cooperation of male chimpanzees in fights against strangers is easily understandable and to be explained as a consequence of the close relationships of the males to one another, i.e., of kin selection. The males are closely related to one another because they remained in their natal groups while the females change groups on the occasion of puberty or shortly thereafter and thus hold incest within tolerable limits. Differential behavior toward group members and strangers is therefore also natural – one does not require the assumption that mechanisms for preservation of the species (of which, from the sociobiological viewpoint, there are none) must fail in order to explain aggression against conspecifics.

Of course, the sociobiological view is known to Jane Goodall; nonetheless, she lapses – characteristically, in the treatment of a line of questioning that directly applies to humans – into the argumentation of another, older school. A school whose best-known representative was actually Konrad Lorenz, who held the preservation of the species for a central matter of evolution.

From the point of view of this school, pseudospeciation in the course of the cultural development of humans presents one of the decisive reasons why humans can behave so “unnaturally” toward their conspecifics as one observes in wars. Very beloved here was, for instance, the argument that the development of modern, long-range weapons first made the brutality of war possible, because the combatants no longer have any contact with one another, which in turn is a requirement for the engagement of aggression-hindering mechanisms. Thus, one finds, e.g., with Eibl-Eibesfeldt (Eibl-Eibesfeldt, 1995):

> “The killing inhibitions inborn in us humans are also turned off in war. A cultural norm-filter is loaded on top of the biological filter that forbids killing, which turns killing into a duty and elevates it to a good deed. It also requires massive indoctrination in whose course, among other things, the opponent is presented as quasi-inhuman. Killing is further facilitated through use of effective distance weapons. The biological norm-filter is not turned off by this, however. It causes a conflict of norms, which we experience as a bad conscience.”

Jane Goodall follows a similar line of argumentation when she mentions that nonmembers of the group are sometimes dehumanized so that the people are freed from inhibitions and societal sanctions, which among other things leads to the monstrosities of war.
When Jane Goodall talks about someone being freed from inhibitions, then she presumes that the presence of inhibitions represents the normal case. From the sociobiological view, however, exactly this should **not** be assumed. Aggression here is much more the normal case, and the construction of inhibition mechanisms is an adaptation. This could be in the service of socialization and would surely apply in such a case only to group members from the beginning.
In the animal world, ritualized fights also occur between individuals who do not belong to the same group. In such cases, the animals hold themselves to certain rules in order to minimize their own risk of injury. According to the statements of Jane Goodall, however, the latter already does not apply to chimpanzees. They know no ritualized fighting procedures in defensive behaviors against strangers; actions with high risks of injury are obviously only avoided within the group.
When Jane Goodall mentions in the same breath that someone is freed from societal sanctions, then she suggests that inhibitions as the product of biological evolution and societal sanctions as the product of cultural development belong together. Before one can draw conclusions about the products of cultural development, however, one must be clear about the mechanisms underlying the cultural development. This is an exceptionally difficult demand that leads directly to scientific terrain fought over hotly by sociologists and sociobiologists.

Thus, before I can develop concrete conceptions of the course of the last 1.8 MY, I cannot avoid constructing some basic thoughts about the mechanisms of biological and cultural evolution. As preparation, so to speak, for these thoughts, however, I will first investigate another very important question to the course of the last 1.8 MY of human development. That is, if our ancestors showed a chimplike group structure 1.8 MY ago, then the question presents itself of how long this stayed that way. If one believes leading sex researchers, then it is to be assumed that human sexuality does not fit the clear assumption of the CTSW model, that the natural sexual behavior and the original group structure of humans corresponded to those of *Pan troglodytes*.

5 CTSW Model and Sexual Behavior

5.1 The relevance of sexuality to an evolutionary model

Human sexual behavior is a special case of human behavior. The determination met at the beginning of this book, that human behavior has become very multilayered and unclear because of cultural development and is therefore poorly suited as evidence for an evolutionary hypothesis, is naturally also true of sexual behavior. Considerations of the natural sexual behavior of humans are always quite speculative. The physical construction of the human body certainly gives valuable indications in itself – however, the room for interpretation remains uncomfortably large. In the end, considerations of natural sexuality are always primarily supported by observed behavior and are thus weakly verified. This is not only true of my own thoughts, though, but rather also for everything else that has thus far been published on this subject.

Now, sexual behavior plays a very significant role for evolution. It determines the methods and value of sexual selection. In addition, it is directly connected with group structure and thus has immediate influence upon kin relationships and the value of kin selection for the evolution of the particular species as well.

In order to develop a feeling for the importance of sexual behavior, one can look at, e.g., *Pan troglodytes*. The multi-male construction of groups means that it is worthwhile because of kin selection for the males to appear jointly against the males of other groups, which in turn is held responsible for chimpanzees already having developed a kind of primitive war-making.

Because the males within the group compete with one another for reproduction with relatively few females, sexual selection also has a major importance in chimpanzees. Different males can deviate significantly in their reproductive success from one another, so that genetically determined characteristics that serve the fitness of a male through sexual selection can spread through the population quite quickly. Sexual selection in multi-male chimpanzee societies presumably presents the most effective evolutionary motor available to apes with their low rate of reproduction.

The high developmental dynamic of the human line and the significance attached to making war in the CTSW model make the conclusion easy, within the model, that human associations in the human developmental timeframe – or at least in the timeframe from the first appearance of *Homo* *erectus* until the appearance of *Homo sapiens* – were similarly organized in this multi-male way, like *Pan troglodytes* is today. And the significance that sexual behavior would have in this case for human evolution would have been enormous.

The evolution of humankind can really only be understood when one places a correct model of the sexual behavior of its ancestors in this developmental time frame at its base. This means primarily that one should never be too sure of oneself, not even when an evolutionary model appears so convincing. Contemporary perceptions of sexual behavior represent a meaningful portion of any model that can hardly be founded with hard evidence.
When I speak of "natural" sexual behavior, I already anticipate part of my conceptions, since I presume that at the transition to the Late Paleolithic – i.e., ca. 70-40 thousand years ago – decisive changes happened in sexual behavior that was previously exceptionally chimplike and afterwards clearly culturally regulated. If the development really happened this way, then it makes sense to speak of natural, precultural, or original sexual behavior.

The sexual behavior of humans in their developmental period is definitely worth researching and represents an important component of every evolutionary model. One should remain aware, though, that in the consideration of sexual behavior no "hard" evidence for the current model jumps out. On the contrary, though, an evolutionary model can be deeply shaken in that it is not able, within its framework, to provide an explanation for the peculiarities of human sexuality. This explanation, however, builds upon the present evolutionary model just as that builds itself upon the underlying primate model.
A primate model can only defend its position within an evolutionary model. It cannot be "proven," since it is among the basic assumptions of the evolutionary model. Equally, the explanation of natural sexual behavior offers an opportunity for the evolutionary model to defend itself without it actually being able to be proven. When one is first initiated into the logic of argumentation, it is very easy to succumb to the temptation to forget how low the proving strength of the arguments used is and thus no longer notice on what unsteady footing one treads. This becomes very touchy for models of hominid evolution, which are primarily constructed upon assumptions about changes in the area of sexual behavior, and this in close connection with the organizational structure of group bands. These assumptions, which potentially are based on nothing more than traditional moral ideas, receive an apparent confirmation through a suitable

choice of presently observed behaviors and thus give the impression to be sufficiently well founded scientific hypotheses.

The CTSW model gives multiple important indications of the sexual behavior of human ancestors in the developmental period it handles:

- The australopithecine phase of hominid evolution was characterized by a constant improvement of throwing qualities and flowed into the highly specialized *Homo erectus*, which by 1.8 MY ago already showed a physique fully optimized for throwing. In the area of sexual behavior, there grew from this above all a grave problem in the approach to potential sexual partners from different groups.
- The Homo phase of hominid evolution begun 1.8 MY ago with *Homo erectus* was primarily marked by intraspecific confrontations and the development of language. The confrontations demonstrated by the physique of *Homo erectus*, the degree of sexual dimorphism, and the close relationship to *Pan troglodytes* make the assumption easy that the group structure of *Homo erectus* was, like in chimpanzees, multi-male in principle and based on the cooperation of related men.
- Because of the conflicts, the inclination to xenophobia surely grew. Xenophobia, on the one hand, made the initial approach toward getting to know potential mates even more difficult, and on the other hand created, with the development of language and the cultural development built upon it, extra hurdles for strange women to overcome in their integration into a new group (pseudospeciation).

All in all, the unusual adaptive traits of the hominids had massive, and in the animal world also unusual, repercussions in the area of their reproduction. Comparisons with other animals and in particular with ones far removed in their developmental histories, such as birds, thus do not help further our attempts to clarify the characteristics of humans in which they clearly deviate from *Pan troglodytes*. It causes additional difficulties in that sexual behavior in humans quite obviously does not only serve for reproduction, but in addition took over social tasks such as we otherwise only find in such quantity with the bonobo.

5.2 Human particularities in the sexual sphere

In the area of human sexuality, some adaptations have developed that come across as very unusual and have offered an entrée to the most diverse hypotheses. Quite clear differences in comparison to chimpanzees appear to be obvious in that the original group structure of humans may not have been multi-male. Since this stands in opposition to my interpretation, I will have to deal with these differences. The following human characteristics must find an explanation in a model of the natural sexuality of humans:

- The breasts of women are constantly enlarged and are perceived as attractive by men. Among chimpanzees, large breasts are signs of infertility, since they only appear in nursing females. In the lactation phase, the females are infertile and are thus not perceived as attractive.
- The female breasts are only a part of the unusual fact that in humans, women are the "pretty sex." In the animal world, it is generally the male who decorates himself with otherwise useless physical attachments in order to please the females. An elementary reason for this is found in the different reproductive potential of males and females. Males can potentially produce very many offspring, whereby the investment in each individual offspring is generally exceptionally low. Because of this, males are generally also not so choosy about their partners and primarily focus on producing as many offspring as possible. Females invest substantially more in individual offspring. Their behavior is thus primarily aimed at high gamete quality, and they are exceptionally choosy in relation to sexual partners.
- In contrast to ape females, women have a hymen, whose purpose seems to consist of providing a brand new [lit.: "freshly baked"] husband with proof of the virginity of his wife.
- Ovulation in women is hidden. Chimpanzee females display, in contrast, their ovulation and thus their fertile days with a marked genital swelling. And the males compete with each other especially over access to the females who are fertile at a given time. Thus, in humans, sexual intercourse takes place independent of the reproductive status of the females, while *Pan troglodytes* males are exclusively interested in females with genital swellings.

- In contrast to chimpanzees, humans show a clear inclination toward exclusive partner bonds with a pronounced fixation upon the current partner. In other words, they tend to fall in love, and this behavioral pattern is obviously cross-cultural and biologically based.
- Men's testicles are significantly smaller than the testicles of multi-male chimpanzee males.
- The high importance of the influences of fashion upon the judgment of the attractiveness of potential sexual partners in humans demands an explanation. The direct significance that sexuality possesses for the reproductive success of an individual actually leads one to expect that the choice of partner should follow strict biological criteria. That fashion does not enjoy a high importance in all human societies plays no role here. It must be explained how it could ever have come to play such an overwhelming role in some societies.

A whole series of human characteristics thus seems to contradict my assumption that humans – and I certainly do mean *Homo sapiens* up to the beginning of the Late Paleolithic here – were originally organized in multi-male groups. In order to point out that this is nonetheless still entirely conceivable – an in the framework of the CTSW model, even obvious – I will first offer a new explanation for the function of the human tendency to fall in love, and therewith clear away the sharpest argument against a multi-male natural group organization for humans. My explanation results directly from the CTSW model.

Based on that, I will – supported by the observations of *Pan troglodytes* and implications of the CTSW model – develop a picture of how human reproductive strategies could have looked before the massive cultural regulation of sexual behavior.

Subsequently, I will take a position on individual aspects of the human physique and sexual behavior in order to round out the picture.

5.3 Why we fall in love

Perhaps the strongest argument against a multi-male natural sexual organization in humans is the fact that we fall in love. Falling in love obviously serves as a means for producing exclusive pairbonds (Grammer, 1993) and at first glance fits poorly into a picture of an exceptionally promiscuous society in the way of the chimpanzees. Exclusive relationships between two unrelated individuals play, however, an important role for the chimpanzees as well.

Chimpanzee bands are, on the one hand, each other's enemies, and on the other hand, they rely on exchanging females with one another in order to limit incest. Young chimpanzee females obviously feel drawn toward strange males and visit the edges of their territory in order to make contact. In connection with the conflicts between the free-living chimpanzees at Gombe, Jane Goodall mentions two cases right away in which young females willing to mate aroused substantially greater interest in the males of the neighboring group than in the males of their own group (Goodall, 1986).

Females that change groups have no access to social networks in the new groups and are seen as enemies, primarily by the old, established females. The transition is facilitated in that the female seeks a protector. Jane Goodall writes: "Young immigrating females must tolerate a lot of animosity from the older females. They are followed to some extent and attacked; often, such a fight is ended by the males present. Upon being followed by three females, Patti fled in the direction where males were spending time and stayed near her "rescuers." A month later, Patti was grooming herself with her former enemies" (Goodall, 1986).

Among common chimpanzees, it is the male who takes the new female under his protection against the others; among bonobos, the new one seeks a high-ranking female, builds a close bond through use of G-G rubbing – the typical form of homosexual sex for bonobo females – and in return is given protection from the other members of the group (de Waal, 1995).

Until the Late Paleolithic, humans lived in groups whose size would hardly ever have exceeded 40 individuals (Trinkaus & Shipman, 1993). These groups were, according to the CTSW hypothesis, much worse enemies of one another than groups of recent chimpanzees and presumably already had fully developed language abilities 300,000 years ago. In such small groups, reproduction cannot have taken place exclusively within the groups – such marked inbreeding would have damaged the descendants severely and presumably would also have led to infertility. There must therefore have been an exchange of women among hominids, up to and including modern humans, between enemy groups. In this, the relationships in the area of sexual behavior differ elementarily from the relationships that can be observed in hunter-gatherer groups today. Ties within the political unit, as are typical today, would automatically have been ties with close relatives and would have led to a correspondingly high genetic burden upon the ensuing offspring.

That means that young women 70,000 years ago still managed, under the jealous glances of the men of their natal groups, to switch to a neighboring band, in which another language was spoken, other customs ruled, and whose males were known to her from stories as brutal, deceitful murderers – actually more animals than humans. Dangerous beasts, from whom one had essentially better keep a distance that clearly exceeded their throwing range. Seen from the other side, young women were regularly integrated into firmly arranged, ethnocentric communities, although they brought with them knowledge of neither the language nor the customs of the group and obviously came from hated enemies, with whom one still had something of a score to settle.

If one takes a chimplike group structure as a basis for humans, it is to be expected that young women should seek protectors from their new groups for the group change and would enter into close bonds with them through use of sexuality. And these strangers, for their part, had to enter into stronger bonds with their protégés the greater the difficulties of introduction into the group were. A strange woman who had not mastered the language of the new group remained unfamiliar for a long time and offered repeated opportunities for animosity. Her unfamiliarity with the customs and habits of the new group also caused difficulties in integration. Thus, there resulted for *Homo* with developed language abilities a transitional time on the order of years, during which the new [female] required reliable support within the group, much longer than a chimpanzee female, who can be integrated within a month.

The human tendency to fall in love thus finds a functional explanation if one considers the additional difficulties with which women were confronted, in comparison to chimpanzees, in original human societies at the change of group because of express xenophobia, the application of a distance weapon, and language abilities. Men, who tended to form strong emotional bonds to young women with whom they had not grown up, brought with them the necessary motivation to stand reliably by the side of the woman during the multi-year integration phase. Falling in love provided women with the necessary motivation to get involved in this dangerous, troublesome adventure of changing groups.

The male preference for youth is, according to Matt Ridley, a human uniqueness. [He says] there is no other animal thus far investigated that is possessed of this with such intensity (Ridley, 1995). To the male preference for youth also belongs the fact that the firm, youthful woman's breast arouses the interest of men everywhere in the world. Reports in which men of certain primitive peoples do not share this preference, according to Eibl-Eibesfeldt, could not withstand further checking (Eibl-Eibesfeldt, 1995). The scenario of the difficult group change explains the facts of this case, since even among chimpanzees only young females change groups.

I am not, however, able to conclude that the preference for young women is an indication of adaptation to lifelong pairbonds; rather, it seems more likely for a man to leave his years-long partner for a younger woman. In addition, women would have had to place value on their partners not being too old, since they would allegedly be reliant upon their support while rearing children. The preferences of women, however, present a picture of an established, mature partner (Eibl-Eibesfeldt, 1995; Grammer, 1993; Ridley, 1995). If one combines male and female preferences in the search for partners and assumes that they developed for functional reasons, then it is to be expected that the bonding of an 18-year-old with a high-ranking 30-year-old would sooner have been sensible. Under conditions such as reigned before the Late Paleolithic, though, 40 years was already a ripe old age for a man (Trinkaus & Shipman, 1993). If he died at this age and everything in the "family" had gone well up until then, then the woman stood there at age 28, with three children of the ages of 9, 5, and one year, without a protector and provider. After three pregnancies, she certainly no longer showed the youthful attributes that would easily have brought her a new partner.

In the scenario of changing groups, on the other hand, the woman only seeks a partner for the next [few] years who can provide the necessary protection in the new group during the transitional phase. That primarily depends on his position, and for that, advanced age is an advantage. The established, still healthy 30-year-old was, from this point of view, a very good choice. The story of Romeo and Juliet might not have turned out so tragically if Romeo hadn't still been a green youth, but a man whose word carried some weight in his clan.

It may seem unscientific to cite Shakespeare here, but we should certainly ask ourselves why millions of humans in different epochs can identify effortlessly with this couple. That could be because this love story occurs under "nature-identical" circumstances, to which our psyche presents adaptations. The function of love originally consisted precisely in bringing together sexual partners from enemy groups. These must have had to prevail over the objections of their mutually warring members in doing so, which in humans also consisted of so-called "rational" arguments. Thus, love also has the power to allow the lovers to behave "against all reason" and against the objections of close relatives.

A clear indication that the tendency to fall in love is a characteristic that developed in connection with changing groups is presented by the determination that humans do not tend to fall in love with close acquaintances. Thereto, Irenäus Eibl-Eibesfeldt writes:

> "Now, E. Westermarck (1894) and H. Ellis (1906) had already brought attention to the fact that sexual attraction between persons who grew up with one another is low, indeed that a sexual aversion builds up, and not even just between blood relatives. Close daily cohabitation in childhood determines the behavior. A. P. Wolf (1966, 1970) was able to substantiate this view through a comparative study of two Chinese marriage forms on Formosa. The two parallel-occurring marriage forms differed mainly in that in the one case, the marriage partners were introduced and married as adults, while with the marriage called sim-pua, the bride was already given to the bridegroom in childhood, adopted by his family, and reared as his sister. The consequence of this growing up together is often a marked sexual disinterest. These marriages are distinguished by a lack of sexual harmony; they are boring and accordingly less fruitful. The marriages in which the partners first married as adults produced 30 percent more children. The divorce rate of sim-pua marriages is higher than that of the other marriage form. Of the 132 child marriages that Wolf investigated, 46.2 percent ended in divorce and/or adultery, versus 10.5 percent of the 171 adult marriages.
>
> Some have now objected that these different results could be traced back to the lower social status of childhood marriage. A. P. Wolf (1974) therefore studied a third Chinese form of marriage, in which the future husband is obligated to the father of the bride in dower services and lives with his father-in-law, since he cannot pay the brideprice. This form of marriage enjoys a very low status, but these marriages turn out to be thoroughly fruitful. Therefore, it cannot be status that reduces the fertility of the partners.

Some have also expressed the supposition that low fertility could be due to the frequent same-agedness of sim-pua spouses. The women could thus more easily resist the man as being of equal rank. But in the marriages set up with dower service, the men are quite certainly inferior in rank to their wives, since the women are, after all, the owners of their property. Nonetheless, these marriages are, as mentioned, very fruitful. A. P. Wolf finally determined a linear relationship between the age of the husband at the time of the adoption of the woman and the divorce rate. If the groom was 4 years old or younger at this point, then 16.4 percent of marriages ended in divorce. If he was between 5 and 9 years old at the time of the adoption of his future wife, then 12 percent of marriages ended in divorce. If, on the other hand, he was already 10 years old or more at this point, then the divorce rate sank to 5.4 percent! This indicates that growing up together during a particular developmental phase results in an inhibition against copulation. This assumption was supported by the reports of J. McCabe (1983) about the FBD marriages (fathers' brothers' daughters) in the Sunnis living in Bayt al-'asir (Lebanon). Their men prefer their patrilineal parallel cousins as marriage partners. They grew up with them in a family group, bound in friendship like siblings. The marriages, however, produce fewer children and lead more often to divorce than other marriages.

Further support for the development of a copulation inhibition in [persons] growing up together is offered by J. Shepher (1971, 1983). In a Kibbutz, children of different parents grow up in communal spaces, organized by age groups. Boys and girls thus used the same showers and toilets, and in order to eliminate sexual discrimination, the children were allowed to see each other casually naked, so that they would become comfortable with being of different sexes. Up to the age of 12 years, the children showed no shyness toward members of the other sex. Afterwards, though, girls declined contact with the boys. They avoided undressing in front of them, refused common showers; in short, they showed all indications of the shame whose development people were trying to prevent (see above). Their interest was directed more distantly toward young men with whom they did not grow up. After puberty, the tensions died down between the boys and girls reared together. The relationship became friendly in a brotherly way. Group members did not, however, marry each other. J. Shepher (1983) studied 2769 marriages of people who grew up in kibbutz.

> In no case had people who grew up together married. The group members considered each other to be like brothers and sisters, and in fact by their own choice, not because of any external pressure. Since the children were not related by blood, their parents had had no objections to marriage; rather, such [marriages] within the community were thoroughly desired. The avoidance resulted because those who grew up together did not find each other sexually attractive. J. Shepher finally discovered in his data set 13 exceptions, that is, marriages between group members who grew up in the same kibbutz. A close analysis of these cases proved that in all of these exceptions, a lengthy interruption of the 'brotherly' cohabitation before the sixth year of life was to be found. Shepher concludes from this that there is obviously a sensitive period before the sixth year, during which one learns with whom one will not later fall in love. This fits well to the mentioned observations of A. P. Wolf." (Eibl-Eibesfeldt, 1995)

So we tend to fall in love with strangers, and that which men have in mind as their ideal picture for this is a woman between puberty and her first child (Ridley, 1995), thus, in the phase of life in which the change of group should ideally have taken place, and during which chimpanzee females also change groups. Making later contact with a strange male seems, from the point of view of the female with respect to the security of her accompanying child, inadvisable. This does not explain, though, why men should prefer young women. Here, a problem hides, toward whose solution I will not make any suggestions at this point, since it does not affect my model of natural human sexuality. I assume a chimplike natural sexuality for humans and therefore need not explain the agreements, just the differences. Chimpanzee males very obviously prefer young, unfamiliar females. Men do the same, and they probably do it for the same reasons – whatever these may be.

For marriage, one certainly searches at least as thoroughly for a partner and – inasmuch as it is a marriage for love – preferentially according to the same criteria as earlier for group changes. In contrast to group changes in remote antiquity, modern marriage to a stranger is not tied to weighty disadvantages. The woman usually enters into it with neither risk to life and limb nor loss of her social networks. To that extent, it is no wonder that those who grew up in a kibbutz in close contact to one another seek unfamiliar marriage partners exclusively. Evaluating this as an indication of a biological "incest taboo," as occurred above, I see with a side-glance at the chimpanzees as somewhat overblown. Chimpanzees also prefer strange sexual partners (for the females, this only obtains until the birth of the first child). This does not mean, however, that group members are shunned as sexual partners. It is much less a matter of excluding reproduction with relatives generally, than simply holding the consequences of incest within tolerable limits through occasional sexual contact with strangers or regular group transfer of young females.

5.4 Human reproductive strategies

Before I lose myself in speculations over the reproductive strategies that might have been the basis for the natural sexuality of humans, I must go into a question that, interestingly, has until now not usually been answered in the way that I find absolutely obvious. It is a matter of the preference of men for a "slender figure" in women. It is certainly right that the influences of fashion underlie beauty ideals, but they do so within certain boundaries. Men quite obviously generally prefer women whose waist circumference is lower than the breast and hip circumferences (these are, by the way, young women as a rule). According to Grammer, "Figures with a normal body weight and a waist-hip ratio of 0.7 are preferred; extremes are declined" (Figure 14).

A whole series of hypotheses has been constructed to explain to what extent women with slender waists could have a reproductive advantage (Ridley, 1995; Grammer, 1993), since from an evolutionary biological perspective this is the most obvious explanation for the development of a corresponding preference by the men. Therein, precisely that process that under natural circumstances was certainly most able to "ruin" the figure of a woman, and which at the same time is undeniably connected to reproduction, has plainly been ignored – pregnancy.

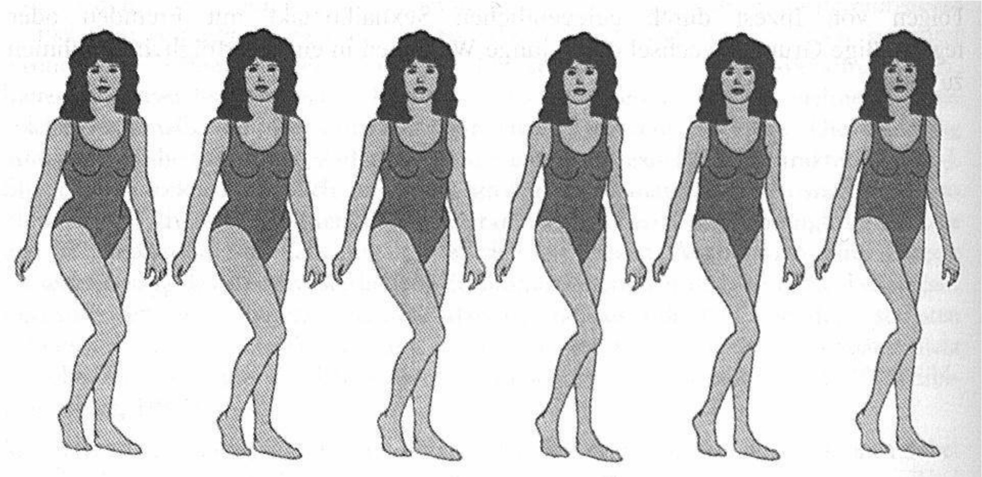


Figure 14: These mock-ups were presented by Singh to men for judging female attractiveness; they are ordered from left to right according to their judged attractiveness. Manipulated was the width of the waist. (Picture source: Grammer, 1993).

First in our modern society is the means, in the form of cheap calories, available to women to change their physical proportions in a similarly lasting way to how pregnancy has always done. If men prefer women with slender waists, then they do this in the effort to avoid women who may already have been pregnant. And the reason for such behavior is obvious. Since if the woman is already pregnant, then the man can't be the father of at least the next child. Such relationships in the animal kingdom don't just lead to the avoidance of pregnant females, which as a rule are neither sexually active nor attractive, but to the killing of dependent young that hinder the mother from becoming receptive again soon. In lions, and also in some harem-building primate species, taking over a harem often comes with the killing of dependent offspring (Voland, 1993).

In our nearest living relatives, the chimpanzees, it has also been observed more than once that males killed the young of strange females and, to some extent, even ate parts of them. It is, however, doubtful in these cases that this happened in order to be able to beget [the males'] own children on the females as soon as possible. In chimpanzees, the relationships seem to be somewhat more complicated.

Since in chimpanzees, the females leave their natal groups, and, according to my approach, female humans originally did this as well, it was of course not a matter of taking over human harems. Instead, the men introduced individual women into the group and had to ensure that they got their money's worth in the process (see below). Right at the introduction of strange women into their own groups, the men made relatively large investments and had to watch out that their partners were not already expecting a child by another man. Within the group also, it was worthwhile, in consideration of one's own reproductive interests, to pay attention to the reproductive status of the women one was specially courting. It is certainly not very polite to spread the perception that it is very natural for pregnant women to decline significantly in their attractiveness to men. Possible social implications also immediately appear before the mind's eye and warn against treading upon such dangerous terrain. One need only think of the practice widespread among the men of Black populations in the United States of leaving their partners as soon as she expects a child. According to that said above, this seems like an exceptionally "natural" behavior, wherewith automatically – even if unfoundedly – the blame surfaces of wanting to justify such behavior.

It is my opinion that an improved understanding of human nature is to be valued much higher than such thoughts. Scientific discussion should not suffer from shyness at addressing the effects of pregnancy on male evaluation of female attractiveness. Additionally, I have never proposed that "natural" is automatically also "good." For every halfway-civilized person, the opposite more likely results from the CTSW model, since it is obvious to interpret xenophobia and willingness to kill conspecifics as natural predispositions of humans.

How, then, did human reproductive strategies look before sexuality was culturally regulated? In the attempt to answer this question, I start from the following conditions:

- neighboring groups were small, enemies of each other, and based upon the cooperation of related males
- the groups used – typically different – languages
- ovulation was concealed

Which reproductive strategy a human followed depended on sex, age, and social position. Primary goals were the number and quality of one's own descendants; for mainly the males, the support of relatives also came into consideration.

A young woman who did not yet have children stood, like recent chimpanzee females, before the choice of leaving her natal group or staying in it. In favor of leaving the group was the unknown possibility of improving the quality of her offspring by avoiding incest. Speaking against it were the obvious dangers of changing groups – which also surely was not tolerated by the males of her own group – and the necessity of building new social ties in the new group. Presumably, there were always some women who left their natal groups and some who stayed. The less women were prepared to change groups, the more their fitness suffered because of incest, and the higher the profits rose of those who changed groups. Thus, there was probably no time at which no women changed groups. Only after the transition to the Late Paleolithic did political associations become large enough that genetic exchange with enemy groups could generally be discontinued. A woman with little social backing in her natal group, because she had no respected brothers (meant here are half-brothers, to whom she was bound from childhood through a common mother) and her mother was either dead or held low social rank, had little to lose and would have invested in a group change from the beginning. In her own natal group, she would have been exceptionally sexually hesitant, since a premature pregnancy would have worsened her chances of a change of group significantly. In a potential partner from the neighboring group, she would have placed especially high value on high position in his group and reliability. In making contact, she would have tried to raise the investment of her partner, in order to ensure that he carried sufficient weight [lit. "he had a long breath"] and "he really meant it." In any case, she was on the point of entering a dangerous adventure and would require his support, in the case of a group change, for a long time. To the partner, whom she then in the end followed, she constructed an intense emotional tie.

A woman who actually got involved with a group change would have had to counter with her behavior the danger of being deceived by the man. If his social position in his group was in actuality only weak, the situation became difficult for her. Higher-ranking men would then guaranteed have shown interest in the "new girl" and put the woman in a fix. Subsequently switching over to a higher-ranking man was problematic, since he surely remained aware than she had been introduced by another. That could weaken his bond, behind which the possibility hid that she was already pregnant by the first partner, such that the investment of the second was misdirected [lit.: "went to the wrong address"]. It could then easily happen that she would stand there, in the course of her first pregnancy, in the new group without a protecting partner. Holding onto the first partner could, however, become equally difficult, since he was surely subject to constant humiliations by higher-ranking [males] trying to stand out in the eyes of the new [female]. It is questionable whether he could offer her the necessary protection under such circumstances.

Perhaps a few words in the margin would be appropriate here, in order to facilitate understanding. All the problems that a young woman had to come to terms with in her behavior were typically unknown to this woman. The women would hardly have had clear ideas about the consequences of incest. Her reproductive success, however, depended directly upon whether she behaved in a way that held incest within tolerable limits. Women who developed tendencies that let them behave "correctly" were preferred by selection and determined the characteristics of future generations. Thus, women prevailed in the population who tended to develop very intense feelings toward strange men.

The obvious motivation for following such a man despite all the difficulties was delivered by the infatuation of the woman. One thus tends to see the cause in falling in love and the result in the group change. On the psychological level, this is also correct. If one places oneself on the evolutionary biological level of consideration, however, then it all looks very different. Changing groups is now the essential behavioral path, and the tendency to fall in love with strangers is a characteristic that developed in the course of evolution so that this behavior would be practiced sufficiently often. On this level of consideration, upon which the basic arguments of this book are made, group change is thus the cause and falling in love the effect.

The behavior of men in relation to young, immigrant women may have gone according to similar rules to the behavior of chimpanzees when dealing with highly prized goods to which a particular male can make a special claim due to special efforts. Chimpanzees have, namely, a well-developed sense of ownership. If it is a matter of captured meat, which is prized to the highest degree by chimpanzees, then the successful hunters are entirely prepared to defend it even against higher-ranking group members. They are also thoroughly successful in this if the difference in rank is not too great. The higher-ranking males seem to sense that the "owner" of the meat is motivated to a confrontation to a much higher degree than, for instance, in connection with a power display. Under such circumstances, a confrontation could escalate out of control and lead to serious injuries. The higher-ranking males are apparently not prepared to pay such a high price for meat after all. Similar behavior was once observed at Gombe in connection with a mating excursion. Here, a chimpanzee male who had been able to get a rosy female away from the center of the group's territory to have for himself alone was so highly motivated to defend this prerogative that a higher-ranking and obviously equally interested male avoided a confrontation and gave up the opportunity to reproduce (Goodall, 1993). As a man in love is normally motivated to the highest degree not to allow other men to become intimate with his lover, it is entirely conceivable that men of high enough rank were capable of keeping even a higher-ranking man away from their lovers.

A young woman who was well-established in her natal group because her mother and her brothers possessed high social ranks should have had a lesser tendency to change groups than a woman of poor relations, since the position in the group affected the distribution of resources and thus the ability to rear children. Nonetheless, this woman presumably sought the potentially dangerous approach to strange men, in order to avoid incest at least with her first child. It was not, however, especially important to her how well he was established in his group compared to her. She also allowed herself to get involved in a fleeting romance and paid more attention to external attributes, which allowed her to draw conclusions about the quality of his genes, than to the momentary social rank of her partner in his group.

As a model for such a woman, the Gombe chimpanzee Fifi will serve, whose development was observed from infancy. Fifi was descended from Flo, who in her time was the highest-ranking female in the group. With Faben and Figan, Fifi also had two high-ranking brothers in her natal group – Figan was even the alpha male of the group for many years, and according to Jane

Goodall's statements, actually the most powerful alpha in the history of observations at Gombe (Goodall, 1993). Fifi was therefore a sort of chimpanzee princess. She remained in her natal group and became – probably not least because of her membership in a strong family (in chimpanzees, the term family is entirely appropriate and is also used by Jane Goodall; one should, however, note that in a chimpanzee family, the role of father is not occupied) – the most successful mother ever observed at Gombe. Jane Goodall is, however, fairly sure that Fifi's first child was begotten by a strange male, as Fifi had been on an outing into the territory of the neighboring group during the time in which she conceived.

Next to her own social position in the natal group, the "general political level" certainly also played a role in whether a young female was inclined to change her group. It was surely sensible to change from a weak group threatened with decline to a superior neighboring group. There were surely a whole series of indications that her own group was poorly situated, which would have increased the readiness of young women to leave their natal groups:

- Losses in confrontations with neighboring groups are mounting.
- The males only still ranged over a small area and lost self-confidence.
- Strange groups of males advanced up to the core territory of the distressed group and conducted power displays there, and her own [group's] men responded to this by staying still and fearful, instead of accepting the challenge.
- Resources became tight, since within the reduced territory it was difficult to provide for oneself adequately.

In such a situation, loyalty toward her own group would have been senseless for a young woman, who in principle had the opportunity to change groups, from evolutionary points of view. The woman should, on the contrary, tend even more to fall in love with men from enemy groups the more superior they appeared.

Women who already had children and could not manage a group change or even just an encounter with a stranger out of consideration for an accompanying child found their partners for reproduction within the group in which they already lived, and oriented themselves in this primarily toward the rank order of the men. High-ranking men corresponded to qualitatively good genes and could usually count on interest from the women. The man who had introduced her to the group surely also enjoyed an advantage, since this process went with a very strong

emotional tie and included a multi-year, very close relationship between the two. The two partners thus surely enjoyed a special status in the eyes of the other for the rest of their lives.
One should not, however, overestimate the freedom of choice of a female among possible reproductive partners in a group dominated by warlike men. A woman whose favor was curried by high-ranking men could hardly have hardly have turned toward an unimportant pretty boy.

The relationships of the men were more interesting inasmuch as their number of offspring could vary much more greatly. Here, rank order had a strong influence on reproductive success. Chimpanzee males orient themselves upon the genital swellings of females and therefore compete especially intensively over fertile females. A dominant male is entirely capable of keeping its competitors away from the female during the key timeframe, which it can determine to within a few days, and ensuring its own fatherhood.
Through humans' concealed ovulation, the possibility disappeared to determine within a few days when a woman could be impregnated. That does not at all mean, however, that a man was now required to watch over and court the woman lifelong in order to be sure of his fatherhood. This is a widespread, unequivocally false assertion, which has often provided the basis for scientific speculations about human sexuality.
That women did not display their fertile days certainly does not mean that men had no clues as to whether they could be impregnated at a given time. For one, they could rule out this possibility in many cases. Women who were obviously pregnant could certainly no longer be fertilized. The same was true for women with children under weaning age. With a woman who had a child every four years, one could easily narrow down the time period during which she might be fertile within these four years, based on external signs, to half a year. For another, menstruation showed reliably that a woman was receptive in principle – if not exactly at the time of the bleeding.
Men find – as already presented – women with a slender waist more attractive because a fat belly under natural conditions indicated a pregnancy. Presumably, men also found women more attractive in whom they had recently observed a menstrual period or had been able to discover signs of such. An indication of that could be that women, in their efforts to make themselves more attractive, regardless of changing fashions always go back to painting their finger- and toenails red. In the orient, the use of henna to color hands and feet is an uninterrupted, millennia-old tradition. In times before clothing was known, due to a woman's menstruation, blood traces would primarily be observed in the genital area, on the legs and feet, and because of efforts to

clean herself, on the hands. If men should basically react positively to red spots in these regions of the body, then this would no longer be surprising. Small traces of blood would presumably remain the longest in the area of the nails, where there are some problem areas that hamper thorough cleaning. The relationship of the color red to human sexuality is clearly expressed – one need only think of the “red light district” – [and] a high importance of menstrual bleeding to male sexual behavior in the human developmental period could certainly have provided the biological basis for this.

High-ranking males were obliged by concealed ovulation to find themselves “life-segment companions,” since they were not able to determine within a few days when a woman could be impregnated. They were by no means obliged, however, to bond with a woman for a lifetime. Anyone who falls for the account that women had “fooled” the men with their concealed ovulation and thus pressed them into taking care of a woman for an entire lifetime if they wanted to ensure their reproductive success (Margulis & Sagan, 1991), underestimates the men.

Human sexual behavior certainly differed superficially quite clearly from that of the chimpanzees, but underneath lay the same multi-male group structure. By far the most children of a band were begotten by a few high-ranking males. For the assumption that men became much more deeply engaged in rearing children, I see no sufficient evidence.

For partners from the same group, the love of a man would usually have lasted until the first signs of a pregnancy, after which his interest declined and his eye was freed to the attractions of other women who offered more chances for him to reproduce quickly again. Especially distinguished men were probably also quite able to monopolize multiple women at the same time. Women still found the necessary protection in the group, and could attach themselves to lower-ranking males during periods of their life in which they were not fertile, who would not have had a chance in the contest over the currently desirable women anyway. It is questionable, however, whether the women would have had any interest in such a partnership. Occasional sexual favors were a much more dependable means for getting access to delicious morsels, such as for instance meat captured by men in confrontations with carnivores, than a firm tie to a partner. Women who were not momentarily claimed by a dominant man would have had little provocation to bind themselves to another man of their own will. They could always dodge unwished-for pursuit by lower-ranking men, in that they came under the protection of higher-ranking men who surely would not let such an opportunity to make themselves important pass them by.

The behavior of a man looked different when his current partner had recently changed over from another group with his support, than in love affairs with women belonging to his group. Had he left her during her first pregnancy, she would have been – a few months after the change of group and equipped with only rough knowledge of the new language – defenseless as a stranger against the animosities put out by group members. Thus, the man, by leaving the woman, would also have endangered his investment in the growing child. He would thus have stuck with her longer and in that he did this, he developed much stronger feelings toward young, strange women with whom he entered into a partnership than toward familiar women from his own group; these feelings are well known to us and clearly outlined in the meaning of falling in love. The tie would normally have been firm enough to survive the first pregnancy and lasted for some time beyond it. From a reproductive point of view, it would have made sense in such a case to maintain the partnership until the next pregnancy and thus in the course of ca. four years become the father of two children. (Perhaps there even exists here a connection to the fact that the divorce rate is highest after four years of marriage (Ridley, 1995).) After the passage of four years, the stranger would surely have counted as integrated, and the feelings of her partner would then typically also have cooled off so much that in the course of the second pregnancy, the temptation of a relationship with a new woman with whom he could quickly have further reproductive success came easily.

Lower-ranking men had poor chances within their groups to become fathers. They could try, though, to put something over on strange women in order to move them to sexual intercourse. They then surely tended more toward delaying an introduction of the woman into their own group, in order to remain in the uncontested position of the lover as long as possible and not be unmasked in the eyes of the courted one. Seeing through such men was the task of women who wanted to change groups. For women for whom changing groups was not a main concern, they were entirely suitable partners, in particular if their low rank was not due to lesser talent, but simply to youth.

A high-ranking man who had gotten involved with a strange woman presumably pushed for a change of group, since he had to count on the woman having sexual partners in her natal group as well, whose approaches he could not suppress. The sooner she left the old group, the better his chances were of becoming the father of her first child. He was therefore pronouncedly jealous and did not like it when she left his sphere of influence. As, however, men with very high rank have high reproductive potential within their own groups, they were probably not the most jealous when it came to getting to know strange women. They had to pay too much attention that the woman (women) that they were trying to monopolize within their own group at the time didn't stray in their absence. Since they could achieve reproductive success with less investment with women of their own group, they should have concentrated their strength on monopolizing these women. This need not mean that they tended less to fall in love with young, strange women. Presumably, though, jealousy prevented them from getting too far away from the women to which they already had access.

If there was a powerful chief within a group, then he presumably reserved for himself sexual intercourse with the women in the group who were in a reproductively promising portion of their lives and therefore were perceived as most attractive by the men. The men who held the next places after him in the rank order could try to introduce young women from other groups and would then also have had a chance to prevail over him in a "claim of ownership" on such a woman. If, that is, the chief tried to take the woman away from such a man, they he would have had to reckon with embittered opposition because of the strong emotions in play. He would thus have provoked serious confrontations in whose course the entire rank order might have been called into question – a process in which he had the most to lose. The upper layer is always interested in the stability of a society. The danger was less, however, the lower the rank of the man who tried to introduce the woman, so that the probability that the claim of ownership of a man would be accepted was directly connected with his rank in the group.

In efforts to gain the favor of strange women, it was probably sensible for all men to emphasize the strength of their own groups. Through joint advances into enemy territory, one could not only intimidate the opposing men. One could also discredit these men thus in the eyes of the young women of their group, as well as contrast oneself favorably with them and thus raise the readiness of these women to change groups. Perfected power displays of a modern type, which for commercial reasons aim to call up corresponding emotional reactions in young women, can be observed among the so-called boy groups. The reactions to this of the young, female fans range into hysteria, which is surely not only due to the mass nature of the production and the enrichment of the breathing air with hormones, since the objects of their desire pull out all the stops in order to make themselves exceptionally attractive:

- The band members are already clearly highlighted and thus emphasized through their position on the raised stage and the spotlights.
- Synchronized movements and singing together document the tight cohesion of the group and its abilities in cooperative, coordinated actions in a downright excessive way.
- Access to extensive resources is – often impressively – demonstrated, in that expensive clothes are worn or expensive guitars are destroyed.
- Although the impression is aroused that the band members could have any woman, exactly those songs are often the most successful that emphasize love of one individual and swear absolute fidelity to her.

It shouldn't surprise anyone that parents' well meant, and in part based on personal experience, objections to these "dream men" fall on deaf ears.

Certainly, young women were, in the course of warlike conflicts, not only convinced to change groups, but were also, if the opportunity arose, forced into it.

Rapes in connection with warlike conflicts presumably have at least a two-million-year-old tradition in the human developmental line. Possibly, the roots of such behaviors reach even farther back, since the behavior of common chimpanzees recruiting strange women to their own group, using force if necessary, shows structural similarities. Since humans have in common with their nearest relatives the use of violence in this context, it could easily already have been in the behavioral repertoire of the common ancestor 5 MY ago, the more so because it makes sense from an evolutionary perspective for the males of a multi-male group (again, the notation is appropriate that this can be neither a justification nor an excuse for behavior of this kind).

Human sexuality surely did not serve only for pure reproduction; it plays too large a role in our lives for that. It became instrumental in preventing aggression within a group and thus strengthening the group association. Physical closeness and exchange of tenderness up to and including sexual intercourse were probably the rule, as long as the female partner was not claimed by a higher-ranking male. The latter occurred primarily during the – in comparison to the total period of her life in which a woman is sexually active, quite short – timeframes in which she was going through a fertile phase and therefore was especially attractive. Lower-ranking men thus also did not lack for sexual contacts, although it was easier for them to go without sex with an especially attractively perceived woman. Thereby, the level of aggression in the group was lowered. In addition, lower-ranking men thus got a – perhaps only low – chance to reproduce after all, since it occasionally happens that a woman ovulates for the first time after stopping lactation before she has her first menstrual period. In such a case, she could be impregnated before the first bleeding induced higher-ranking men to increase their efforts toward her.

Women for themselves were again – just like chimpanzee females – probably interested in having sexual intercourse with as many men in the group as possible before the birth of a child, in order to prevent any attacks by the men on the child. This is also a possible explanation for why many women tend to enjoy sexual intercourse especially intensely right during pregnancy – this really can no longer serve for fertilization. With the disappearance of her periods and the appearance of the first clear indications of pregnancy, the jealousy of the high-ranking man, who up until then had claimed the woman for himself alone and was also most probably the father of the child, disappeared. This was the right time, through an expressly intense sex life, to win the good wishes of the other men for the coming child, or also simply to confirm her own position in the group, for which fun in sex was a definite advantage.

A further important role of sexuality probably consisted in allowing women access to the man-resource of meat.

These two uses of sexuality are also found in chimpanzees. Common chimpanzees occasionally exchange meat for sex (Goodall, 1986); bonobos strengthen group cohesion through their greatly expanded sexuality (Savage-Rumbaugh & Lewin, 1995). Interestingly, ovulation in bonobos is also de facto concealed. They do show a marked genital swelling, but this is retained for so long that its value as an indicator of ovulation has decreased significantly. This process has led, however, to anything but exceptional fidelity of partners. The instrumentation of sexuality for the stabilization of groups is the result of a parallel development in humans and bonobos, whereby humans were presumably the first to walk this path. The excessive sexuality of the bonobos is presumably an adaptation to the current interglacial period and is thus a very recent development.

A main point of attention for the bonobos lies in the limitation of aggression, which as a rule can appear among unrelated females of quite a large group – hence also the marked physical adaptation to homosexual intercourse between females. In humans, the males have developed into the best at fighting and most aggressive primates of all time. Simultaneously, because of group conflicts, very high requirements were placed on the cohesion of the group. Human sexuality was therefore primarily instrumented in order to limit the aggression between the men of the group (this could again be one of the causes for the quite frequent appearance of male homosexuality, see Chap. 5.5).

Studies of human sexuality should consider that the group changes of women, as by far most demanding, but most necessary, portion of human sexual behavior, should have led to the most prominent adaptations. In the context of group changing, the most intense feelings and bonds came about. Human templates for seeking partners have developed so that it regularly occurred that humans preferred a strange sexual partner, although a known one was much more readily available. Most children were not conceived between strangers, however, but between close acquaintances. And the criteria by which these partners were chosen within the group are only difficult to make out because the human partner search template was dominated by ideal figures for the group change.

It is to be assumed that men do not only prefer young, strange women that do not yet show any signs of pregnancy. Men probably find familiar women who have a three-year-old child more attractive than those with a one-year-old child, since in the latter case, the mother will probably wait longer to become pregnant again (more precisely stated, a one-year-old child would, under the conditions that prevailed during the decisive evolutionary developmental period for humans 1.8-0.07 MY ago, have held the mother back longer from a new pregnancy).

Maybe men also feel especially drawn to women whose youngest child initiates big arguments at about three years old. On the one hand, the powerful child shows that it has a good mother; on the other hand, the racket could indicate that it is presently being weaned. This would mean that the woman could soon become pregnant again. It would be very interesting to study what influence the fact that a woman has milk has on whether she is felt to be attractive. Presumably, a mother’s breast that is still giving milk will substantially lower the attractiveness of a woman in the eyes of men.

Respected women surely also had better opportunities in human social bands to support their children; they would thus have had higher than average reproductive success. This would be reason enough to find the socially higher-placed among known women more attractive.

In any case, men should feel more strongly drawn to familiar women who have just lost their youngest child.

All of these preferences will, however, be difficult to prove, because they pale next to the glowing image of the young stranger before her first pregnancy (not for nothing do this sort of "young strangers" rule the high-gloss pages of men's magazines as well as the runways of the fashion makers).

Menstrual bleeding presumably developed into the most important indication of the reproductive condition of a woman. After a direct indication of her fertile days was no longer available, bleeding became the most reliable indicator for the reproductive status of a woman. A woman who got her period was with high probability not yet pregnant. That she, at the time of the bleeding itself, could not be impregnated played a subordinate role, since for lack of a direct indication of fertility, men were already required to monopolize women for longer periods of time.

Men should thus feel more strongly drawn to women in whom they observe bleeding. At the latest with the beginning of the first menstruation after a preceding pregnancy and nursing phase, a woman stood at the center of male interest again and was consequently probably claimed by a high-ranking man for himself.

Unfortunately, exactly this area of human sexuality is very strong culturally adulterated. The period is seen as an "uncleanness" that a woman has to handle as discreetly as possible. Presenting a man with a bloody thigh for scrutiny is an absolutely impossible behavior. An even halfway natural relationship to one's own body is, on the subject of menstruation, which was taboo for generations, out of the question. In fact, it is easily conceivable that menstruation was so rigorously made taboo exactly because of its high significance to human sexuality.

I would like to conclude this speculation-laced chapter with an attempt at "rescuing its honor":

If a man in his best years, under obvious disregard for all practicality, endangers his familial happiness and risks putting his position in society on the rocks and slapping a trusted partner in the face just to start an affair with a young woman he didn't even know half a year ago – then this man isn't feeling his oats, he's not experiencing a second spring, no, [untranslatable pun, lit.: "an ape is picking lice from this man," fig.: "this man can't believe his eyes"] – and it [the ape] is within all of us.

5.4.1 Concealed ovulation

In my considerations of the natural sexuality of humans, I have simply presupposed that ovulation in women was not shown. Within my model, this is justified inasmuch as I bring the transition to the Late Paleolithic into conjunction with a substantial change in human sexual behavior and before that, assume an extensively natural sexual behavior just 0.07 MY ago. The question of the natural sexual behavior of humanity is thus a question of its behavior of, from an evolutionary perspective, a very short time ago, and the assumption that ovulation was concealed by then is obvious.

Nonetheless, the question of why ovulation is concealed in women, in contrast to female chimpanzees, is entirely worth studying here. Concealed ovulation is, namely, popularly used as evidence for the thesis that humans are biologically adapted to spend their lives with a firm sexual partner. And this thesis stands in clear opposition to the ideas I present. To be precise, I have already rejected this thesis with the statement that with menstruation and with signs of a pregnancy, even without rump swellings clear indications of the reproductive status of a woman were available to the men. Complementarily, I will now also take a position on concealed ovulation.

That I did not treat concealed ovulation with the rest already is not because no explanation for it occurs to me in the framework of my evolutionary model. I have the opposite problem – I can think of two equally conceivable scenarios and have no opportunity to falsify one of them. I would therefore like to present both explanatory concepts.

First scenario: A strategy described by Jane Goodall for the male chimpanzees of Gombe to raise their own reproductive success is, as she calls it, the "honeymoon excursion." A male tries to lead a female into the edges of the group's territory right before ovulation, in order to ensure his own reproductive success without troublesome competition from other males of the same group. Now, the females are not always interested in that sort of excursion. At the edges of the group's territory, they are placed at much higher risk to life and limb than in the center. And if they are accompanied by a small child, then it is truly endangered for the first time. Sometimes, it would really be better for the female not to go along. It is, however, visibly difficult for a female in the male-dominated chimpanzee society to close herself to a male's emphatically presented wish.

Through the advance of the australopithecines into the savannahs, it could have become much more dangerous for the females to allow themselves to get involved in a "honeymoon excursion." The same can also be assumed in connection with the intensive confrontations between groups that appeared with late *Homo habilis*. In the end, at Gombe and not just there, it was observed often enough how at the edges of territories females with their offspring were attacked by strange males, whereby the young were not infrequently killed and partially eaten.

Such changes in the environment and in lifestyle could have shifted the cost-benefit balance of visible ovulation for the females and led to concealed ovulation. The benefits of displayed ovulation lie in giving the males the opportunity to compete over the female during the decisive phase, and in this way to ensure high-quality gametes for her own offspring. In addition, the females are in this way spared for the vastly larger part of their lives from male impositions and can devote themselves to important things, like looking for food or rearing children. The costs result from the fact that because of the advertised ovulation, it is worthwhile for the males to isolate females from the group for a short time, from which results a higher risk to the female and the child accompanying her. With increasing endangerment of the female outside the group, the costs may have outweighed [the benefits], and females who were less attractive to males because of a less marked genital swelling managed for just that reason a higher reproductive success. At the end of this development stood concealed ovulation.

Second scenario: One of the theses integrated into my evolutionary model says that human sexuality was instrumented analogously to the relationships among bonobos, in order to stabilize groups. This presumably occurred during the course of the last 2 MY. If ovulation is not to have been hidden at the beginning of this process, then concealed ovulation could be concomitant to this process.

Similar to bonobos, the increase in importance of sexual behavior will have led first to emphasis on the genital swelling and the expansion of the timeframe in which it appeared over the larger part of the cycle. Thus, it would have lost its value as an indicator of ovulation, and men who found a marked genital swelling attractive would no longer have been able to draw any reproductive advantages from it. With time, men would have prevailed who judged female attractiveness according to other criteria more interesting to their own reproductive success – such as, for instance, menstrual bleeding or a slender figure. Genital swelling would thus have lost its functionality and would have waned, over the course of time, as a troublesome hindrance to walking upright.

A similar fate may await the bonobos, if they yet survive long enough. They are now just at the beginning of this development, since they must just have employed their sexuality for the stabilization of groups during the last ten thousand years (since the end of the last Ice Age). In bonobo females, genital swelling is displayed over a large part of the cycle and has already declined significantly in value as an indicator of ovulation. And the males have already reacted to this. While males of the common chimpanzee as a rule find females without genital swellings uninteresting and only copulate with females who show such a swelling, bonobo males are by far not so choosy and ask females without genital swellings for sexual intercourse as well.

5.4.2 Sperm competition

In a multi-male society, many males often have access to a female. Above all during phases when there is no expressly dominant leader in the group, it is sometimes impossible under certain conditions for any of the males to monopolize an attractive female. Competition for reproductive success then takes place in part on the elementary level of a race between sperm. Raising the sperm count is an easy means for a male in a multi-male society to improve his own fitness. Consequently, chimpanzees have the largest testicles among the apes. The testicles of *Homo sapiens* are significantly smaller, and this is taken as evidence that the original human group structure cannot have been multi-male (Lewin, 1992).

Meanwhile, however, subtler forms of competition among human sperm have been determined. The number of sperm in an ejaculation rises, for instance, when the man is jealous, and also particularly when he has reason to believe that another man had an opportunity to have sexual intercourse with his sex partner. Thereby, not only the number of sperm changes, but also their characteristics. Jealous men produce a multitude of “killer sperm” and “blockers,” which are not at all meant for reproduction. Killer sperm attack foreign sperm, and the blockers construct a blockade around the egg cell and only let their “own” sperm through (Morris, 1994). These are clear evidence for elementary competition between men at the sperm level. Such adaptations only make sense in a social structure in which multiple men regularly have intercourse with the same woman – a clear indication of the multi-male origins of humans.

Nonetheless, it remains to be clarified why men have passed up the most elementary means in the battle of the sperm: large testicles. Here, the throwing hypothesis helps again. Large testicles don't just bring advantages with them. They are also a "soft target," at which chimpanzees (de Waal, 1991) as well as humans really like to direct their attacks.

Testicles have to be placed outside the body for cooling and in bipeds are extra exposed by the body posture. It is thus only obvious that an organism like *Homo erectus*, which showed greatly thickened bones because of conflicts involving the use of stones, would reduce the attack surface in the sensitive genital region through reduction of the testicles. For a thrower, human testicles – they are larger than a gorilla's – are surely still sensitively oversized.

Another peculiarity reflects even more clearly the necessity, appearing in the course of human evolution, to minimize damage from stone projectiles in the impact-sensitive genital area. In contrast to all other great apes, humans have no baculum (Steitz, 1993), which represents an important aid to erection. The only advantage is clearly at hand: where there is no bone, no bone can be broken. Without a baculum, the man is solely dependent upon the erectile tissue; the erection is difficult to produce, which can then lead to problems of potency.

5.4.3 The hymen

"The hymen is usually a sickle-shaped flap of skin partially covering the vaginal opening and is more useless than the appendix or the tonsils; if it is still undamaged, then it will be thoroughly torn apart during a woman's first sexual intercourse, which hurts a little and bleeds. As with the teary crying of adults that is only encountered in humans, the hymen plays a rather dark physiological role – if any at all." This text passage is found in the book, "Secret and Ritual – The Evolution of Human Sexuality" by Lynn Margulis and Dorion Sagan. What crying is for, over which Darwin – with exceptional futility – slaved, was already presented with a clear explanation within the CTSW model – in this chapter, the issue is the hymen.

It may certainly be that the hymen "arose as a birth defect of little consequence, similar to webbing between fingers and toes" (Margulis & Sagan, 1991); what presents difficulties, however, is an explanation for the success in expansion of this feature. Up to and including the

present time, great importance is placed in many societies on whether a woman marries as a virgin, and the hymen must hold up as proof of that. Since for the hymen no additional function is known, the assumption seems clear that it was "bred" into women by men, through sexual selection, for just this purpose. The following scenario is proposed:
Men, who because of a transition to a small family unit invested a lot in their offspring, had to be certain that their chosen one was not already pregnant by another man, and therefore preferred virgins. Women who went into "marriage" as virgins and could also prove this with a present and undamaged hymen got a good man and provider more easily and as a result showed higher reproductive success. This again led to this feature spreading in the population.

Of course, I could accept this argumentation with slight changes. The raised investment of the men would then result from the requirements of introduction to the group. The advantage of virgin women would have resulted from their finding a reliable partner for changing groups more easily. This course of argumentation places a false assumption at its base, though – the assumption that a man could only be sure that his woman was not yet pregnant by another man if he could determine her virginity. With the menstrual period, there exists a second reliable feature that, independent of whether a woman is still a virgin or not, makes clear that she is not yet pregnant. Decisive for the reproductive value of a young woman is whether she is pregnant – virginity plays no role in this from a biological perspective. Limiting oneself to virgins and excluding women with equally high reproductive value, although they can prove with their periods that they are not pregnant, makes no evolutionary-biological sense from the perspective of the men (culturally, in comparison, such nonsense can quite easily come to be, since cultural development is, as we will yet see, not oriented toward reproductive success).
The hymen thus presumably did not develop and spread as a sign for virginity, but as a pretense of a menstrual period at the right time. The hymen makes an appearance only one time in the entire life of a woman – at her deflowering. This occurred either in the natal group before her first encounter with a stranger or through this stranger. In the second case, the attractive power of the woman toward this new companion was strengthened, since bleeding was usually a case of menstrual bleeding, which showed that a woman did not yet expect a child, and therefore had the effect of increasing her attractiveness to men. Precisely women who were depending on a change of group and had therefore been very sexually hesitant in their own natal groups (in order to prevent a premature pregnancy) often had their first sexual intercourse with strangers. If such a

woman had a hymen, it was now torn, whereby the bond of the man was strengthened at the decisive moment. This did not happen, however, because he now recognized her as a virgin, but because he found bloody thighs attractive, since they had "always" represented a sure indication of the reproductive status of the woman.

For the man, no disadvantage grew out of this "error," since a deflowering rules out an already existing pregnancy just as surely as, if not more surely than, menstrual blood. For the woman, the hymen presented from the beginning a helpful tool for the solution of the most difficult task that stood ahead of her in life – the successful change of group. As it was, on the other hand, not tied to any sort of disadvantages, this feature spread widely through the entire population.

For the sexual behavior of young women in their natal groups, the spread of the hymen presumably had its own important consequences. It was now more worthwhile for young women to be exceptionally hesitant about their first sexual intercourse and thus to wait for a strange "dream man." Otherwise, they would have forfeited an important means of assistance in changing groups prematurely. Thus, for humans, even under precultural conditions, it would not have been at all typical for a young woman after reaching sexual maturity to first spend her days for two years in exceptionally excessive sexual behavior in her own group, as was documented of the Gombe chimpanzee female Fifi (Goodall, 1993). It could, however, be that the behavior of young women in this respect depended strongly on their position in the natal group. "Princesses" like Fifi, for whom a change of group offered on the bottom line more disadvantages than advantages, could afford to be much more sexually open. They were also presumably judged to be more attractive because of their high rank, and in any case had more trouble keeping admirers from their own groups out of their hair [lit.: "hold them away from her throat"]. Young women with especially low status in the natal group got, on the one hand, more out of changing groups. On the other hand, it would also surely have been easier for them to avoid sexual contacts in the natal group.

5.4.4 Why are women the "pretty sex"?

Men place uncommonly high value on the external appearance of women. They are thus quite choosy, which again is interpreted as an indication of high male investment and thus a natural predisposition to lifelong pairbonding and active participation in childrearing. But even this interpretation, which I can take on slightly altered because the introduction of a strange woman into one's own group was tied to high investment of the man, helps no further when it comes to the female breast.

Women have permanently enlarged breasts, whereby the size of the breast has no functional relationship to the ability to produce milk. Nonetheless, men show an especially keen interest in the female breast. The male preference for firm women's breasts and the fact that women wear permanently enlarged breasts for show present some problems from the evolutionary-biological perspective. This becomes clear when one looks, for instance, at chimpanzees. Among our chimpanzee cousins, only nursing mothers display enlarged breasts. Such females are classified by the males as sexually unattractive, which makes sense, since they are infertile during this slice of life. In chimpanzees, full breasts thus do not increase attractiveness; rather, they decrease it. The ideal of beauty is the flat-chested female (in estrus).

An obvious explanation for the permanently enlarged breasts of women is sexual selection by men, but these must then have already developed a preference for full-bosomed women ahead of time. As long as most women only showed full breasts during their nursing time, men would clearly have been disadvantaged in reproduction by such a preference. They could not have prevailed, therefore, in a population. For this reason, the popular explanation that the preference for the female breast might go back to an association with the roundings of the rear end makes little sense. Such a "confusion" was not selectively neutral to begin with, rather fitness reducing, and would not have been able to prevail in the population.

Now, the full female breast of chimpanzees is not just an indication of the reproductive status of the female, it is additionally a reliable criterion for differentiating between the sexes. In humans, the body outlines of the sexes differ much more strongly than in chimpanzees, and exactly those features that emphasize the difference are perceived as exceptionally attractive.

This could be a direct consequence of the throwing adaptations inasmuch as the availability of a distance weapon ought to have made initiation of contact between potential sexual partners very difficult. I would thus like to offer an additional explanation for the fact that women are the pretty sex among humans, which rests upon the special adaptations of the hominids, and thus cannot be demonstrated through observations in the animal kingdom.

According to Grammer, animals must overcome circumstances that do not permit the necessary physical closeness in the process of advertising themselves. As the most frequent adversities, he names territoriality, aggression, status differences, and fear (Grammer, 1993). Chimpanzee males encountering strange females are quite obviously placed in an inner conflict between the devotion that a potential sexual partner triggers and the refusal that all strangers provoke. This conflict expresses itself in that, in the behavior of a male toward a strange female, open animosity and social grooming can directly follow each other (Goodall, 1986). This happens even though the male is so close to the female that even the sense of smell can serve to convince him that she belongs to the opposite sex and could be an interesting sex partner.

The problems with the approach must have been even more strongly emphasized in the sexual behavior of throwers, since it must precede an initiation of contact, while an attack with stone projectiles can already occur at a notable distance. Early *Homo erectus*, at 1.8 MY ago, was already perfectly physically adapted to throwing and thus capable of causing serious injury to an opponent across a distance of over 50 m. Strangers were not only hated and fought [hand-to-hand], as in chimpanzees; it was essentially not a good idea to allow them to get too close. And yet, strange men and women had to get closer to each other, since exclusively within-group reproduction in the small groups would have led to an intolerable burden on the heirs through incest. Parallel to the improvements in the area of throwing and to increasing xenophobia, adaptations in the sexual arena must thus have developed that ensured that women who wanted to switch groups could be recognized as such by males at large distances and would not be attacked. Vice-versa, women had to tolerate the approach of potentially exceptionally dangerous men.

I would like to point out again here that there are different explanatory levels for the motivation underlying a behavior. There is, for instance, the level on which the person explains his own behavior and integrates it into his worldview. On this level of explanation, feelings are a possible explanation for observed behavior. Further points of view on this explanatory level could be socially enforced norms, to which one must hold oneself. The explanatory level of evolutionary biology is another. Here, one asks after the function behind the behavior. Feelings certainly belong among the immediate causes for behavior, but they are adaptive traits in themselves, which have the task of arranging the behavior of an organism such that it follows its fitness interests. And the question that interests us here is how these fitness interests, which stood behind the feelings, looked.

At the first encounter of two potential sexual partners, it was very important that they recognized that they belonged to two different sexes. Among the australopithecines including *Homo habilis*, this was probably not all too difficult because of the enormous size difference between the sexes.

No later than the transition to *Homo erectus*, however, a different solution had to be developed, since a *Homo erectus* woman could easily have a body height of 1.80 m.

Throwing is an exceptionally demanding activity that places very narrow requirements on the physique of the thrower. Similarly to chimpanzee males, whose canines are significantly longer than in the females, men's throwing qualities are more expressed than are women's. Since men were very narrowly determined in their external appearance through their throwing adaptations, the women developed divergent features in which they clearly differed from the men. They thus became the "pretty sex" among humans and made sure that at the first encounter, they would not be confused with a man and preemptively stoned. Flat chests and wide shoulders are characteristics of good throwers that the men could not do without. Women stood out more reliably who wore narrow shoulders and full breasts for show. Among the men, then, those were more reproductively successful who reacted positively to this type of differential features and could create contacts with strange females more easily.

The female breast is not only found most attractive in the phase of life in which a chimpanzee female would try to change groups; it also emphasizes the difference between the sexes in a region of the body that has decisive significance to throwing qualities. The female breasts present, in humans, a throwing handicap visible from far away that ensured in this way that young women were perceived as less threatening and at the same time recognized as women, and thus relieved the strange man in his inner conflict between approach and avoidance brought on by the stranger. That a full breast originally indicated that a woman was already nursing a child and was thus infertile at this time played no great role in this. The preference for large breasts developed in the context of encounters with foreign women. Children by whom they may have been accompanied were presumably also killed, as has been observed in corresponding encounters between chimpanzees. The women thus quickly had a subsequent ovulation.

5.4.5 The first rendezvous

Until the transition to the Late Paleolithic, the initiation of contact with strange members of the other sex was presumably among the most difficult tasks that stood before humans in their lives. Thus, nonverbal advertising behavior of humans was displayed in order to overcome a significant barrier in the initiation of contact. If a man wanted to get close to a woman, he would have to, ahead of time – over a distance of perhaps 50 meters – arouse her interest in him. He had to convince her at that distance that he had no hostile intentions, that he was interested in her, and that it was worth it to him to take the risks of an approach to her.

The man as well as the woman was exposed to substantial risks during the initiation of contact. It was the men, after all, who entered strange territory in order to get to know the women. They ran the risk of being caught by men of the enemy group, which could easily happen because of a betrayal by their partners if something went wrong in the relationship. Women turned themselves over without immediate protection to strange men, who were clearly physically superior to them and could become directly dangerous. Under such circumstances, it was primarily a case for proceeding carefully. So a rushed attempt by a man to get close to a woman could prompt her to flee and call for help, whereby he could then come into acute danger.

For that reason, human flirting behavior is set up for deciding further proceedings at large distances, even before the actual approach takes place. To this, one finds in Eibl-Eibesfeldt: “In the initiation of relations over distance, eye contact plays a large role. One attempts it and thus shares with the partner that he is the object of interest. Thanks to the whites of the eyes, we humans can read the eye movements of our partners well. If the gaze is returned, this is generally a positive answer” (Eibl-Eibesfeldt, 1995). The exceptionally white eyeballs mentioned here and the very marked mimicry of humans can certainly be matters of throwing adaptations, since they made it possible to perceive social signals over large distances correctly – an important ability for a social organism with a distance weapon.

The attempt to initiate a relationship is usually preceded in humans by a phase of undirected display. Actually, humans always display when they are aware of being observed by members of the other sex. Men try in this to emphasize their social status and demonstrate their – also physical – capabilities. Women primarily try to bring their physical appeal into effect (Grammer, 1993). Thus, it is decided in men as well as in women within the first 30 seconds whether there might be any interest in the other. For this decision, ideal images of the potential partner ought to play a role (Eibl-Eibesfeldt, 1995). Humans are also specialized for quickly determining the market value as a partner of a stranger at large distances. This is an ability that, in the face of a stranger holding a distance weapon in a generally expressly aggressive species, is very valuable.

Of the actual approach, Karl Grammer (Grammer, 1993) writes:

> “Cook assumes that the approach (here, an approach on the part of the man is assumed) usually occurred very cautiously. First, he will turn his body toward her, but avoid staring at her and instead keep glancing in her direction. If eye contact

> occurs, it is quickly broken off again; simultaneously, a suggestive smile can often be observed. Jerky head motions ensue, wherein the head is moved to the back or to the side. These movements are often accompanied by touching oneself (automanipulation).
>
> Givens also describes a multitude of body movements that follow one another during this phase in very rapid sequence, such as: automanipulation, arranging clothing, stretching oneself, glancing sideways, etc.
>
> With increasing proximity to the desired person, the number of automanipulations increases. Scratching, touching the face, and playing with the hair appear. All of these motions could serve as indications to the other that his[/her] presence exercises a certain influence on him[/her].”

Above all, though, they must indicate that the approacher is unarmed. The use of the hands, which are known to be able to direct dangerous weapons, for activities that belong more to the realm of social grooming thus emphasizes the harmlessness of the approacher and his peaceful intentions.

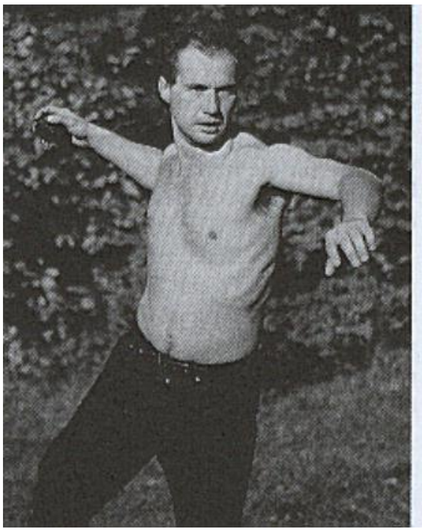


Figure 15: The fixation of the target, a characteristic body position, and the carrying of a suitable throwing projectile in the hand indicate that a thrower is about to attack.

Since men could throw exceptionally, strange women had every reason to be careful and to observe a decrease in distance with caution. And just because of this, an approach by the man had to happen extremely carefully. Not staring at the woman during this made sense for many reasons at once. On the one hand, staring represents a challenge to many primates and would be felt as threatening; on the other hand, staring at a target is indispensable to a thrower if he wants to hit it. Staring thus belongs for a thrower among the immediate preparations for attack. If a woman is stared at by a thrower in whose range she is located, then she has very especially good reasons to feel threatened.

If a young woman and a man unknown to her were able to “get closer,” very different relationships could result from this, whose function primarily consisted of holding incest within limits. The bandwidth of relationships would have ranged from a “one night stand,” in whose course a self-confident young woman with no intentions of changing groups might conceive her first child, up to a long-term romantic love relationship that led to a change of group for the woman and ensured her a reliable partner in the new group for years to come. All relationships presumably had in common that they involved a separation of the lovers from their groups for a time. Here something took place that came very close to the "honeymoon excursions" observed by Jane Goodall in chimpanzees.

Different from chimpanzees, though, such "honeymoon excursions" presumably took place only among young, childless women and primarily with foreign sexual partners. The reason for this assumption is the significantly higher danger from predators for a primate that spends the night on the ground. Stones could primarily be very effective weapons in good visibility and with the common action of a group. I have already speculated that in a larger, well-formed group of *Homo erectus*, spending the night on the ground might be tied to lower risk than spending the night in the trees. For an isolated couple, this would have looked different. Such a [couple] would still have been, even in the very talented thrower *Homo erectus*, exceptionally endangered at night. The partners presumably only undertook such a risk if it was really "worth it," and this was the case primarily for strange sexual partners.

The high risk that went with the "honeymoon excursions" is probably also the cause of the romantic significance of the moon for humans. The brighter the moon shines, the better the vision at night and thus the better defended the individual thrower. Predators have great difficulties taking prey on a full moon night, since they are recognized early by the potential prey animals. If "honeymoon excursions" led to people spending the night without the protection of the group, then it was surely better if one primarily fell into romantic moods and undertook such excursions at the full moon.

5.4.6 Fashion

The susceptibility of humans to changes in fashion is quite remarkable. Women primarily follow fashion in an effort to raise their attractiveness. That they are generally also actually successful in this is hardly doubtable. It is quite obvious that a new hairdo, a new, differently-cut dress, as well as many other changes in external appearance are able to raise attractiveness and can occasionally also lead a long-term partner to risk a somewhat longer glance. If we let ourselves be positively influenced in judging the attractiveness of a sexual partner by such, in principle, extensively arbitrary cultural variations in exterior, then this easily raises the specter that humans are culturally mutable in any way – without consideration of origins-historically acquired points. Precisely sexual behavior stands in immediate relation to reproductive success. If any area of human behavior is strongly subordinate to the dictates of genes, then it should be sexual behavior. Error in this area has an enormous influence on the fitness of the individual and should thus hardly be tolerated, as long as an effective influence of the genes on behavior exists. If our biological inheritance still has meaningful influence on our behavior, then one should be able to demonstrate this right in the partner search templates of humans. If this does not work, then the behaviorists' tabula rasa hypothesis gains in plausibility, which assumes that humans are culturally mutable at will.

Now, I do not think all too highly of the tabula rasa approach, and for the fact that humans respond positively to fashion changes, my model of the natural sexuality of humans has a sound biological reason. In women, the attractiveness-increasing effect of fashion is based, on the one hand, on the emphasis of features to which men react positively, and on the other hand, on constant change.

Features that are emphasized or pretended are primarily youth, a promising reproductive status (slender figure; traces of red color that could indicate a recent monthly bleeding under natural circumstances, e.g., red painted finger- and toenails), health, and the power to dispose of resources. Why these characteristics individually act to increase attractiveness, I have already explained.

Constant change leads, to a certain extent, to estrangement. The discovery of new aspects in a known person can let this [person] seem strange to a certain extent and thus serves, together with the aforementioned emphasis on youth and a favorable reproductive status, the ideal image dominating the partner search template of man of the young, untouched stranger.

5.4.7 Men and children

There are scientists who believe they can prove that men demonstrate adaptations to the role of father (Eibl-Eibesfeldt, 1995). This is taken as clear evidence that the nuclear family (including the father) truly represents a biological adaptive trait of humans and not a purely cultural discovery. Observations, according to which men like to play with children, can behave in a child-oriented way, and obviously develop a keen interest in children, are interpreted as evidence for a genetic fixation of the father role. Such an interpretation excludes, however, that chimpanzees, which know no father role, can behave similarly. – Observations contradict it.

Males that like to play with children can also be observed among chimpanzees. The interest in newborns is also very marked. What affects child-oriented behavior and care, Jane Goodall cites best:

> "Passion was dead. She had fallen down in the night and hung in a tangle of lianas, in which she had caught herself with one arm. Her three offspring, who had accompanied her constantly for the last three weeks of her life, were with her. Pom and Prof just sat there most of the time and stared at the body of their mother. But Pax *(4 years old)* kept coming closer, and tried to drink at her cold, wet breast. He kept becoming unhappier and shrieked ever more loudly, and finally began to pull on and tear at her dangling hand. He was so violent in his agony that he finally managed to tear her loose. When Passion lay lifeless on the soaked ground, her three children investigated her body many times. Sometimes they distanced themselves a short while in order to eat a bit, indifferently; then they hurried back to their dead mother. Over the course of the day, Pax became a little quieter and no longer tried to drink, but seemed to be even more deeply depressed, cried softly, and pulled now and then on Passion's cold hand. Shortly before nightfall, the three finally left with one another.
>
> During the following weeks, Pax let us see many signs of dejectedness. He was apathetic, did not play, and soon developed, like all orphaned children, a emaciated belly. But he recovered again bewilderingly quickly. For about a year, the three siblings spent almost the entire time together. When Prof sometimes hiked off with the adult males for a while, Pax usually stayed with Pom. But although they stayed together and although he always ran to her when he needed protection, Pax for some reason never again let his sister carry him on her back: not even when they traveled with a group of adult, fast males and Pax stayed behind and whimpered; not even when she reached out her hand to him and invited him to climb on board. At the beginning, Pom, whose motherly instincts had been awakened, had tried to *force* him to ride. But Pax had clung onto a branch and screeched hysterically until she finally gave up. Prof had also tried to carry his brother, but Pax had inexplicably turned

down his offer, too. It was exactly the same when his older siblings invited him to share their sleeping nest. He refused, although they reached out a hand to him lovingly. So they had watched while Pax, whimpering sadly as he went, built his own small nest near theirs. How much we still have to learn!

A year after Passion's death, Pom emigrated and joined the Mitumba society in the north. Presumably, she did this because she, after having lost her high-ranking mother, was at the mercy of the other Kasakela females who doubtless held many hostile feelings toward her: chimpanzees have a good memory *(years earlier, Passion and Pom had hunted cooperatively for the children of other females and had eaten the little ones).* But even before his sister left, Pax had attached himself to his brother and followed Prof like a hairy little shadow, wherever he went. The relationship between the two had always been a loving one, since Prof was taken with Pax from the beginning and had often carried the little brother and played with him. I remember how Pax had a sniffle one time and sneezed loudly and wetly. Prof hurried to him and examined Pax's runny nose exactly – then he lifted a handful of leaves and carefully wiped away the snot.

Now, a year after Passion's death, Prof took care of Pax in a certain way, as a mother would have done; he waited for him on hikes and protected him. Even when Pax was six, he became unusually restless when he was accidentally separated from Prof. And Prof also worried. One time, for example, two years after they had lost their mother, the brothers went off in different directions when the large group with which they had eaten split up. When Pax noticed that Prof was not there, he began to whimper and cry. Many times, he climbed up high trees, cried more loudly, and combed his surroundings. But Prof was already out of eyeshot and earshot, so Pax continued with Jomeo and built his sleeping next near this large male. But the entire night, he still cried now and then. Prof, for himself, left the other chimpanzees as soon as it became clear to him what had happened, and set out on the search for Pax. I did not experience the reunion, but the next day at noon, they were rejoined with one another.

One incident I will never forget. The brothers were wandering together in a small group with Miff, who was in heat, and Goblin, who was jealously protecting his rights as alpha and preventing other males from mating with her. He did not pay attention when Pax courted Miff – the little one was no threat. Miff, however, seemed irritated by the courtship of this unimportant suitor, and when he persevered, she struck out and went after him. Pax flew head over heels [lit.: "neck over head"] into the bushes. Poor Pax. He threw one of the most violent tantrums I have ever seen. He flung himself to the ground, tore at his hair, and shrieked louder and louder. Goblin, who was obviously annoyed by the din, looked at Pax with blazing eyes, and his fur began to bristle. At this moment, Prof, who had been eating some distance away, came by to see what was going on. For a moment, he stood there and took in the scene, then it became clear to him that Pax was in danger of being punished severely; he grabbed his still-shrieking little brother by the wrist and hastily dragged him away! Only when they were at least twenty meters away and out of danger did Prof let go: then, Pax had also quit his shouting and was ready to continue on with his brother.

Gimble was eight years old when Melissa died, and he was, although still small for his age, entirely able to provide for himself. Nonetheless, he was quite beside himself and a little dazed when he lost his mother. He sought solace from his siblings, and in fact mostly attached himself to Goblin, and soon he followed his older brother everywhere. Often, they sat side by side in a tree and ate, and Gimble built his sleeping nest near Goblin's nest. Very important from Gimble's point of view was that Goblin commonly supported his little brother if he was threatened or attacked by one of the others. So Goblin, alpha male and thirteen years older than his brother, took over Melissa's role in Gimble's life." …

… "Skosha was a firstborn child and had neither brothers nor sisters who could have taken care of her when her mother died. During the first two months, the five-year-old spent most of her time with one or another of the adult males. But then she took a liking to Pallas, a female who had lost her own first child a few months before." …

… "And now Miff herself was gone, and left behind a sickly three-year-old, Mel. He was completely alone in the world; Miff's oldest child, her daughter Moeza, was still alive, but she had emigrated three years earlier to the Mitumba society.

I was on my annual lecture trip to the United States when I received a letter with this news from Gombe. Mel, I read, was very weak. He wandered around behind different animals, mostly adult males, who did all show a lot of tolerance, but took no particular care of Mel. I did not expect to see Mel again. Even before Miff's death, he had been so thin and emaciated and lethargic that I had sent in a fecal sample for analysis. The results had shown a severe infestation of parasites and had not been very encouraging. But then, I got a telegram: *Mel adopted by Spindle.* I was perplexed, since as far as we knew, Spindle, the twelve-year-old son of old Sprout, was not remotely related to Miff. Such a relationship couldn't last, could it?

Soon afterwards, I returned to Gombe. Mel was still alive and was still together with Spindle. When I saw the little one, with his emaciated belly, his skinny arms and legs, and his lackluster, thin hair, I was amazed by his great fighting spirit that enabled him to hold fast to life against all adversities. I was also amazed by the care and fondness that his big friend showed. Spindle was actually an orphan himself, since Sprout had died during the same epidemic as Miff and so many others. Spindle could of course take care of himself quite well: but was it perhaps the feeling of loss, of loneliness, that led to this incredible bond with an unrelated, motherless small child? Whatever the reason was, Spindle took wonderful care of Mel. He shared his sleeping nest and his food with him. He did everything in order to protect the little one, and hurried over to collect him when the large males spread social unrest. When Mel whimpered while traveling, Spindle waited and allowed him to climb onto his back, and in the rain and cold, even to cling to him in the belly position. In fact, Spindle carried Mel so often that on his hips, where Mel clung with his feet, the hair was practically worn off, and he got two large, light, hairless spots.

Mel's main problem aside from the loss of his mother, his serious parasite attack, and his general sickliness was the fact that Spindle traveled with the adult males, and that they covered large distances at this time of year in order to search for fallen mbula fruit. They often took to the northern periphery of their range on these excursions, and sometimes they ran, when they had heard the calls of the males of the powerful Mitumba society, quietly and very quickly back into the center of their territory. That was hard for little Mel, since Spindle, as patient as he was, did not always wait for his little ward. Mel had to cover large stretches alone.

Most of the other chimpanzees, above all the adult males, dealt astoundingly gently and considerately with the orphan child. Mel could approach anyone without fear and

> beg for food – he even pressed between them when there was meat after a hunt and the mood between the competing males was tense. His boldness prompted at most a mild threat gesture – which regularly sent *him* into a temper tantrum. And often, he was successful in his attempt to get a piece.
>
> Toward the end of July, Spindle and Mel were separated. Mel was very unhappy. For a couple of days, he attached himself to one adult male or another, and when excitement suddenly broke out, even jumped onto their backs. Then he found a transitory replacement for Spindle. It was – quite unbelievably – Pax who took him on.
>
> Passion's death lay five years back, and Pax was ten years old, but was, like all orphans who survive the loss of their mother, very small for his age. Prof and he were still inseparable; the bond between them was as strong as ever. I will never forget that summer and the days that I spent with the two brothers and little Mel. Prof mostly led during their travels, while Pax, with Mel clamped to his back, tramped along the forest paths and over the streams behind his brother. It didn't take long before Pax had also developed his trademarks – two white, hairless spots on the hips. Like Spindle, Pax shared his sleeping nest and his food with Mel. And Prof sometimes shared *his* food with both! It looked as though the three were very close, but after a couple of weeks, Mel was reunited with Spindle, and those two remained inseparable for many more months."

After all these observations, men's behavior toward children – as child-oriented and tender as it may be in individual cases – can hardly be taken as evidence that the natural group organization of humans was not multi-male. In addition, it is to be expected that specialized throwers react especially strongly toward the child pattern and take it upon themselves to give more consideration to children than chimpanzee males. During chimpanzee power displays, children can easily be injured if the mothers do not promptly bring them to safety. During the power displays – or even just throwing practice – of specialized throwers, the mothers were probably overwhelmed by this task because of the high range. It thus stands to reason that already with australopithecine males, a special consideration for children, going above and beyond the amount observed in chimpanzee males, developed so that their own offspring were not injured too often. After all, in a multi-male band, all males have kin relationships to nearly all children. A man could therefore also raise his personal total fitness by being careful, even if he was not the father of the child at hand.

In a chimpanzee society, above all the relationship of chimpanzee children to their older siblings takes on a high significance. After the death of the mother, the probability is quite high that the orphan child will be adopted by a sister or brother. This is surely not because they feel or smell their kinship. The older siblings get access to the baby very early, which is refused the other group members longer. The mother, as a common, close contact person, produces the relationship. In a similar way today, in communities with marriage, a close relationship is produced between the father and his children from the beginning. The father behaves exactly as an older brother would have before the Late Paleolithic, and thus uses the same biological rules. To that comes an understanding of the reproductive connections and a culturally very strongly emphasized father role in modern societies (among modern societies, I also count those of the so-called “primitive people”), which contribute additionally to a strong bond with the child.

5.5 Male homosexuality

One can imagine only with difficulty that the preference for same-sex sexual partners by a man could increase his reproductive success. Seen thus, the position of those who hold homosexual behavior to be unnatural even in our enlightened age is somewhat understandable, since one can apparently assume that a corresponding [heritable] disposition, if there is one, would be eradicated in short order by natural selection. The, despite all possible societal objections, still high number of homosexuals who profess to their homosexuality, and scientific studies, speak another language, though. In fact, we can quite confidently assume that an inborn sexual preference for one's own sex occurs frequently, at least in men. And if this seems developmental-historically senseless, then the important relevant detail must well have been overlooked in human developmental models.

Individual homosexuals in original human communities could have made a significant contribution to the stabilization of large group associations. Sexuality is very well suited for the release of aggressions and for the support of alliances. In an analogous way, it is applied among female bonobos. In addition, it also serves for them to get an influential female protector in the new group for a strange young female undergoing a change of group. There are also sexual interactions between male bonobos, although they do not come to coitus.

A homosexual man in an original human group could have ensured, in addition to the loyalty of his brothers, also the loyalty of one or more members of his own sex and thus have gathered a larger, relatively stable men's association around him. Through the creation of new bonds between different groups of brothers, homosexuals could have achieved a significant contribution to the stability of larger groups in this way, and the stability of his own group had a decisive influence on the success of the expansion of his own genes for every member of the warring human association. Thus, a possible explanation for homosexuality is illustrated, but it is long not yet explained how the development of such an adaptation could come about. Since the assertion is still on the table that a characteristic that leads to its bearer not reproducing would have to have been genetically eliminated. This assertion is, however, quite obviously false, since otherwise there could be no insect colonies that mostly consist of sterile individuals.

Now, homosexual men are not sterile at all, and one can thus argue that in the original human associations, whose members were not committed to certain sexual partners by sexual norms, they often also had relations with women even though they preferred men as sexual partners. This argument, however, has the catch within my model of the natural sexuality of humans, that women in a favorable phase from a reproductive perspective were particularly desired. Over such women, the men probably competed very strenuously, and a man who was in principle not especially enthusiastic about women would hardly have had the necessary motivation for being successful in this contest. Male homosexuality thus surely went along with low direct reproductive success of the affected man. Here also, the reason lies buried why I do not concern myself with female homosexuality. This presents no puzzle, since a woman who preferred same-sex sexual partners still had access to reproductively capable sexual partners of the other sex at any time. Presumably, such a woman in a reproductively favorable phase would not have had a chance to withdraw from male advances in a multi-male group association. The reproductive success of a homosexual woman was thus hardly affected by her sexual preferences. That intensive sexual contact between women can fulfill, on the other hand, very important functions, the bonobos show us.

The direct reproductive success of a man was thus significantly lowered through homosexuality. If the homosexual man had a heterosexual brother, however, then homosexuality surely helped the reproductive success of the brother. He, namely, had access to a reliable ally in the within-group competition over reproductive resources, who himself was not especially interested in these resources. In a multi-male group association in which individual males showed enormous differences in their direct reproductive success, a homosexual man could thus achieve high fitness along the path of kin selection, without reproducing directly himself. In a similar way, the origin of sterile insect castes is usually traced back to kin selection (Voland, 1993).

I have some difficulties with this explanatory approach – although it can, as presented above, be used in my developmental model of humans for the explanation of male homosexuality. If among related individuals only those always reproduce who do not have a certain characteristic, then this characteristic should be lost with time, even if the total fitness of the individuals who do not reproduce directly has a quite respectable value. Pointing to total fitness alone is not sufficient to explain why sterility is passed on. The total fitness of a sterile individual results solely from the success of non-sterile relatives. If, for example, there were a simple dominant gene for sterility, it would reliably be eliminated from the gene pool within a single generation under these circumstances, even if its bearers should show the highest fitness within the total population by means of kin selection. One must thus imagine a concept, in addition to pointing to total fitness, of in what way sterility was genetically encoded so that it was passed on by non-sterile individuals. In principle, this could happen just through a simple recessive gene path.

Sterility would then only be expressed when the allele for sterility lay in the gamete from the father as well as from the mother. Individuals whose genomes only had the sterility allele in them once were thus able to reproduce and could pass on this allele to their offspring with 50% probability. In reality, the relationships are surely not so simple and require, from case to case, different models for how sterility or homosexuality is passed on.

There are, however, several alternative explanations for how male homosexuality – and perhaps also in one case or another the sterility of entire insect castes – is passed on genetically.
One gets a further explanation if one does not look at the fitness of the homosexual man, but at that of his mother. It is certainly widespread to judge the total fitness of an individual according to how many of its genes were passed on to the next generation, but this measure often reaches too shallow. Actually, one should not only consider the number of copies, but also their prospects of success for further reproduction. If one considers the children of a mother, they are of course all equally related to the mother. For the reproductive success of the mother of two sons, it is thus entirely irrelevant whether one of them begets two children and the other none or each begets one child apiece – in both cases, she can log two grandchildren. If, though, through the turning down by one son of his own reproduction, the other is able to beget more children, then the mother profits from this. And she profits from it earlier than does the son who foregoes his own reproduction.
In the calculation of total fitness, the use of the so-called kinship coefficient is popular. For identical twins, it is equal to 1. Between parents and children or between full siblings, [it is] 0.5; between uncles and nephews as well as between grandparents and grandchildren, 0.25. If the helping son of a mother does without two children and through this waiver, his brother begets three more children, then the total fitness of the helping brother suffers from this. He passes up two relatives with a kinship coefficient of 0.5 and receives in return only three relatives with a kinship coefficient of 0.25. The total fitness of the mother of the two brothers, however, profits from this. If the helping brother does not help his full brother, but only a half-brother – and this would have been the rule in a multi-male society, since the children of a woman most often descended from different fathers – his balance sheet looks even much worse. The balance sheet of his mother, however, remains unaffected.
The question thus presents itself whether perhaps the mothers developed the characteristic of placing, among others, homosexual men in the world as well. They would then have optimized

their own fitness, in that they would have turned loose a cooperating team instead of mutually rivaled individual fighters in the contest over the reproductive resources of the next generation. In a multi-male association, in which a man with reliable allies has good changes to beget more children than two individual fighters, such a strategy could definitely have paid off. Even if it is tied to a high risk, since if a mother is only able to rear one son, it would be a catastrophe for her if he was homosexual also.

A further, if only quantifiable with difficulty, fitness advantage for the mother was provided by a homosexual son through his over-proportional contribution to the stability of the group. This may have been the decisive difference from chimpanzees that justified the development of male homosexuality in humans. That male homosexuality may in part be passed on through inheritance in the maternal line also appears in a statistical elevation in the USA. To that, Simon LeVay and Dean H. Hamer (LeVay & Hamer, 1994):

> "The first results – for male sexuality – are corroborated by the earlier numbers of siblings. Accordingly, the brothers of homosexuals are similarly homosexual 14 percent of the time, brothers of heterosexual men only 2 percent. (That the second value – practically the average for the total population – is so low lies in the very strict definition of homosexuality in this study.) When we included other relatives, an unexpected distribution appeared:
>
> Brothers of the mother of a homosexual were equally homosexual with a probability of 7 percent, and their sisters had 8 percent homosexual sons; in contrast, there was no correlation to the father, his siblings, or their children, nor to the sons of brothers of the mother. Such data in themselves speak in favor of the involvement of a genetic component. However, homosexuality would appear much more frequently if a single gene were responsible for it that was passed on in one of the known simple inheritance paths. It may be possible, though, that certain genes express themselves more strongly in some families than in others. We came to this supposition when we investigated families with two homosexual brothers at the same time:
>
> Uncles on the maternal side were then 10 percent homosexual and cousins in the female line 13 percent. If a feature accumulates in that way, and indeed even outside the nuclear family, this is a strong indication of a genetic root."

Next to the genetic transmission of male homosexuality, the long developmental period of her children in a mother's womb offered a second method for the production of homosexual sons. She could interfere, in the course of the individual development of the child as a reaction to environmental influences – perhaps hormonally –to the effect that a son became homosexual without showing a corresponding genetic predisposition. If the stabilization of one's own group association belonged among the tasks of male homosexuality (In any case, the mother bore all children into the same group, and only a portion of her daughters had a chance to leave this group. The state of the group thus decided the long-term reproductive success of a woman and belonged – from the standpoint of fitness – to her most elemental interests.), it would be sensible primarily in times of lasting conflict with other groups to produce homosexual sons in this way. There are also indications of such a mechanism. It has been discovered that among men born during the stressful period of the Second World War, a higher percentage of homosexuals is to be found (Eibl-Eibesfeldt, 1995).

Here, though, the trail grows extraordinarily faint. First, there seem to be parallels to rats here, among whom stressed mothers bring homosexual sons into the world. It is therefore questionable whether this is a matter of a specifically human characteristic connected with the special conditions of hominid evolution. Second, the period of time between the introduction of homosexuality in the womb and the appearance of the positive effects that this characteristic of the adult son could have on group cohesion is very large. It thus appears questionable whether such a measure on the part of the mother made sense as a reaction to a given environmental situation.

It is still to be expected that populations that lived under particularly good circumstances and showed a high population surplus were simultaneously those that had to deal with the most intensive territorial conflicts. For many maternal developmental lines, it would thus have been worthwhile for centuries – until the next change of climate or habitat – to be able to count homosexual, group-stabilizing men among their children on a regular basis.

The discussion of whether and in what part male homosexuality is genetically determined is still open and exceptionally multi-layered. By no means do I pretend to have found decisive evidence within the framework of the CTSW model that male homosexuality is genetically fixed. This would be a hypothesis based on a hypothesis based on numerous assumptions. The demonstrative power of such a statement approaches zero. If, however, the suspicion that male homosexuality is in significant part genetically determined and that this tendency is passed down along the maternal line should actually be substantiated, then the CTSW model offers a functional explanation for this phenomenon.

6 The Double Evolution of Human Behavior

6.1 Cultural and cognitive development

There surely exist relationships between the development of the human brain and its cultural capability. One of the most important questions to be explained in connection with the course of the last 1.8 MY of human evolution is the nature of these relationships.

There is hardly any doubt that high cognitive capacity and in particular language ability represent prerequisites for the enormous dynamism of human cultural evolution. Just as self-evidently, however, many scientists assume that cultural development was a prerequisite for human cognitive development. Human development is popularly viewed as the result of a "positive feedback loop." The use of cultural acquisitions is to have ensured that the further development of the brain was worthwhile, and vice-versa, more effective brains are to have made cultural advances possible.

This perspective presents some weaknesses, however. On the one hand, I doubt that cultural and organic evolution actually went in such harmony as is postulated here – my thoughts in this direction I will yet discuss thoroughly. On the other hand, this perspective contradicts the archaeological record. Actually, the second point in itself should suffice to falsify the assumption that brain evolution was driven by cultural development. It is, however, quite obviously difficult for most paleoanthropologists to separate themselves from this thesis, even more so because a better explanation for the development of the brain has not yet been in view. The following passage from the book "Lucy and Her Children" is very illuminating of the state of the scientific discussion:

> "During our development, cultural evolution for the most part played no great role. Its importance first increased during the Late Paleolithic about 40,000 years ago. As one easily recognizes in looking back at the time of the australopithecines, four to one million years ago, culture hardly affected the lives of these creatures: they were subject to the same evolutionary pressure as other organisms with which they shared the ecosystem. The hominids thus developed for almost the entire time just like other organisms.
>
> After our ancestors became dependent upon culture for survival, however, a new level was added to their evolution. In the opinion of the American professor Sherwood Washburn of the University of California at Berkeley, an unequivocal relationship

> between culture and biology exists, which he calls 'biocultural feedback.' The unique interplay between biological and cultural change could, according to Washburn, be the reason why humans are so different. His basic assumption goes: The more advantages culture brought for the survival of our ancestors, the more natural selection favored the corresponding genes. Therefore, genes offer an adaptive advantage for better cultural capacities. In the end, the interplay between genes and culture led to a strongly accelerated evolution evident, among others, in the growth of our brain and its cognitive abilities during the last two million years." (Johanson & Edgar, 1998)

On the one hand, it is determined here that culture played hardly any role up to ca. 40,000 years ago – this results quite clearly from the archaeological record – on the other hand, a hypothesis is cited, according to which cultural evolution exerted a decisive influence on brain development in the last 2,000,000 years!

Friedemann Schrenk has developed a scenario that at first glance seems to have the potential to resolve this contradiction without dropping one of the two statements. I would like to cite him at this time, exactly because I am of a very different opinion on many points. Thus should be shown how deep-reaching the effects of the throwing hypothesis on the evaluation of the relative value of the factors underlying human evolution are:

> "One of the most exciting chapters of human evolution, though, results from the fact that the earliest representatives of the genus *Homo* (*Homo rudolfensis*) arose in East Africa at the same time as the robust australopithecines, that is, ca. 2.5 million years ago. The beginnings of the *Homo* line, represented through *Homo rudolfensis*, were thus equally marked by their descent from *Australopithecus afarensis*. For these reasons, *Homo rudolfensis* shared with the robust australopithecines some of the skull and tooth features related to the chewing apparatus that made the inclusion of the harder fruit and plant foods of the savannah possible for the early hominids. *Homo rudolfensis* remained, in its eating style, quite conservative and very predominantly herbivorous.
>
> From the simultaneity of the results, the conclusion can only be drawn that there obviously was an alternative to the development of a hyperrobust chewing apparatus also suited for chopping up increasingly harder food with rising aridity. This

alternative was the beginning of tool culture. Thus, while the robust australopithecines, with a powerful chewing apparatus, were essentially specialized for tough and abrasive foods, *Homo rudolfensis* showed greater flexibility, primarily in behavior. Its adaptation to the climatic changes went along with the development of a larger and more capable brain. Hereby, a change to the inclusion of less abrasive foods with an increasing tendency toward an omnivorous (all-eating) means of nutrition was completed. The beginning tool culture covered the effects of the climatic change to the point that *Homo rudolfensis* could use other food sources better than every other hominid species that had come before. Thus, early humans gained, through the systematic application of stones for chopping up hard plant food, an immense advantage over all other hominids: a slowly increasing independence from direct environmental influences.

Tools in the sense of aids for a task are certainly widespread in the animal kingdom and above all among the higher primates. But under the pressure of the environmental problem 2.5 million years ago, it was obviously exactly the abilities of the hominids in cultural behavior that allowed the genus *Homo* to arise. But still more, it was the 'evolutionary strategy' to put all of this on one ticket. The late robust australopithecines also used bone tools; however, it was their main evolutionary strategy to face the environmental conditions through increasing physical overspecialization. In contrast to that, the great advantage of the genus *Homo* is the retention of a more unspecialized, and thus offering of many developmental possibilities, physique in combination with cultural overspecialization.

Although 'typical human' behavior, such as consciousness, art, or music, cannot begin to be proven, the beginning of the genus *Homo* is bound to them: increasing independence from the habitat led without fail from this time forth to increasing dependence on the tools used for this, a dilemma that characterizes humanity to the present day.

The initial use of stone tools for hammering hard foods soon brought advantages in unimaginable quantity: coincidentally produced sharp-edged debris were applied as cutting tools. This revolutionized working with meat and the butchering of prey cadavers. For specialized herbivores like the robust australopithecines, however, the application of stone tools would not have provided any immediate advantage. As long

> as both nutrition strategies were successful, i.e., for more than 1 million years, different hominid genera and species existed side by side. …
>
> Such is the way to *Homo sapiens* marked even today with a manifold interweaving of relationships of different networked factors. Also, the changes undergone in the millions of years of the early human period underlay the influences of different, mutually conditional and sometimes fed-back factors in the course of biological and cultural evolution. Thus, a sharp delineation of humans in opposition to the animal kingdom is no more possible than a precise answer to the question of whenceforth the primates can be identified as humans. As presented in the individual chapters of this book, the development of humans runs neither goal-oriented nor chronologically synchronized in all features. Almost all evolutionary characteristics of humankind, such as tool culture, communication, social behavior, brain structure, and physique, are in some form or another already lain out in its primate ancestors (Figure). In *Homo sapiens*, that is, in Neandertals as well as in modern humans, an overlapping and synergistic effect of different factors begins to play out. First through this, and with simultaneous increases in social organization, a new quality of life in the animal kingdom is achieved. Only now finally arise what are often seen as characteristics of humanity: human cognition and consciousness." (Schrenk, 1997)

Pictures often say more than a thousand words, and in the above explanations, Schrenk also points to an illustration that rounds out the text and makes the underlying concept clear. Thus, it is also appropriate to "quote" this illustration:

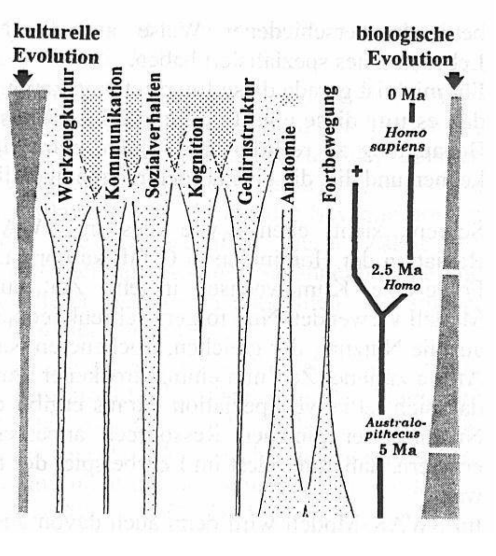


Figure 16: Illustration in Schrenk (1997), his commentary reads: "Important evolutionary features of humans. The width of the arrows corresponds to the degree of change in the features during the last 5 million years."
[Terms in the figure, right to left:] cultural evolution, tool culture, social behavior, cognition, brain structure, anatomy, locomotion, biological evolution

Where, then, do the differences to the CTSW model of hominid evolution lie?

In Schrenk’s estimation, *Homo* retained an unspecialized, and thus offering of many developmental possibilities, physique, in connection with a cultural overspecialization.

The first statement is, upon consideration of throwing adaptations, quite clearly false. The development of *Homo* and in particular the transition to *Homo erectus* was characterized above all by throwing specializations. There is no primate more strongly physically specialized than was the male *Homo erectus*. The robust australopithecines were also certainly highly specialized, but held a few more options open in their physiques with the retention of climbing adaptations. It is precisely the extreme specialization of the *Homo* line that made possible its further developments, especially in the cultural arena. One need only think there of the significance of the hand, tailored in the framework of throwing evolution for elite performances in the area of object manipulation, which comes in exceptionally handy for humans in the manufacture and handling of tools.

The second assumption, the cultural overspecialization that is to have marked the survival strategies of *Homo* from the beginning, is based solely on extremely limited tool finds and the necessity of explaining the growing brain. The increase in brain volume at least through early *Homo erectus* as well as the physical development is explained in the CTSW model mainly as specializations for targeted throwing. For the assumption of a high significance for the production and use of tools in human evolution, there are neither sufficient evidence nor – within the CTSW model – a need. This point is discussed thoroughly in the next chapter.

For the simultaneity of the first appearance of his *Homo rudolfensis* and the robust australopithecines, Schrenk sees only one explanation; that is, that they both specialized in different ways in the use of the same altered habitat.
For me, precisely this interpretation is hardly demonstrable, and the presumption that there is **only** this one explanation is essentially unfounded. In order to justify such a proposal, one would actually have to be familiar with all conceivable explanations, and no one can be familiar with those that haven’t occurred to him yet.

Schrenk sees, just as is assumed in the CTSW model, a radiation of the hominids in East Africa ca. 2.5 MY ago. He sees this radiation as the consequence of a climatic change at that time; this assumption, too, is used in the CTSW model. Now, however, Schrenk infers that both new lines must initially have specialized in the use of the same dry foods; since Africa at that time did become drier, [he continues as though] it were self-evident that radiative speciation results from different branches adapting to the use of the same resources. I may mention that, at least in the teaching example of Darwin's finches, the opposite was the case.

In the CTSW model, it is then also assumed that at the radiation of the hominids 2.5 MY ago, the habitats used by the australopithecines split into two parts from the beginning. On the one hand, the few, relatively moist habitats used by the gracile australopithecines (corresponding to Schrenk's *Homo rudolfensis*), and on the other hand, the many, drier habitats used by the robust australopithecines. In the end, then, Schrenk's *Homo rudolfensis* also completed the change to less abrasive foods, although supposedly only later, because of brain adaptations and not directly because of the radiation.

Aside from the possibility to derive increases in brain volume and the appearance of tool culture to climatic changes in this way, there is no reason to assume such a course of evolution. Both find another explanation in the CTSW model.

In Schrenk and equally in many other authors, arguments that concern food intake dominate the discussion of the development of the early hominids in particular. This is not exactly a surprise, and for just that reason, one must be cautious of them. Here lurks the danger of a reductionist approach.

The high significance of food in the scientific discussion is based less on its equally high significance for evolution than on the fact that the fossil record is comprised above all of hard teeth and jaw bones, which are more easily preserved. Of course, hypotheses come off better when they can be demonstrated through fossils and are then – neither is this entirely insignificant to the scientific discussion – also published sooner. Through the relative frequency of tooth and jaw fossils, we automatically have a heap of works and greater familiarity with arguments that hinge on food acquisition.

The more frequent appearance of teeth among fossils does not mean, however, that teeth had a towering importance to the course of evolution. Of course, the large grinding teeth with extra thick tooth enamel in the case of the robust australopithecines indicate that these hominids ate especially hard plant foods of the savannah. This does not mean, however, that the characteristics of these teeth represent the decisive prerequisite for the settlement of dry savannah biomes and the decisive adaptive trait of these hominids. Such a conclusion goes too far and does the teeth too much honor.

Two "nutcrackers" should help me to illustrate what I mean. On the one hand, *Australopithecus boisei*, the robust australopithecine of East Africa, got the nickname of Nutcracker Man because it presented especially large molars with extremely thick tooth enamel. If one sees such teeth, then one easily comes to the thought that one needs them, and not only them, but also a short face with especially favorable lever arm ratios for the achievement of high chewing forces, in order to survive in the savannah. On the other hand, however, baboons live in the savannah, and there are also "nut crackers" among them. That is, this name was given to an old baboon at Gombe who had the habit of cracking especially hard nuts through application of the long lever arm of his snout, in that he laid them between his molar teeth in order then to press his jaws together with his hands.

There are often many ways to reach a goal; one should therefore beware of explaining the way that one knows too quickly as the only way. There are often details that decide which way will finally be taken. We also should not forget, in this context, that baboons have exceptionally long canines that, in the australopithecines, would supposedly not have been compatible with the requirements of nutrition in the same habitats. Our ancestors presumably had bigger brains than recent baboons by 5 MY ago and were surely also more intelligent – are they to have been unable to feed themselves on the savannah under retention of long canines, if they had still needed them as weapons?

As far as the acquisition of food is concerned, the nature of the teeth decides less whether one can essentially survive in a habitat than how old one, on average, becomes there. "Wrong" teeth are used up sooner and thus limit life expectancy. Now, it will have interested a hominid little who was eaten by a lion at ten years old, whether his teeth might still have given him good service for another fifteen or perhaps even seventeen years. The "wrong" teeth thus only become relevant for natural selection in a savannah biome when a sufficiently large number of individuals under these living conditions can become old enough to have problems with their teeth. Teeth only document how far the hominids had come in their advance into the savannahs; they do not say how the hominids accomplished this.

In the CTSW model, the most important contribution that the teeth can make for the reconstruction of hominid evolution – as also already in Darwin – rests on one characteristic that they no longer have. Decisive adaptive traits are, for an ape with exceptionally low fertility that settles the savannah, to be assumed in the area of predator avoidance and not in the intake of food. In the end, a clear thickening of the tooth enamel in the course of umpteen thousand generations is really no overly impressive adaptive trait.

Very interesting is, finally, the overlapping and synergy effect of different factors of human evolution supposed by Schrenk, whereby biological and cultural factors are again named in one breath, as we also already saw with Jane Goodall.

Schrenk uses his postulated overlapping and synergy effect in order to weld together multiple factors that were previously placed into the discussion individually as conceivable driving forces for human brain development into an unmanageable, omnipotent whole. This “whole” now possesses, because of the multitude of included elements, on the one hand the potential to offer explanations for anything; on the other hand, it is so generally composed that it can easily avoid concrete testing. A model built such is, in my opinion, badly formulated because it lacks precision, which again is a key requirement of the principle falsifiability of a hypothesis. Scientific hypotheses should, as much as possible, be formulated so that they can easily be tested and not such that they already extensively withdraw from tests for structural reasons. The task of the scientist does not consist of conjuring up a “manifold interweaving of relationships of different networked factors,” but rather, of unraveling it.

There is more, though, to contradict Schrenk’s overlapping and synergy effect than these cognotheoretical considerations. With his late synergy effect, Schrenk tries to get around a structural problem of his evolutionary model: on the one hand, he postulates a high importance of cultural development for evolution as soon as 2.5 MY ago; on the other hand, the traces of human cultural activity over long periods of time show absolutely no developmental dynamism, and the level of demonstrated cultural achievements remains overall expressly modest until the Late Paleolithic. This does not fit together, but is brought under one roof – at least semantically – through the overlapping and synergy effect. What is supposed to stand behind these grand buzzwords is illustrated in the figure. Primarily the evolutionary features tool culture, communication, cognition, and brain structure change here at more breakneck speeds the closer one comes to the present. Changes in social behavior also increase. Only relatively recently do the individual areas overlap, whereby the finer stippling in the overlapping areas is presumably to represent the overlapping and synergy effect.

This synergy effect is, for Schrenk, an important constructive element of his model. With it, he decouples brain volume and intelligence, so that he can claim that intelligence in the first 2 MY of human brain expansion – in agreement with the cultural development during this period – only increased a little. Only consequent to the synergy effect and a corresponding rebuilding of brain structures is it then to have come to a strong increase in the actual capability of the brain in the most recent past, accompanied by a correspondingly breakneck cultural development.

That synergies have a high significance for the capability of the human brain is a well-founded assumption that I do not think to draw into doubt. The constructive element that Schrenk uses in his model and also needs is not, however, a synergy, rather a synergy effect. These only appear when previously separate areas are placed together – as in the most generally familiar case in which synergy effects appear, the fusion of two companies. It is not for Schrenk to explain why the human brain is so capable today, but to [give a] reason for his assumption that over long periods of time, despite clearly rising brain volumes, it was by far not so capable. In judging his model, then, it does not depend on whether it is plausible that the beams overlap for modern humans in his illustration – Schrenk's decisive claim is much more that these beams were strictly separated for the majority of hominid evolution.

I do not agree that there ever was such a separation. Tool culture, communication, and social behavior rest upon the performances of the same brains and should therefore always have influenced one another and would also have been influenced from the beginning by changes in brain structure or cognition. Every performance increase of the brain in one of the named areas should therefore have led directly to corresponding synergies, and not first at a later time. After all, our ancestors of 5 MY ago presumably already possessed a highly integrated brain on the level of recent apes. The drawn separation of the arrows before the appearance of *Homo sapiens* therefore seems arbitrary to me. In principle, our ancestors are given multiple personality disorders here, in order to rescue the thesis that cultural development drove brain evolution.

Equally doubtful is the assumed increase in developmental speed for the structure of the brain and cognitive achievements in the most recent past. Here, it is extensively a matter of biological adaptations, for which, in my opinion, the developmental dynamics should look very different. I will devote a chapter to this theme (Chap. 6.4).

The assumed change in brain structure causes further problems because it presumably never happened. We will also cover this problem area in a separate chapter (Chap. 6.3).

I also view the positive feedback between biological and cultural evolution with pronounced skepticism. I will present, in the following, the view that right in the area of cognitive capacity, biological evolution practically fell victim in that "moment" in which the conclusive victory charge of cultural evolution began (Chap. 6.6).

In the CTSW model, the assumption of a high significance of cultural development for human cognitive development for more than 2 MY is not needed. Thus, in the CTSW model, a much simpler explanation offers itself for the fact that the archaeological evidence of human cultural development, despite the clear expansion of the brain, is exceptionally limited until the Late Paleolithic. This evidence plainly reflects in the correct way the low importance of cultural evolution – for the behavior as well as the brain development of our ancestors. Schrenk correctly indicates that the use of tools is also widespread in the animal kingdom. And the achievements of the chimpanzees are not all too far behind what the hominids in the first two million years of their tradition brought to light for the production of stone tools. There thus exists no reason whatsoever to assume substantially more behind this tool culture than behind the use and production of tools by chimpanzees – unless one sees no other explanation for the increase of the volume of the human brain.

Finally, the claim that human consciousness is first to have appeared right at the end of hominid evolution, so to speak first in "us," reeks of anthropocentrism. I therefore hold it in principle to be advisable to approach such a claim especially skeptically until weighty evidence for it has been assembled.

In the framework of the CTSW model, there is no reason to assume substantial changes in the kind and extent of cognitive capacity so late in human development (first with *Homo sapiens*).

It is already notable to observe how geneticists, brain researchers, and primatologists on the one hand do not tire of explaining how close we stand to chimpanzees, and how on the other hand, many scientists who deal directly with the evidence of human evolution repeatedly bring up arguments to “prove” how far, e.g., our ancestors belonging to late *Homo erectus*, with their fully human physique, a genetic distance from us smaller by a factor of 20 compared to chimpanzees, and a brain volume of 1200 cc – that would be evaluated as entirely sufficient for a *Homo sapiens* – were still separated from us in their development. In my opinion, this contradiction is based on the false basic assumption that the status of cognitive development and cultural productivity at a given time in the course of human evolution were correlated with each other.

6.2 Production of tools

The production of tools in the CTSW model plays an only relatively late and comparatively limited role for the course of human evolution. A tradition of solving problems through the discovery of technical aids simply did not exist in the time during which the decisive biological adaptations occurred. New tool cultures surfaced only sporadically and were passed on over downright unbelievable periods of time. Improved abilities in handiwork compared to chimpanzees, such as the highly developed precision grip and evolved geometrical thought, resulted as products of throwing evolution.

Perhaps the well-known “first stone tools” do not even point to an intensified use of stone tools, rather the beginning of the entry into the scavenger niche. Schrenk indicates that the first worked stone tools are preceded as a rule before ca. 2.5 MY ago by unworked “hammer stones,” which were already in use 2.6 MY ago. The interesting thing about these hammer stones is, from the point of view of the throwing hypothesis, that they are all handy throwing stones. I would therefore like to plead for consideration of the following scenario for the “appearance” of the first stone tools 2.6 MY ago:
Experiments with apes have show that their intelligence is sufficient to utilize tools in considerable scope. In the wild, however, only common chimpanzees apply this ability to a great extent, although bonobos and orangutans by no means come out dumber in the experiments. This is explained by the fact that the latter, in their quite “original” habitats from the point of view of an ape, need no tools, since their physiques are prominently adapted to the use of these habitats. First with the advance of *Pan troglodytes* into quite dry habitats did the use of tools present an advantage and was also introduced without difficulty, since it already lay within the range of performance of the brain of this ape. Just like recent chimpanzees, human ancestors probably also used tools increasingly in the acquisition of food upon advancing into drier habitats – which, however, neither required nor caused expansion of brain capacity. The australopithecines used stones from the beginning for processing and acquiring foodstuffs, and they did it to at least an equally high, and presumably an even higher, degree than recent chimpanzees. In addition, thrown stones played a prominent role for them for defense against predators. It is obvious that stones carried for predator defense would also have found uses in, for instance, the cracking of nuts.

The change in behavior that led to the appearance of the first "hammer stones" in the archaeological record ca. 2.6 MY ago consisted in that the australopithecines, who entered the scavenger niche at that time, began to place much higher value on the quality of their throwing projectiles. They preferred – in light of the raised requirements upon their performances in throwing – handy throwing stones. These were collected with greater effort, preferentially carried along, and of course applied for all other interests beyond throwing. The decisive effect for archaeologists now consists in that no longer were many stones moved and used a little, rather, a few stones a lot. Only through that do piled up stones appear in the archaeological record that can clearly be identified as tools because they were found far from their natural provenience, show clear use-wear marks, and are also geometrically similar to one another. Of course, archaeological evidence should be expected for the preceding time, but this will only actually be identifiable in individual cases and with great effort.

Upon consideration of the throwing hypothesis, the development of the Olduwan tool culture, whose oldest artifacts were found in 2.5 MY-old deposits, also seems pronouncedly undramatic. The first producers of stone tools apparently wanted primarily to get sharp-edged flakes that were well suited for cutting. If these toolmakers belonged to a line that had already begun to advance into the scavenger niche 0.1 MY earlier, then they doubtless had a suitable use for these flakes in the butchery of cadavers.

A being that carries stones around with it for its entire life and, when needed, flings them at attackers, is regularly confronted with the case that a stone breaks up upon impact with a boulder. It is only a matter of time before an animal with the intelligence of an ape recognizes the useful characteristics of the accumulating fragments and switches over to producing them itself as needed – at first perhaps by flinging the stones against boulders, but with time also by hitting stones against each other.

The material for the production of the Olduwan stone tools was also not transported with the wise foresight that one could use it if one happened upon carrion. Much more, the flakes were made from the throwing stones that the australopithecines had always carried around with them and that had already shown themselves for 0.1 MY to be particularly handy. Without these stones, they would presumably have been quite defenseless in open ground. Flaking cores that could still be used as projectiles were thus also carried with them again, so that at the find sites an excess of flakes accumulated (Toth, 1987).

The intellect of a chimpanzee and the precision grip of an australopithecine halfway advanced in its throwing adaptations are sufficient anytime for the foundation of such a toolmaker "culture." The achievements of recent chimpanzees in Africa in the cracking of nuts by the hammer-and-anvil method place similar demands on practice and intelligence.

At the beginning of the nineties, Nicholas Toth and Sue Savage-Rumbaugh undertook the attempt to educate an especially gifted pygmy chimpanzee in the production of Olduwan flake tools. Kanzi, the experimental animal, went along enthusiastically, but did not manage to get the special knack through which it becomes possible to produce the long flakes well suited for cutting of the Olduwan industry. Nonetheless, he impressed the research leaders, since he decided in light of his repeated failures to go another way: instead of using a hammer stone for splintering flakes off another stone, he successfully tried shattering a stone on the floor in order to then choose the most suitable broken piece. According to the perceptions of his human research leaders, this was cheating – so they prevented this sort of naughty deed in that they covered the floor with mats. Kanzi, however, had acquired a taste for this. After he had determined that the mats were a hindrance to his technique, he pushed them apart and smashed his stone on the cleared off floor segment.

Still, though, the humans had the upper hand [lit.: "were at the longer lever"]; they prevented these violations of their holy playing rules as well and ensured that Kanzi really only had the two stones available to him.

Deeply convinced of the superiority of his shatter technique, Kanzi then switched over after a time to placing one stone on the ground and bombarding it with the other stone, whereby he developed some precision of aim and again had successes to show (Lewin, 1995 b; Savage-Rumbaugh & Lewin, 1995).

In light of this sort of achievement by a pygmy chimpanzee, I hold it for exceptionally risky to see in the first stone tools the first, mighty coming to light of the germinating human mind. For me, the presence of most of the necessary intellectual abilities for the production of Olduwan tools in Kanzi is beyond doubt. Presumably, he was missing nothing more than the precision grip of an australopithecine. Their improved abilities in geometric thought and the ability to generate an effective additional acceleration from the wrist also would have acted to the advantage of the actual founders of the Olduwan tradition.

The course of movement in the production of Olduwan flakes is strongly similar to that of throwing, so that specialized throwers brought with them the best preconditions for founding such a tradition. The reverse conclusion, which, by the way, Calvin still holds open in his work, does not, however, work. The requirements of a good thrower exceed by far the requirements in the production of Olduwan flakes and could therefore hardly have occurred as side effects of adaptation to the manufacture of tools.

A decisive advantage of the Olduwan technology compared to Kanzi's method, which actually must have confronted the throwing-specialized australopithecines, was economy. After all, they did not just bring along their stones in order to take apart a cadaver; rather, they used them as weapons. And these weapons needed to be damaged as little as possible through the production of flakes. A couple of small flakes didn't hurt anything; Kanzi's demolition method, however, was from their point of view really a strategy for disarmament, loosely according to the motto "swords into ploughshares."

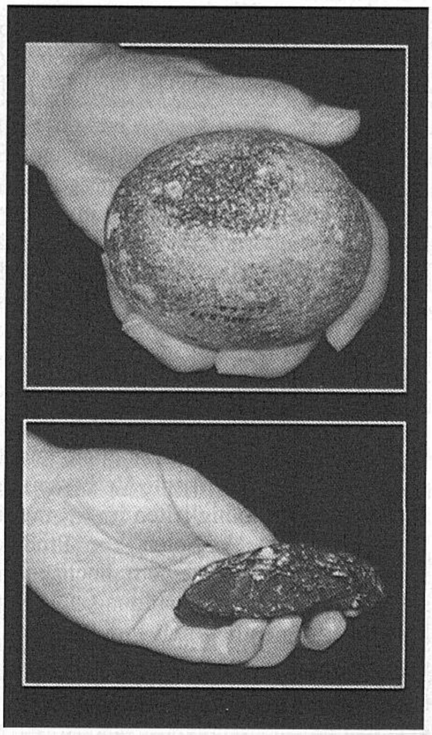


Figure 17: Primitive stone tools from Longgupo in China. The levels in which they were found have been dated to an age of 1.9 MY. In my opinion, the upper "hammer stone" presents an exceptional throwing projectile. In light of the enormous capability in throwing that the hominids have developed in the course of their evolution and the short canines of the hominids, I hardly believe that such stones were primarily carried in order to produce flakes such as the lower one. (Picture source: Spektrum der Wissenschaft 6/1997, photos by R. Clochon)

This scenario also offers a very simple explanation for the origins of spherical hammer stones, which, according to Toth, one automatically gets when a stone is used as a hammer stone for very long (Figure 17, above). The question here is whether a spherical form is necessary for a stone to be especially well suited as a hammer stone. If this is not the case, as I assume, then the question presents itself why the hominids always reused the same stones as hammer stones – long enough that they took on a perfect ball form in the end. I propose that the following played out here:

The tool manufacturers did not use stones brought along for that purpose as raw material, rather, their throwing stones. Of course, in doing so, the stones from which the fragments were split off took heavy damage, while the hammer stones remained extensively unharmed. The throwers thus paid careful attention to ensure that only their worst throwing stones at a given time were used as raw material; good throwing stones were at most considered as hammer stones. Ball-shaped stones make the best throwing projectiles and were therefore probably especially beloved by the throwers. The closer the shape of a stone came to a ball, the more likely it was to be carried for a long period of time, and thus the more often it was used as a hammer stone, through which its ball shape was automatically further perfected. Even if such a stone was thrown away – and it was, after all, carried for that – the probability was great that it was intensively sought afterwards, or that another thrower picked it up later because its qualities were obvious and apparent to the eye. The next thrower treated the stone, even if in the meantime hundreds of years might have passed, for the same reasons in the same manner as its previous owner.

I propose that an oval stone would make an even better hammer stone than a spherical one. It would, however, hardly cross the mind of a thrower to schlep around such a stone that would "egg" [wobble like an egg] in flight for that reason.

For *Homo erectus*, also, the production of tools probably had no evolutionary consequences. The Acheulean tool culture tied to them was passed along extensively unchanged for over 1 MY and in no way reflects the simultaneously occurring expansion of brain capacity. The introduction of these tools was also none too spectacular. The manufacture of the hand axe demanded more investment than the manufacture of the previously used flakes. This investment was only justified if the tool was used over longer periods. Thus, hand axes made little sense for *Homo habilis*, since it still lived partly arboreally and presumably usually threw away the stones that had given it good service on the ground before it went up a tree.

The use of hand axes probably reflects a change in lifestyle more than a significant improvement in the ability to produce tools. The evolved abilities in geometric thought that were needed [more] in the production of hand axes compared to the production of Olduwan flakes were surely long since available to a highly specialized thrower such as *Homo erectus*. Hand axes were, for *Homo erectus*, surely by no means indispensable – on the contrary; in East Asia, this technology was never introduced. As we now know, this new tool tradition also was not connected to the expansion of *Homo erectus* out of Africa.

The most important tool of *Homo erectus* was again the throwing stone, and this was not worked, but gathered (Calvin, though, points to the hypothesis that hand axes themselves were improved throwing stones with a dangerous sharp edge (Calvin, 1994)). The decisive importance of the stone within the confrontations is reflected in the robusticity and skull shape of this species, characteristics that in light of the strongly growing brain volume were retained unchanged with downright sinister consequences. The reason for that lay in that these characteristics represented the optimal adaptation to the conduct of war with thrown stones. And this again was – extensively independent of habitat – of higher significance to selection. All populations of *Homo erectus* were the children of war and, to a certain extent, standardized by the stone (see Chap. 4.1).

Characteristic of the end of *Homo erectus* and the transition to presapiens is the weakening of exactly those features that, in my hypothesis, served to limit the danger of injury from thrown stones: the head shape changed and the robusticity also retreated. The fossils still collected together today under "presapiens" come overwhelmingly from individuals that, in comparison to *Homo erectus*, were more susceptible to injuries from thrown stones. The stone had thus lost its normalizing effect in this area. The condition that had led to persistent animosities among the groups, that is, ecological dominance, surely continued to exist, though. Therewith, however, the confrontations were carried further. The physique also remained extensively optimized for throwing, and at this time, as well, no more effective distance weapon appeared. Nonetheless, the biological protections from injuries caused by stones seems have lost significance at that time. So what happened?

The logical compliment to the weapon of stone is the protective shield, and I favor the discovery of the shield or another portable protective measure against stone projectiles as an explanation for the end of the *erectus* phase. As an alternative explanation for the loss of importance of stones in confrontations, one could also imagine the development of a more effective distance weapon. A good throwing spear would surely have been an advance in comparison to a stone, but a good throwing spear is technologically very demanding. In advance of a good spear, a less good one must have come, but this would have been, if only because of its lower range, inferior to stones in confrontations.

The introduction of shields, on the other hand, would have led to a decrease in the distance between the enemy groups in the course of confrontations and brought a clear advantage to the party that developed the shield first. Shields could have led to the development of pikes that opened up the opportunity to penetrate shields. Development and improvement of spears secondarily opened certain opportunities for hunting large prey animals and thus the expansion of food availability. The oldest wooden spears are 400,000 years old and thus actually do come from the time in which the typical *erectus* features generally retreated in large parts of its range. Interesting is the quite late-coming end of the *erectus* phase and the presumably related late invention of the shield. The represents a relatively simple and very obvious invention, and nonetheless, *Homo erectus* was not in a position to do it for more than a million years. I take this as a further indication of how little invention and the use of new tools stimulated the development of human mental abilities. Still, I know of no direct proof that the shield already played a role at the transition from *Homo erectus* to presapiens, but we can rule out that it was discovered sooner, since the characteristics of *Homo erectus* would otherwise have changed sooner. The consequences that result from this for the image of *Homo erectus* are much more extensive than one might think on first glance. One should not let spin-off effects out of consideration with the development of the technologies of the Stone Age. That is, it should hardly be assumed that something as useful for stone throwers as a shield was not invented earlier, although structurally similar objects were used. This means in particular that, until shortly before the appearance of presapiens, neither carrying baskets nor protective clothing or artificial shelter existed. Older stone circles did not serve to weight down tent flaps; rather, if they were gathered by hominids at all, more likely as stockpiles of projectiles.

Seen thus, the expansion of the human settlement range to the north through presapiens is an – admittedly weak – indication that its appearance really did have something to do with the development of shields (or otherwise disposed protective measures, such as for instance woven armor) by late *Homo erectus*. The settlement of the North was presumably made possible by the development of clothing or artificial shelters, both products whose manufacture requires similar techniques to the manufacture of shields or other portable protective devices.

If *Homo erectus* knew no clothing, then one should not assume too self-assuredly that it had already forfeited its pelt, since nights even in Africa – and there particularly in the savannahs – can be bitterly cold.

Presumably, then, only at the end of the *erectus* phase did use objects manufactured by humans begin to have their influence on the evolution of humans. The customary weapon of the thrower, the handy stone flung with one hand, began to lose its frightfulness in intraspecific confrontations. Alongside it appeared other different weapon traditions, presumably with regional differences. An interesting answer to the shield would have been, for instance, a sharp wooden pike, which a specialized thrower then over the course of time must inevitably have developed further into a spear. Very gradually, next to the biological, technological development also gained in importance for the arms race that took place. The intellect needed for that had already long been made ready by the roughly 1.5 MY of sustained intensive confrontations.

Whether a possibly intensified cultural development after the development of shields finally contributed to the further development of the human brain after all is a very interesting question. It is known that the transition to presapiens went along with another clear increase in brain volume. I do not believe, however, that the production of tools had anything directly to do with that.

The demands of tool manufacture are above all brought into connection with geometric thought. One can imagine, of course, that the throwing adaptations at some point were no longer sufficient in this area, in order to satisfy the requirements of the increasingly important production of tools. In such a case, the demands of tool production would, at the end, have contributed to an improvement of geometric thought after all, given it a final polish, so to speak. Then, though, our capacities in geometric thought would be limited to the level that was necessary for the production of stone tools before the Late Paleolithic (I presume that there was no further expansion of the biological basis of our thinking after the Late Paleolithic; a reason for this assumption comes later).

If, on the other hand, the requirements on geometric thought in throwing were substantially higher and the throwing adaptations had not even been exhausted in the production of stone tools, then our abilities in this area could extend far beyond the requirements of the production of stone tools and give us the opportunity to master more demanding tasks.

I assume that the creation of a technical drawing, in which a geometrically complex structure is presented only in abstract form, places substantially higher demands on geometric thought than the production of a tool from the Middle Paleolithic. Therefore, I presume that tool manufacture never played a role in the development of human geometric thought.

Indirectly, though, new tools – above all, new weapon traditions – could certainly have led again to a clear expansion of the capabilities of the brain. The increasing complexity of confrontations could namely have favored a more intensive exchange of information within the groups and promoted the development of language ability. To this point, I will return once more (Chap. 7).

In mountainous regions, it was easy at the end of the *erectus* phase to use, among others, larger stones as well. These made possible, when thrown down at opponents from above, an effective use of gravity and resulted in an effective weapon of medium range against which shields were also of little help. The Neandertals were presumably not only adapted to life in the cold North, but also to making war in mountainous country. Their skull shape, robusticity (in particular also of the arches of the feet), enormous physical strength, and many broken bones incurred in life point to the practice of bombarding the opponent from a higher-lying place with heavy boulders. In Eastern Europe, where in the last Ice Age mountainous country as well as broad flatland was present, the Neandertals were the most gracile. The hyperrobust classic Neandertal appeared on the one hand in the mountainous West and on the other hand in the Near East (Trinkaus & Shipman, 1993). In the Near East, this is presumably explained in that their access to flatter habitats was prevented by the more mobile, better adapted to life in the flatlands, *Homo sapiens*. The different adaptations made it possible for these two prototypes of humans to exist side by side in this region for many thousands of years.

In contrast to mountains, where one easily finds places that can be defended well, plains offer hardly any opportunities to select an area in which one possesses clear advantages over an opponent. As a supposed flatland occupant, *Homo sapiens* after the introduction of shields had above all to be very mobile. Perhaps it is exceptionally gracile for this reason, and it is also entirely conceivable that it lost its fur in favor of a skin covered in sweat pores. The size of the group would also have had a much higher value for *Homo sapiens*, if it was really a flatland occupant, than for people that lived in mountainous regions. This basic rule has not forfeited its applicability in the present. Mountainous regions often serve as areas of retreat for small ethnic communities that could not have held out on flat land. The Balkans, Lebanon, or the Caucasus, in which mutually hostile peoples of different religious affiliations live close to one another, should suffice as examples. Seen thus, *Homo sapiens* was perhaps the better candidate for the solution of the task of stabilizing larger groups than, for instance, the Neandertals, even if the latter are actually supposed to have been even more intelligent.

It is also questionable, though, to what extent Neandertal or *sapiens* features actually reflect kin relationships among those populations. The body size of Neandertals was less because they were adapted to colder habitats. Robusticity and skull shape may have resulted from the requirements of making war in mountainous country after the introduction of shields. Both characteristic complexes could certainly have developed in parallel as reactions to the same requirements in different areas. Molecular genetics have produced clear evidence that parallel evolution and convergent evolution have played a substantially higher role than had been assumed based on physical features. Many classifications based on similarities in physical features have since had to be called into question (Lewin, 1998).

It is thus quite questionable whether the common features of the Neandertals in northern Iraq and in France indicate a common development and genetic exchange. Both populations could certainly have developed their Neandertal features in isolation. Similar is true for early *Homo sapiens* populations in the Near East and South Africa. The close relationship of all humans living today to each other is by no means a contradiction of this statement. There is no cogent reason to postulate that we are much more closely related to the early representatives of *Homo sapiens* in the Near East 90,000 years ago than to the Neandertals from the north of Iraq. Our ancestors from this time presumably lived in a closely outlined region of Africa – without anyone being able to say exactly where this region lay. From a few million humans that lived in the world ca. 70,000 years ago only ca. 10 000 belonged to our ancestors. The question where this 10000 were living no one can presently answer more precisely than with “presumably somewhere in Africa.”

If the transition to presapiens went along with clear changes in the conduct of war, then a significant superiority of local populations could also have resulted from this. Perhaps because of this, there was a wave of conquest and advancement at the end of the *erectus* phase, during which course many local populations were replaced by superior opponents with more advanced war-making. A similar wave of advancement, which ran over the whole world, we will discuss in connection with the transition to the Late Paleolithic.

At the end of the *erectus* phase, it need not have come to such a wave if, as I suppose, the decisive changes in the type of weapons used took place. The speed of an expansion wave was tied to the reproductive rate, since new areas were not only conquered, but also settled. Thus, for the conquest of a continent by a small original population, millennia were required. We will yet see that *Homo sapiens* needed about 40,000 years for the conquest of the world. New weapon traditions whose use is directly understandable, on the other hand, could have expanded beyond the limits of groups relatively easily. If the new traditions expanded more quickly than their inventors could and thus eliminated their advantages, then no wave of expansion occurred.

6.3 The human brain in comparison

The title of this chapter should actually be emphasized in the font just like the following citation from Gerhard Roth, since he named the chapter from which this citation is taken the same way (Roth, Prinz; 1996):

> "The cognitive abilities of humans are closely connected to the construction and functions of the human brain. It is thus close at hand to view the stipulated human cognitive abilities as results of the uniqueness of the human brain. We must ask ourselves whether this view is justified. Is the human brain really unique, and if so, in what respect?
>
> That the human brain is *completely incomparable* one certainly cannot claim because of the anatomy and functional organization of the human brain presented here. The human brain is constructed of nerve cells and glial cells like all brains, and there is also nothing in the way of other material components in it that is not also found in animal brains. … The human brain is extraordinarily similar to those of the other apes, and it is not possible for an expert to discover any differences in the construction of the isocortex or the cerebellum between the two primate groups under a microscope. If we compare the brains of the primates with those of the other mammals, we find similarities and dissimilarities according to how these groups are related to one another in descent. This is of course also true for the other classes of vertebrates and means that the evolution of the brain follows biological evolution in general. The human brain clearly fits into this evolution.
>
> The next thesis to discuss is that humans have the *largest* brains among animals. Such a claim is obvious, since a large brain is seen as a sign of special intelligence, and popular opinion says that humans are so clever and superior to the animals because they have large brains. … The human brain weighs on average 1.3 kg, the brain of an elephant 4.5 kg and that of a sperm whale 7.9 kg (the largest brain of all). Given, the human brain is in the 'top group' concerning its brain volume, since the vast majority of animals have much smaller brains even when they surpass humans in body size, such as horses or gorillas. …
>
> What really distinguishes the human brain is the fact that it is extraordinarily large in light of humans' absolute body size, since because of the allometric conditions applicable to vertebrates or mammals, it should be much smaller. … In summary,

then, it can be said that humans do not have very large brains seen absolutely, but seen relatively. They have brains that are seven to eight times larger than they actually should have, based on their mammalian Bauplan (and the brain allometry contained therein). This does not make them unique, however, since dolphins show an EQ *(EQ is the encephalization quotient; it is defined elsewhere as the relationship of expected to actual relative brain size)* of 5-6. …

The earliest human-like [creatures], the australopithecines, to which 'Lucy' (*Australopithecus afarensis*) belonged, lived 3-4 million years ago and had a brain that at ca. 450 cc was hardly larger than that of the modern chimpanzees. A significant brain enlargement first occurred with *Homo habilis*, which appeared around 2 million years ago and had a brain size of ca. 700 cc. This meant that the brain size of our ancestors remained more or less constant over a timeframe of 1.5 million years. A further step in brain evolution was completed 1.8 million years ago with the appearance of *Homo erectus*, which had a brain volume of 800-1000 cc. The appearance of the earliest *Homo sapiens* no more than 400,000 years ago, with a brain volume between 1100 and 1800 cc, represents the last step thus far in the brain evolution of the hominids. It must be noted here that not modern humans, *Homo sapiens sapiens*, but rather the Neandertals, *Homo sapiens neandertalensis*, possessed the largest brains of all hominids.

The reasons for these step-wise increases in brain size are unclear, although there are many scenarios for it. Most authors assume drastic environmental changes, e.g., encroaching steppe, and correspondingly necessitated adaptations of the hominids to, e.g., life on the savannah and the related necessity of hunting in groups and developing the social and communication forms required by this context. Since, however, in the last 4 million years Nature has changed dramatically many times in Africa, Europe, and Asia, while the brain volumes of our ancestors at the same time remained more or less constant for long periods, it is appropriate to doubt a direct connection between environmental conditions and brain volume. Many features seen as typical of humans, such as walking upright and using tools, were developed *long before* a significant enlargement of the brain over the ape level. We will thus have to wait patiently for better explanations of human brain evolution.

Next in line [lit.: “the next standing in the room”] is the claim that humans have the *largest cortex*. It is thought that the human cortex is something special anatomically, or it is especially large, either with respect to its absolute size or at least relative to the rest of the brain. As we have already heard, however, the cellular construction of the human isocortex is not differentiable from those of the rest of the apes. With respect to absolute size, the human isocortex is by no means especially large; elephants, dolphins, and other whales possess a much larger isocortex than that of humans. Accordingly, the *relative size* of the cortex remains. This is also by no means unusual in humans. If, that is, we determine the relationships in mammals between brain size and cortical surface area, we find a nearly constant isometric increase in both sizes, and the human brain also follows this rule. The enlargement of the isocortex in humans or in dolphins is thus most substantially a consequence of the enlargement of the brain. According to Jerison, the human isocortex is in fact somewhat smaller than it should actually be, while dolphins … have a more overproportional isocortex.

The number of folds in the brain, to which many authors like to point in praising the special role of the human brain, also inclines more toward modesty. The high point in this development is namely not located in humans, but in the sperm whale, whose 8.5 kg brain possesses the proverbial overboard isocortex even compared to the human brain. The oversized cortex of the whale, though, seems in respect to stratification, [and] number of nerve cells and different types of nerve cells, to be secondarily simplified, possibly consequent to adaptation to the relatively specialized life in the water of a marine mammal.

We now come to the claim that humans have the *largest association cortex*. This view is of interest inasmuch as one locates in the association areas of the cortex, i.e., in the parietal, temporal, and prefrontal cortex, the mental and cognitive achievements of humans. It is therefore assumed that, in comparison to other mammals and other monkeys and apes, humans possess the largest associative areas in the isocortex. This is certainly applicable in comparing humans to other apes and monkeys, but the apes already have a strongly enlarged associative cortex compared to the majority of other mammals. Humans thus only advance the trend typical of primate brains, and this trend is at least in part a natural consequence of the enlargement of the brain, since the primary sensory and motor areas fall behind in the great size increase of the brain.

> They cannot enlarge at will, since they are closely tied to the sense organs and to sense centers outside the cortex and to the subcortical motor systems and the muscles. For the associative areas, this limitation does not apply, and they can expand.
> In humans and apes, within the enlargement of the isocortex, the *prefrontal cortex* has increased the most. Thus, in comparison to the other apes and monkeys, humans, have an especially large frontal lobe. This has led to many speculations, since in general the complex mental achievements of humans are located in the prefrontal cortex. One must also think about the fact, though, that whales have a much larger prefrontal cortex than do humans, relatively and absolutely, even if it is constructed differently. …
> In summary, then, it remains to be held to that the human brain possesses the same basic construction as the brains of all other vertebrates. It is not differentiable from the brains of the rest of the mammals in most details. The cellular construction of the human brain and its isocortex also does not differ in any way from the other primates. What highlights humans compared to animals is the large volume of their brains in comparison to their body volumes (relatively large brains are normally found only in very small animals), an especially large association cortex, and hereby an especially large prefrontal cortex. But here also humans lie – as we have seen – only along the "trend" of primates and the whales and dolphins. Many features of our brain, of which we are so proud, have occurred because of allo- and isometric growth rules and not primarily because of strong environmental selection pressure. This of course does not rule out the possibility that this sort of neutral growth processes proved advantageous in the presence of hypothetical selection pressure."

To assume based on the determined allo- and isometric growth rules that we are only dealing with neutral growth processes here, I think, is to reach too shallow. Not only brain size and the construction of the brain show dependence on body size, but also reproductive and survival strategies. Larger animals live longer, they have fewer children later, and they invest more in the individual child (Lewin, 1992). They must therefore also be, among other things, more intelligent, so that in light of their lower fertility enough offspring reach reproductive age. That primary motor and sensory areas are relatively smaller in the larger brains of larger animals surely indicates that these brains, although they are not as greatly enlarged as the bodies, are still larger than would be necessary to reach the same mental potential as a smaller animal.

With the sizes of animals, then, not only do their brains generally grow, so does the level of the demands on these brains. Perhaps then the determined allo- and isometric growth rules rest directly upon the environmental selection pressure mentioned above and do not just coincidentally suit it; I, at least, find this interpretation more plausible.

Similar considerations also obtain when one looks at the primates in particular. They have larger brains than other mammals, but they are also more intelligent, and there is no lack of explanatory approaches for why they must be so in their way of life. If one supposes, then, that the larger association cortex and above all the especially large prefrontal cortex of humans have contributed to their exceptional mental position, then this assumption is in no way disturbed by the determination that already in the primates and in particular among the apes, a tendency toward the enlargement of these areas can be made out. The opposite is sooner the case, since exactly those primates that come closest to us in brain construction also prove most intelligent in corresponding tests.

All in all, the determination of a tendency according to which the brains of primates resemble the human brain in construction and size more the more closely these primates are related to us provides little toward an understanding of our evolution. If one assumes that humans are a product of evolution, then nothing else is to be expected. This tendency thus only proves the relationship, and in no way contributes to a functional explanation of the development. Instead of always emphasizing that humans “only” advance a trend recognizable in the primates, one should rather ask which devil drove our ancestors to go even farther in this direction. The enlargement of the brain is, namely, absolutely no guarantee for success among the primates. The apes, which “bet” on especially large brains, were substantially more successful in the Pliocene; since then, their species diversity has declined significantly in favor of the species frequency of monkeys. The survival strategies of the monkeys, with their smaller brains, have obviously proven more successful in the long term.

The cause of this can be seen primarily in that large brains only make sense when one takes very intensive care of one’s offspring. Apes thus distinguish themselves through an extremely low reproductive rate and therefore live constantly on the edge of extinction. One could certainly say that large-brained-ness has proven to be an evolutionary cul-de-sac in the primates. Only the ancestors of the hominids, somewhere way back in the corner of this cul-de-sac, already pressed against the wall by the drying out of Africa and the accompanying increase in predator-rich habitats, discovered a surprise loophole. A niche whose use paved the way to humanity. It is thus not true at all that the developmental line of humans "only advanced a trend" – when the development of the hominids began, the trend toward larger brains in the primates had long since reversed itself. Our ancestors, in contrast, bet on an enlargement of the brain in just those habitats in which they, according to what we know about primates, should actually have been the least successful. This urgently demands an explanation, and to deliver one is a main desire of this book.

The most important thing one can read from the overview of a brain specialist cited above for an evolutionary scenario is, in my opinion, that the fundamental construction of the brain is quite closely tied to its size. Obviously, nothing in the construction of the human brain supports the assumption that the size increase of the human brain only came with a limited increase in mental capacity, which then only in a second step, starting from an already very large brain – through reconstructive measures of some sort, such as for example are assumed by Schrenk – reached a very high level. Everything looks as though humans had depended, in the further development of their mental capabilities, upon the further development of the same measures that had already led to the very capable brains in comparison to other animals of their ape ancestors.

6.4 Organic evolution

I have already announced that one cannot get around concerning oneself with how organic and cultural evolution function if one wants to have any chance of understanding the course of human evolution in the last 1.8 MY. Since the room for speculation in this period is very great, it is obvious to attempt to limit it by calling upon evolutionary theoretical considerations. The limitation of the room for speculation is bought, however, along with the fact that the results of the considerations become directly dependent upon the quality of the evolutionary theoretical working hypotheses. If these working hypotheses are wrong, then this is generally also true of the conclusions about human evolution. For precisely this reason, I have limited myself in my observations of hominid evolution up until the appearance of early *Homo erectus* to researching which adaptations took place, without adding speculations about how these adaptations came into being.

The goal of the considerations following now is the preparation of working hypotheses for the following lines of questioning:

- Which characteristics are optimized in the course of organic evolution?
- Are characteristics also optimized in the course of cultural evolution, and if so, which?
- What chronological course do the optimization processes show (evolutionary kinetics)?
- In what ways do cultural and organic evolution affect each other?

In this chapter, working hypotheses are presented for the first and, as far as it concerns organic evolution, the third question. The next chapter deals with cultural evolution.

In my work on the CTSW model of hominid evolution, I had the impression many times that I did not tread in new terrain, rather only followed in Darwin’s footsteps or investigated questions raised by him more closely. Even if it is now a matter of becoming clear on a few important aspects of evolution, in my opinion one still does well to keep an eye to Darwin, although – or perhaps precisely because – he did not have the slightest idea of how hereditary information is fixed.

I have enormous respect for Darwin’s statements about evolution. Darwin had in his work a very rewarding, if also very painstaking, approach. His theories are based on a plethora of observations and have with that a strongly descriptive character. As Darwin’s fundamental assumptions were very obviously correct, he additionally had available an exceptional instrumentation for the interpretation of his data. One must thus differentiate between Darwin's fundamental assumptions, among which belongs the assumption of evolution as an interplay between variation and selection, and the conclusions to which he came through use of these assumptions. His conclusions were bound to his basic assumptions through an abundance of facts, and thus [were] anything but independent assumptions. If someone arrives at statements because of new understandings (e.g., about the molecular biological processes underlying inheritance) that contradict Darwin's claims (e.g., the claim that the variations underlying evolution are small), then as a rule these statements automatically contradict either Darwin's meanwhile multiply verified fundamental assumptions or his empirical material. In both cases, the new statements hold a difficult position.

On top of this, Darwin developed his evolutionary theory himself. As "inventor" of this thought edifice, he had very different access to the data and a deeper understanding of the relationships than one of his "students." We will, in my view, only then understand how evolution works when we can explain why it functions on the level of the individuals with which Darwin dealt exactly as Darwin described it.

Work with genes, the "elementary particles" of evolution, easily leads to hasty doubt of older understandings, since their discoverers hadn't the faintest glimmer of important aspects – indeed, of the characteristics of the carrier of hereditary information – of evolution. Contradictions of one's own, newly developed concepts of long-standing views are quickly attributed to the ignorance of those who represented these views at the time. Modern representatives of the same, allegedly overhauled views run the risk of being mildly laughed at. A similar attitude is also brought up by some sociobiologists against the sociologists who adamantly contradict them. Frequently, though, exactly this sort of contradiction is a sign of inadequacies in the new model, and their clean clarification offers valuable opportunities for improving the model.

One must thus investigate such contradictions under the premise that there is something to them until one has cleared up their origin. Instead, one sooner tends to seek arguments that shake the plausibility of the information that doesn't fit in one's own picture and that allow one to duck a serious confrontation with the information. A potentially fruitful confrontation between different scientific hypotheses degenerates into a fight for position between the scientists more readily understood as a conflict over rank or territory than a common effort in the service of scientific progress. Our primate heritage obviously offers anything but ideal conditions for scientific activity.

Classical thermodynamics are also based on macroscopic observations. A deeper understanding of the quantities introduced there, such as heat capacity or the expansion coefficient, results only when one investigates the processes on a molecular level. No thermodynamicist, however, would have accepted because of this a kinetic theory of gasses that contradicted classical thermodynamics in its predictions.

How, then, does organic evolution function in higher mammals, among which humans and all of their ancestors in the evolutionary period considered in this book belong or belonged? The answer to this question is not so simple, and above all not as unequivocal as one would perhaps expect after more than a hundred years of evolutionary research. While there is long since no more defensible doubt that humans are a product of evolution, the question of how this evolution works is still far from being conclusively explained. I believe, however, that one can formulate usable working hypotheses based on available knowledge, with which the questions addressed above may be answered.

There is agreement that hereditary information is stored in complex chains of organic molecules, DNA. This is constructed of four different components, and its information content results from the order in which these components are arranged. Sections of DNA serve as instructions for the synthesis of proteins, which in turn undertake the most diverse tasks. A gene is understood as a section of DNA that constitutes a functional unit. There are structural genes, which code for proteins, and regulator genes, which control the expression of the structural genes.

The differences in the genetic material (genome) of any two individuals of a population are substantial. The actual quantity of these differences surprised evolutionary theoreticians of the time. In the genome of a sexually reproducing organism, genes are present in two versions; one comes from the mother, the other from the father. In about 10% of cases, one gene differs from the other; one speaks then of two different alleles of the gene. In the total population, one finds different alleles for about 30% of the genes. For some of these genes, there are more than twenty different alleles in the gene pool (Lewin, 1998). These differences in genotypes constitute the basis of the observed, in part significant, variability of the phenotypes in the individuals of a population. They thus somehow go along with differences in physique and surely also behavior. From this results then perhaps an advantage or disadvantage for the reproductive success of these individuals relative to each other, and thus for the degree to which the genes of single individuals spread through the population.

In sexual reproduction, though, the same genome is not passed on, rather only half of the genetic material that has temporarily made up a genome; the other half necessary for the creation of a new genome is given by the sexual partner. Observed from the standpoint of the gene, the present genome represents something like a "working group" in which it participates with the "goal" of making room for copies of itself in as many new and hopefully successful genomes. The enormous effectiveness of these "work groups" can be seen in the complexity and impressive adaptive traits of the individuals.

For every single gene of a genome, the chance of being present in a new genome in the form of a copy is equal, in sexual reproduction, to 50%. In the case of asexual reproduction, in which the entire genome is passed on to the following generation, it would be equal to 100%. In addition, in asexual reproduction, the effectiveness of the ancestral genome is followed with high probability by equally high effectiveness of the offspring genome. This only does not apply when the offspring genome is disadvantageously changed through mutations, or when the "environment" changes so that the phenotype produced by the genotype is no longer so well adapted. Sexual reproduction is therefore interpreted as an exceptionally "expensive" adaptation from the standpoint of the genes, which ensures high variability of geno- and phenotypes. This variability increases the probability that some of the daughter genomes, to which the genes "entrust" their copies for further expansion, will also count among the continuously successful even in the event of changing environmental conditions.

Stated differently, this interpretation says that sexual reproduction is so successful despite the high associated costs to the genes because sexuality offers the possibility to adapt more quickly to changed environmental conditions. The whole, complex functional arrangement of sexual reproduction is thus viewed as an **adaptive trait** for the improvement of evolutionary ability. And this makes complete sense:

If we look at a contemporary higher organism, let us say – without limitation of generality – a mammal, then we are dealing in each of its genes with the last member of a line of genes that have, in part over millions of generations and without sitting out even once, managed to "work together" in genomes that put forth current, frequently modified phenotypes for selection that were better suited to compete successfully in the fight over reproductive resources in the conditions applicable at each time. Times of rapid change, which preferred changed phenotypes, were survived primarily by gene lines that also appeared in altered genotypes. Seen thus, adaptations to evolutionary ability belong among the potentially most promising adaptations of all of evolutionary history.

We must thus become familiar with the thought that not only organisms as such are products of evolution. Evolution itself is an optimization process optimized in the course of evolutionary history, whose characteristics were determined in part by genes, and which the genes "served" in order to have the highest probability of being present among the successful genotypes of the future in the form of copies. I believe that this view is not all too widespread, although it is included in the commonly known claim that sexuality would "serve" to prepare variability required for evolution.

The highly complicated and, from the standpoint of fitness, very expensive functional complex of sexual reproduction is thus handled by many scientists in principle as an adaptation for evolutionary ability. This reflects how high the evolutionary value of evolutionary ability really is, and makes it obvious to search for further adaptations of this type.

It is seemingly contradictory to assume that higher organisms have on the one hand developed such a complicated, expensive, and powerful tool as sexual reproduction in order to improve their adaptive capacity, but that on the other hand the course of evolution is still determined by coincidental mutations. This corresponds somewhat to a demand on modern programmers of highly integrated computer programs to adapt to new tasks through random interference with its binary code.

The comparison with computer programmers is by no means a poor one here. Good programmers arrange the construction of their programs such that the can be adapted to new, similar tasks with relatively little effort, even when they do not know in advance what demands the new tasks will make. The programs are cut up into functional units, which then themselves can be adapted to different tasks through well-defined variables. The genes of sexually reproducing organisms have perhaps taken similar measures in order to adapt their "programs," i.e., geno- and phenotypes, like programmers. Hereto, a quotation from Gerd B, Müller (Müller, 1994):

> "The example of the transformation of the extremity patterns shows that the multitude of phylogenetic structure and form changes is achieved through the modeling of cellular and supercellular developmental processes and not through genetic changes on the level of structural genes. The molecular repertoire of the involved cells

> remains the same. There are cases, though, where changes of structural genes may possibly have a direct influence on morphological evolution. …
>
> As the classic diagrams of D'Arcy Thompson (1917) show, phylogenetic form changes predominantly rest upon proportional shifts of body parts. All necessary relative enlargements and reductions of the components of an organism can be achieved through the modification of quantitative developmental parameters. These parameters are primarily influenced by the chronological control of developmental processes. Every developmental process, whether it plays out on the molecular, cellular, or supercellular level, is defined by its beginning, its operating speed, and its end. Changes in these three variables can in principle effect every conceivable proportional change in bodily structures. For this reason, heterochrony – the phylogenetic alteration of time variables in developmental processes – presents one of the most important mechanisms for evolutionary influence on ontogeny. Thus, for instance, an earlier beginning or a lengthened duration of cell divisions or an increase in the division rate can let the number of cells and thus the size of an organ or tissue grow, or in the opposite case, decrease. This concept of heterochrony, whose definition has fluctuated greatly since its formulation (Gould 1977, 1988), is being ever more confirmed through empirical studies, above all in paleontology, but also in experimental and comparative developmental biology, whereby the examples now include a multitude of organisms of numerous taxa from nearly all classes of animals (McKinney 1988; McKinney and McNamara 1991)."

Evolution thus occurs to a great extent through "the modification of quantitative developmental parameters" that lead to "relative enlargements and reductions of the components of an organism." Similarly, the units of a computer program are adapted for the solution of new tasks through changing suitably defined variables. In computer programs, however, this requires that they be correspondingly conceptualized from the start. Brilliant programs "cast from the same mold" are certainly suited to work out the concrete program for which they were developed, but hardly can be applied for the solution of changed problems. Should this be different in organisms? Should they allow themselves to be modified in a similar way without being "developed" for it? – I think not.

On the other hand, genetic variability in the genome truly seems to rest upon the accumulation of random mutations. How can the functionality of the evolutionary process on the level of the individual be brought into accord with these chaotic processes on the genetic level? Presumably, the functionality of the evolutionary process does not result from the characteristics of the individual genes, but rather from the way in which these genes “work together” on a higher level. Just as the functionality of a phenotype cannot be traced back to a single gene, but is rather based on the interactions of all genes in the genome, the evolutionary ability of a population could be based on the interactions of the genes included in the gene pool. The selection occurring on the level of the individuals leads to the functionality of these individuals, a functionality that results from the characteristics of the genome and therefore must be included in it in some form as information. We will see that the same selection occurring on the level of the individuals could have led to a functional variability of individuals and of the gene pool in the case of sexual reproduction, which made possible a rapid adaptation of geno- and phenotypes. The constant mutation pressure would then not have been the direct cause of evolution, rather an aspect of the environment to be considered in the development of evolutionary capacity, and upon which the evolutionarily competent sexual reproduction system oriented itself so that the genetic variations needed in any event for evolution ensued on the right scale.

How this evolutionarily competent sexual reproduction system (ECSR [EKSF]) came to be in its time is a difficult question with which I will not concern myself here. This developmental process lies in the distant past and may have resulted in the “Cambrian Explosion” ca. 540 MY ago, in which the complexity of the most complex beings of the time increased substantially, and wherein the “Bauplans” of recent higher organisms were developed.
The complexity of an organism realizable by evolution naturally depends directly upon the effectiveness of this optimization procedure. The fact that life on Earth did not surpass the level of single cells for 3 billion years could thus certainly be related to that evolution, in the ways in which it functioned at that time, presented no particularly effective optimization procedure. One should also remember that biological and physical eras do not coincide. Biological time is measured better in generation lengths – these mark the duration of an iterative step in the optimization procedure of evolution. For microorganisms, whose generation length can be less than an hour, 3,000 MY were an insanely long time, during which it could be thoroughly plumbed what one could achieve with the available optimization processes.

For the line of questioning handled in this book, it is much more important how this ECSR functions today than how it came to be. And of that, one can make an image quite well:

The genetic material of a gene pool is very variable, but nonetheless well enough attuned to itself that if one took a simple set of hereditary material from each of two genomes and united them into a new genome, this genome brings forth a phenotype that as a rule is fully able to function and in which a high degree of adaptedness can be recognized. Precisely this process occurs constantly in sexual reproduction and functions exceptionally. The variations of the phenotype may be high in many areas that hardly affect fitness; in fitness-relevant areas, they are very low. The degree of adaptedness surely does not depend, however, in light of the enormous variability of the gametes, primarily on the availability of individual new, advantageous mutations in a genome, rather on how well this combination of alleles long since present in the gene pool proves itself.

The characteristics of individuals are statistically correlated with their reproductive success. They are based on the interaction of the alleles at hand and are retained in part in the individuals of the next generation. Their genome namely originates half from each of two successful genomes of the ancestor generation, and the genes, which from the point of view of one of the ancestor genomes are exchanged, are still present in 70% of cases in only one version. In addition to the 50% of the genes that remain together anyway, at least 70% of the exchanged 50% are then replaced with identical genes. In all, then, at least 85% of the child-genes correspond to those of each of both parents. To that comes yet an indeterminate number of genes that are certainly present in multiple alleles in the population, but in the concrete case are replaced by the same allele from the other parent, and a multitude of genes for which another allele is actually introduced, but the new allele comes very close in its effect to the observed characteristics of the old one. Characteristics based on the combination of multiple concrete alleles thus have good changes of being retained in the next generation. This agrees with the observation that children look like their parents and lays the foundation for rearing new lines with desired characteristics. If such characteristics, in the case of natural selection, are accompanied by higher reproductive success, then they spread through the population with the underlying gene combinations. Thus, in the course of time they enrich the number of individuals in a population with characteristics that maximize their reproductive success. One also speaks of a fitness maximization taking place at the level of the individuals.

Why, though, does this process, to the extent that it affects morphology, give the impression that not just any characteristics are changed, but rather that well-defined variables are adapted?

In order to offer an explanation here, something further must be sounded out.

As already mentioned, the genetic material of a gene pool is doubtless very well attuned to itself; otherwise, it would hardly be possible to take half from each of two genomes, place the halves together, and therewith acquire a new, fully functional genome. You may try once subjecting two books with the same number of pages to a similar procedure, in which you leave it to chance from which of the two books you take the individual pages with given page numbers. The first page could, for instance, be the first page of the second book, then the second page of the first book follows, and so on. You will then certainly end up with a book with the same number of pages and lots of familiar words and sentences – but a good, internally logical book will not come out of this. That sort of thing can only work if the two books used were already prepared for this procedure in their construction – “attuned to each other.”

On the level of phenotypes, there is at the same time to be seen an impressive functionality, which indicates that evolution works quite well as an optimization process. Successful phenotypes obviously come very close, as a rule, to the optimal solution of the task of adapting the underlying Bauplan to present selection conditions. This view is supported by the observation that isolated developmental lines with a similar Bauplan have generated the same adaptive traits for the same niches.

There must be a reason why these separate lines have developed the same combinations of features, and this reason presumably consists in that exactly this combination of features represents an optimal adaptation to the common survival strategy. The frequency of parallel and convergent evolution therefore refers to the effectiveness of evolution as an optimization process and that on the level of phenotypes, necessity clearly dominates over chance. To that, an example from Roger Lewin (Lewin, 1998):

> “How does it stand, though, with the songbirds, a group to which more than half of all bird species on Earth belong? In Australia, there are more than 700 indigenous species, among which many are not practically differentiable from African, European, or American species. When in the last century the classification of Australian songbirds was undertaken, the European ornithologists had already classified birds nearly everywhere else in the world. The Australian songbirds looked so similar to

> familiar species of the Old and New Worlds that it seemed only natural to classify them in known groups. Sibley and Ahlquist remark that ‘many of the convergences are so subtle that the true kin relationships … probably could not have been clarified through anatomical comparisons alone.’ For this reason, for example, the South Sea warblers (Acanthizidae) were classified as Sylviidae (kinglets or warblers), the South Sea [“snappers”] with the Muscicapidae (thrushes or gnatcatchers), the [“tree sliders”] (Climacteridae) as Certhiidae (creepers), and the honey eater (Meliphagedae) with the nectar-eating Afro-Asiatic nectar birds (Nectariniidae). This classification made sense seen morphologically, but not geographically, since Australia has been separated from the rest of the world for at least 30 million years. The only explanation for such kin relationships would have been repeated immigration of species from other continents – a perhaps not impossible, but improbable scenario. Moreover, the pattern of species expansion implied by the immigration hypothesis differs strongly from that of the indigenous marsupials limited to Australia, while one normally expects, particularly in spatially limited evolution, geographical agreement of different species groups.
>
> The data from DNA-DNA hybridization placed the prior classification of the birds completely in doubt. They showed that the Australian songbirds are natives of their continent, and thus brought the biogeography of the birds in accord with the mammals. Like the marsupials, the songbirds of Australia have adapted to ecological niches that are the same as the niches in other regions of the Earth, and resemble their counterparts native there because of convergent evolution, whereby the degree of similarity is often astounding.”

Since the majority of the individuals of a population are very well adapted, large changes in the fitness-relevant characteristics of a child in comparison to its parents are almost always associated with a clear reduction in fitness. Alleles that would lead to substantially different expression of such characteristics in different genomes, would regularly produce waste after successive recombination. The genomes in which they cooperated would then be, because of just this cooperation, statistically less successful, which would eventually lead to the elimination of such alleles in the gene pool. Therefore, such alleles only exist rarely in a gene pool, when they appear due to mutations, since they are typically selected back out very quickly. The 70% of the genes for which only one variant is present in a gene pool must react quite sensitively with clearly altered influence on fitness-relevant characteristics of the phenotype. For this reason, no variations of these genes have been able to take hold in the gene pool.

The claim that Darwinian evolution, which emphasizes the importance of selection for evolutionary progress, leads to the assumption that exactly those mutations that exercise strong influence on the phenotype should spread especially quickly through the gene pool, is false. For an optimization procedure constructed like evolution, a strong dependency of its effectiveness upon the degree of variation in the individual iterative steps is to be counted on. A corresponding [situation] is known in mathematical optimization procedures, and it is known that a too-strong variation leads to that the optimization process no longer converges, i.e., that the optimum is no longer found. Why this is so, one can understand quite clearly graphically:
Let us assume that we wanted to approach a given, unknown to us, Point A as closely as possible with a process structurally similar to evolution. We have a measuring device that gives us the distance from every investigated point X to A. Now, we would investigate a number of [points] X and make from the one with the lowest distance to A the working point of the first iterative step. Around this working point, a group of new points X would be generated that lay in different directions at a distance of 1-3 meters from it. Each of these Xs would now be investigated as to its distance from A, and the closest would be set as the new working point for the next iterative step. With this procedure, we would doubtless be able reliably to approach A within a distance on the order of one meter.
Should we then, however, coincidentally acquire a working point only 40 cm away from A, then the generation of a group of new points with a distance of 1-3 meters from the working point in the next iterations would necessarily lead to that not one of these points lies closer to A than 60 cm. For a variation of 3 m there actually results a minimum distance of 2.6 m; such a variation would thus have from the start no chance of being the next working point. A new point group around the working point 60 cm distant could again not come closer than 40 cm, and so forth. The procedure would jump around the point sought without coming closer to it.
From this, one recognizes that a coincidental approach to A in the range of centimeters requires that the variation also lie in the same size order. The ideal variation size for an iterative step depends strongly upon how far one is still located from the optimum. If one is close to it, then only small variations lead to progress.

The natural choice, which acquires decisive importance in evolution, corresponds to the selection of a working point from a group of newly generated points in this conceptual optimization procedure. In the case of the evolution of sexually reproducing organisms, we have, as mentioned, to deal with very well adapted organisms – that is, with working points that already lie very close to the desired point. New points derived from it only have a chance of becoming working points of the next iteration of they result from a small variation from the working points – the children will only demonstrate a higher fitness if their characteristics do not deviate too greatly from those of their parents. Natural selection ensures that genetic variations with strong influence on the characteristics of individuals cannot gain a foothold. Only new alleles that exercise slight (functionally hardly harmful) influence on important (fitness-relevant) characteristics take hold in the gene pool. This certainly corresponds to the according statements of the neutrality theory of evolution, but by no means stands in contradiction to Darwinian evolutionary theory. The shaping principle of evolution, the decisive procedure that first makes functional complexity possible, is again selection. The neutrality theory only applies to the origin of genetic variability and thus illuminates only a partial aspect of evolution. A partial aspect, as well, that presumably plays only a subordinate role in the development of new characteristics upon which we are now concentrating.

From the assumption that in the gene pool, primarily those variations take hold that possess only limited influence on fitness-relevant, functional aspects on the level of individuals, to the observation that evolution primarily proceeds through variation of quantitative parameters, is only a small step. The principle functionality of an organ typically depends only weakly or not at all on its size. Size changes certainly do lead to changes in effectiveness, in “efficiency” and other optimizable aspects, but only in exceptional cases do they influence functionality. Thus, quantitative parameters, such as for instance the sizes of individual components, are ideal tools for adapting a given Bauplan to the requirements of different tasks without significantly deharmonizing its function – there are plenty of examples from technology in which exactly this is done. Genetic variations whose effects are limited to quantitative aspects of individual development, however, are therefore – because they only rarely place the functionality of the phenotype in question and therefore often belong among the “small” variations from the standpoint of overall fitness – also those that should, according to the neutrality theory, be most able to spread through the gene pool (if one disregards the truly neutral variations that exercise absolutely no influence on phenotype). Thus, in the case of sexual reproduction, genetic variations accumulate that lead to high variability of precisely those characteristics with whose adaptation one should functionally react on the level of phenotypic evolution to changed requirements. These variations then present the tool that is called upon by the ECSR in the optimization process. That this custom-tailored "tool" is already available in emergencies is presumably the secret of the success of sexual reproduction. On the one hand, it makes possible rapid adaptation to a changing environment – we have already addressed this advantage of sexual reproduction. On the other hand, though, it also explains why organisms that reproduce sexually can achieve higher complexity. In complex organisms, very many characteristics must be very finely attuned to one another. For that, in the course of evolution lots of suitable, small variations of the sort present in great number in sexually reproducing organisms were required and constantly made ready. The opportunity to develop more complex organisms and thus to advance into as yet unoccupied niches represents a further advantage of sexual reproduction and surely contributed – perhaps even decisively – to the success of this reproductive system.

In complex organisms with strongly differentiated and specialized body parts, changes in the Bauplan typically exercise very strong influence over functionality and therefore also over fitness. Mutations that cause such changes thus as a rule do not have a chance to take hold in a gene pool. Therefore, the evolution of complex organisms has for a considerable time represented only a result of interpretations of the same fundamental pattern. The poodle, seen thus, is an extreme interpretation of the wolf; humans generally are an extreme interpretation of the chimpanzees (more precisely, they are both two different interpretations of the same fundamental pattern). It has not yet been possible to detect in the human brain even one functional unit that is not – at least as a trace – available to chimpanzees. Evolution runs over long stretches through rebalancing existing functional units, whereby in extreme cases even entirely new characteristics can be generated, as for instance the language ability of humans. Here also, units are used that are apparently all present in chimpanzees, but had to be enormously altered in the course of human evolution. The species that one can now observe are only interpretations of the possibilities given them through their present combinations of functional units and available variables.

Which interpretation prevails at the time depends on the requirements of the environment and on the preceding development. Preceding development plays a large role because the optimization process with the name evolution as a rule only functions when the variations are small. True developmental leaps are thus hardly to be expected in the course of genetic evolution. Point mutations that lead to major changes of the phenotype are of course possible at any time – they are not, however, with probability bordering on certainty, constructive. It does happen that two clearly different expressions of the phenotype, observed from the perspective of fitness, are not different and can exist side by side in the population – these are, however, the exception. Exceptions, though, that have played a very large role in the scientific discussion, at least a much larger one than in the real course of evolution.

Observation shows that the evolution of organisms, as far as one understands this as a phenotypic change, occurs in thrusts. Long periods of phenotypic stability alternate with short phases of dynamic change. Genetic variation is, in contrast, continuously generated; in many areas of the genome, it has many characteristics of a molecular clock, so that one can for instance draw conclusions about the branching times of different developmental lines from the number of accumulated mutations in those lines.

As we have seen above, though, genetic evolution presumably led to high variability within the population in those very characteristics of which evolution on the level of the phenotype preferentially consists. On most of these characteristics, a whole series of genes exercises an influence, and genetic evolution leads to exactly these genes appearing in the gene pool of a population in the form of – now and then very many – different alleles. A certain size – e.g., the length of a thighbone – results from the summary influence of all corresponding alleles of a genome. One can imagine the gene pool as the habitat of these alleles, in which, for instance, all alleles that "plead" for a longer femur compete with one another. Their "population density" depends here on how long the femur, under the given environmental conditions, should actually be. This size, decisive for the fitness of the individual, is dictated by selection – the particulars of how it is realized lie in the "discretionary freedom" of the genes. If long bones are demanded by selection, then the populations of "long bone" alleles in the gene pool grow, while the populations of "short bone" alleles become smaller. Only occasionally does it then happen that particular alleles are completely eliminated from the gene pool. Mostly, the variability of the gene pool is retained – only the frequencies of appearance of single alleles change. This leads to phenotypic evolution running, in principle, reversibly over long stretches. This kind of reversal in evolution, such as for instance the reactivation of old patterns, has been observed many times without anyone understanding previously how it could happen. An example with which we dealt in this book was the brow ridges of *Homo erectus*. They are an original feature of the apes that was reactivated in the course of hominid evolution.

It has become high time to remind ourselves of hominid evolution, since I have already diverged significantly in this chapter from the line of questioning with which this book tries to deal. In this chapter, only two working hypotheses were to be presented, which had to do with organic evolution. In one case, it was a matter of which characteristics are optimized in the course of organic evolution; the other was about the chronological course of such optimization processes. In both cases, we are only interested in the level of phenotypic evolution.

On the first working hypothesis, I stand in accord with the majority of scientists and could simply have prepared it in the form of a [brief] quotation:

Organic evolution leads to the maximization of individual fitness, which is recently also popularly called Darwin-fitness.

The only thing needed for the formulation of this hypothesis is the understanding that genetic information is transmitted through reproduction and is variable.

For a usable formulation of the second hypothesis, on the other hand, it is helpful if one has a usable concept of how genetic information is structured and is related to changes in phenotype. Essential to my working hypothesis is here that populations are in principle "evolutionarily competent" because of their genetic variability. It is not necessarily required to assume from this that an evolution of evolutionary competence actually took place (to that extent, I have actually shot beyond the target in my explanations). If the variations applied in phenotypic evolution primarily come to be through sexual recombination of variable genetic material already extant in the gene pool (and that is the present position of the science), then populations can practically react "from standing still" with adaptations to altered selection conditions. They need not first wait for suitable mutations. They are thus in principle "evolutionarily competent." With that, the assumption is easy that populations in principle react similarly to changed selection conditions as regulatory systems to changes in the size of the entrance. A reaction with special evolutionary theoretical relevance is, for this, the so-called "learning curve" [lit.: "jump answer"].

The learning curve is the course that the regulated value (resulting value) shows over time when one alters the target value at the beginning of the regulatory system in a jump. If populations behave similarly to a regulatory system, then they would react similarly to jump-wise changes in selection conditions. Such can result through rapid changes in the environment or through behavioral changes. In the CTSW model, primarily behavioral changes play a large part; these, however, often represent in turn reactions to a changing environment.

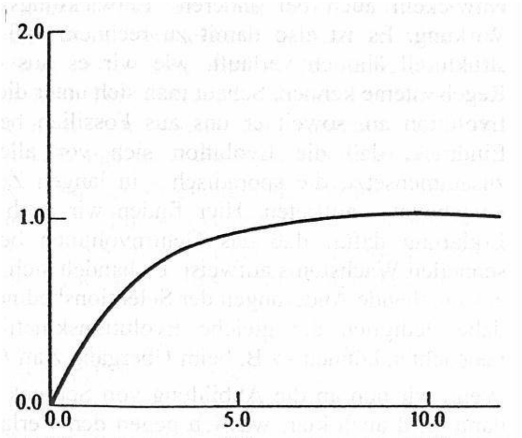


Figure 18: The course of the learning curve of a simple regulatory system, as presumably frequently occurs in the qualitative course of evolution. The horizontal axis is the time axis; on the vertical axis, the course of the regulated size can be read. The target value that the regulatory system is supposed to produce was changed at time t=0 from 0 to 1.

That a "learning curve" with the qualitative course for evolutionary scenarios presented in Figure 18 actually makes sense, the following considerations should illustrate.

Let us consider, for example, a "developmental intention" such as the transition to the upright gait at the beginning of hominid evolution. This process was introduced – according to the CTSW model – through a behavioral change that itself is seen as an answer to climatic changes. The ancestral population consisted of knuckle-walkers that were capable of walking upright, if not particularly well.

Consequent to the behavioral changes, the selection conditions – measured in evolutionary time – were shifted jump-wise. Capability in knucklewalking now was valued lower, capability in walking upright more highly. The population reacted to this immediately with a shift in characteristics that led to the improvement of the upright gait at the cost of knucklewalking.

As long as the upright gait did not function all too well, many points of approach naturally offered themselves for improving it significantly. [Otherwise] insignificant changes in the geometry, for instance, of the knee joint could lead to significant improvement in this characteristic. At the beginning of the development, therefore, progress was achieved rapidly. With the approach to the new optimum, however, it became progressively more difficult to improve the already clearly improved upright gait even further. The speed of development continuously decreased in the course of the adaptive process, since on the one hand, it became more difficult to achieve further improvements, and on the other hand, smaller improvements were also accompanied by lower selective advantages and thus spread more slowly through the population. At the end, "fine tuning" followed, which only contributed a little to capabilities in walking upright, but for this – compared to the dynamic beginning of the adaptive process – still required considerable time.

The aspects of this example relevant for the dynamics of the adaptive process also develop their effect in the same way in other "developmental plans." It is thus to be expected that the "learning curve" of an ECSR runs structurally similarly to what we know from regulation technology for some regulatory systems. If one views the course of evolution from this perspective, as far as we know it from fossils, then one gains the impression that evolution primarily consists of such learning curves, which sporadically – embedded in long periods of phenotypic stability – appear. Here, we also find the explanation demanded by Gerhard Roth for the brain volumes of our ancestors showing three phases of rapid growth. It is a matter of three "learning curves," which indicate corresponding changes in selection conditions. The brain shows only the same evolutionary kinetics in this that we can also observe in the physique – e.g., at the transition to *Homo erectus*.

If we now think back to Schrenk's illustration (Figure 16, Chap. 6.1), then it also becomes clear what I have to object to in the course that he postulates for the development of the brain's structure and cognitive abilities. His curves show the wrong bend, which corresponds to the assumption that the further development of these characteristics continued to accelerate with time. As I have stated above, we should expect, on the contrary, a developmental shift within organic evolution with a rapid beginning and a slow run, and because of this, with the opposite bending course of the developmental curve.

Often, such developmental shifts in the course of evolution introduce radiative speciations. This, too, is understandable, since a shift in the adaptive pattern can open the possibility of conquering new niches, above all when it is accompanied by the development of new abilities.

Such a view of the course of evolution was already obvious in Darwin's time, in my opinion, based on his evolutionary theory. Darwin supported himself in his theory building on observed phenotypic variability in populations; he knew that this is large and can be called upon for adaptive processes at any time. After all, he maintained intensive relationships with breeders and carried out breeding experiments himself. In such experiments, the "evolutionary competence" of populations becomes obvious, since new characteristics can be "produced" through arbitrary selection.

It was also known to him how well individual organisms are adapted; after all, he had grown up in surroundings in which enthusiastic naturalists were always describing new species and saw in their functionality proof of the work of an almighty creator.

All of this should actually have made obvious a view, according to which most organisms are already optimized, phenotypic evolution for the most part stagnates, and only in individual cases because of altered selection conditions do adaptive processes come about. One could thus have made very usable predictions about evolutionary kinetics based on Darwinian evolutionary theory. Instead, continuous progress in evolution was assumed in the early age of evolutionary theory. Presumably, this interpretation was based primarily upon the Zeitgeist and the time-venerated, anthropocentric thought edifice of the scala naturae.

The Zeitgeist was saturated by a strong belief in progress, since society was in the middle of a phase of dynamic technological development. This belief in progress was projected upon evolutionary theory, although the technological development of the nineteenth century was not of the least consequence to it.

In the scala naturae, on the other hand, a natural rank order of all life was postulated, at whose peak was of course Man. Such ballast, which may finally be traceable back to our primate heritage, still marks our thoughts today and lies at the base of such verbal creations as, for instance, the "higher mammals." If one wanted to retain the human-flattering concept of the scala naturae, then it was obvious to assume that lower animals simply were not as far developed in their evolution as the higher. If, however, they were not yet fully developed, then they still possessed room for further improvement, which presumably occurred constantly. Here, then, the non-Darwinian concept of an "internal developmental drive" residing in the organisms also played a role in the early period of evolutionary theory. The fewest scientists at the time agreed with Darwin's mechanistic concept of evolution in the form of an interplay between random variation and natural selection. The break that had to be made with tradition, and above all with religiously marked world views, was too great for a clean evaluation of the implications of evolutionary theory to have been possible.

Early ideas about evolutionary kinetics, which were later associated with Darwinian evolutionary theory and stand in contradiction to the fossil record, were thus not at all derived from the evolutionary theory. Much more, the evolutionary theory was superficially brought into accord with prevailing prejudices in a new thought edifice. In pseudoscientific, unclean ways, evolutionary theory was misused by racist and Social Darwinist currents. These, though, represent in turn aspects of cultural evolution; we will now deal with its laws.

6.5 Cultural evolution

Imagine a group of meteorologists who have developed an exceptionally effective atmospheric model, with which all of the air currents on the Earth can be calculated several days in advance (granted, a science fiction scenario). These scientists have carried out some experiments thereupon, in which they have successfully predicted, through use of their atmospheric model and the largest available computer, what flight path experimental balloons would take.

What would you say if these previously undoubtedly successful scientists wanted to obtain further research monies from the Ministry of Defense with the claim that they could predict the flight path of enemy jet fighters with the same method. After all, that would still only be a matter of flying bodies, just like the balloons set out in the wind. The jet engines wouldn't affect the thing; one would only need a more powerful computer for the mastery of this task.

I hope you do not belong among the people who would have granted the money with a glance at the academic titles of the proposers and their doubtless proven professional competence. I, for myself, sometimes tend toward a certain irreverence, and would in the given case probably have asked the modest question of whether the jet engines might perhaps, maybe under unforeseen circumstances, be able to exercise a certain influence on the flight behavior of the jet fighters.

What, then, does this story have to do with cultural evolution and with human behavior? For me, the supposed proving strength of the meteorologists' (invented by me) presented arguments that their model is also applicable to jet fighters is at stake. From membership in the same, higher category, "flying bodies," it is concluded that the same model can be applied. Structurally identical "evidence" is regularly presented to underline that human behavior, too, can be explained with the methods of sociobiology – cultural evolution may be a fact and, granted, takes place to this extent only in humans – but this doesn't affect the thing. To that, for example, Franz M. Wuketits (Wuketits, 1997):

> "… and considering the underlying mechanisms of social behavior, no 'fault line' should be pretended between the animals and humans; such a line, namely, cannot exist if humans are a result of organic evolution."

Whoever thinks that there might be much more behind this statement, perhaps a clean, natural science derivation of the "impossibility of a fault line" from the circumstances of organic evolution, will be disappointed. This statement is seen as convincing in itself and practically constitutes the basis for the claim of some sociobiologists to be able to trace even human behavior to fitness optimization: Man is also an animal, so his behavior can be studied with the same methods as that of the animals – presto. How shaky this basis is, is shown by comparison with the anecdote above. The "argumentation" is structurally identical and cognotheoretically not one bit better founded – it proves absolutely nothing.

I have the impression that the question of how cultural evolution works and to what adaptations it leads is today treated similarly superficially and marked with the prejudices of the individual schools of thought, as with evolutionary kinetics in Darwin's time. Just as many sociobiologists, whose thought edifice is saturated with the results of evolutionary thought and who actually should bring with them the best preconditions for recognizing how cultural evolution can be understood as an evolutionary process, trouble themselves the least with those special conditions of cultural evolution that exercise the greatest influence on its course. Edward O. Wilson simply postulated that, "genes hold culture in check," and further (Wilson, 1980):

> "The reins are very long, but ethical values are subject to unavoidably determined forces, according to how they affect the human genetic stock. The brain is a product of evolution. Human behavior is, exactly like the deep-rooted aptitudes for emotional reaction that drive and steer it, the detour- and coincidence-rich process of Nature, through which it has held and will hold human hereditary material intact. In the end, morality has no other demonstrable function."

I presume that Wilson was primarily led onto thin ice in his evaluation of the importance that cultural evolution has by the hunter-gatherer hypothesis. This postulated that the lifeways of recent hunter-gatherers correspond in principle to the human lifestyle of the last 2 MJ. This is, then, to be the ecological niche to which humans have adapted, and group structure and sexual behavior would have had equally old roots.

That during this time important genetic adaptations still took place can be considered certain – after all, brain volume was doubled. Equally certain is that the signs of intensive cultural development are substantially younger. And it is an indisputable fact that in hunter-gatherer groups as well, behavior is dominated by culture. They possess a rich tradition that, for instance, concerns itself intensively with sexual behavior and understandably also strongly influences it.

If, however, the underlying structures of social behavior are older than this tradition – archaeological indications of it are all younger than 0.1 MY – then cultural evolution, at least in the hunters and gatherers, cannot have injured the points of genetic evolution appreciably.

The whole thought edifice that is to serve as the cornerstone of a human sociobiology, that should make possible a natural-scientific and therewith grounded investigation of human behavior, is thus constructed upon a hypothesis borrowed from anthropologists. This hypothesis is in turn primarily based on behavior observed in modern humans, and thus involved all of the risks that I indicated in the overview at the beginning of this book. I have also already mentioned that modern hunter-gatherer societies, just like all other humans in the course of the last 0.1 MY, came from one small, presumably African population. Comparative observations of these societies do permit, in principle, conclusions about the past, but then at most to the point in time at which their ancestors set out to conquer the world. This is likely to have been about 70,000 years ago. Of the behavior of our ancestors of more than 0.07 MY ago, then, even with the best statistical methods, one can say nothing reliable based on observations of hunters and gatherers. Here, only comparative observations with our nearest living relatives, the chimpanzees, can help further. These, however, by no means deliver indications of when and in what context the behavioral ways typical of humans alone were developed. The assumption, for example, that human sexual behavior was already characterized in the developmental period of humans by lifelong partner bonds, with which one of the bases of the sociobiology of humans is constructed, is pure speculation.

Interestingly, Wilson was fully aware of the unreliability of this type of conclusion. He tried to evaluate how reliable the conclusion is that early humans had developed the same social feature that is known today as a generally appearing feature of hunter-gatherer societies. With social features, which in my opinion were still differently structured during the decisive evolutionary period of humans between 2 MY before our time and the Late Paleolithic, he regularly assumed that these conclusions are not reliable. Thus, one cannot, in his opinion, depend on that in early humans the family represented the basic social unit, that there was a division of labor between the sexes in the sense that men hunted and women gathered, that there were long-term sexual bonds (marriage), and that there was universal exogamy (with sometimes complex marriage rules) (Wuketits, 1997). Each of these features is, according to my yet-to-be-presented hypothesis, to be traced back to the cultural change of group structure at the transition to the Late Paleolithic.

I belabor this point here in order to indicate once more how difficult and speculative the treatment of the last 1.8 MY of human evolution is. Even sociobiology offers no wonder drug here. Sociobiologists are primarily strong in explaining the basis of behaviors that they can observe. If the behavior cannot be observed, as in the case of humans during their developmental period, then errors in the underlying evolutionary model lead to errors in the sociobiological interpretations. In the case of humans, the uncertainty resting thereupon unfortunately extends into the fundamental line of questioning of in what scope and in what ways sociobiological understandings can contribute to a better understanding of human behavior.

Another argument is given by Richard Dawkins, the author of the "selfish gene," to substantiate the low importance of cultural evolution for the principle construction of human behavior (Dawkins, 1988):

> "The only case in which Darwin himself – says Ruse – was prepared to support a sort of group selection applied to the evolution of cooperation among humans. 'One must not forget that while a higher moral standard lends each individual human and its children only a small advantage or no advantage at all over the other humans of the same tribe, the progress of morality and an increase in humans with firm moral standards would with certainty grant a tribe a tremendous advantage over another.'
> I would agree that tribal selection of this kind very probably occurs. But it is a matter of one-step selection, not of cumulative selection, in order to use each key difference that I have already mentioned. The world will one day be ruled by successful tribes. As long as there is no metapopulation of tribes within which these tribes produce daughter tribes that inherit their tribal features, though, there will be no true evolutionary selection on the tribal level. Certainly, genetic or cultural evolution within tribes is possible, but that is not the same thing as evolution on the basis of selection between the tribes."

The way in which is postulated simply here that no true evolution can take place on the tribal level, rather just one-step selection, seems exceptionally affected. The special conditions of the generation and transmission of cultural information and the possibly resulting selection process are not investigated. Cultural evolution is only superficially judged as to whether it fits in one of the drawers that were developed to bring order to the thought edifice of organic evolution. In addition, Dawkins simply sails over a clear contradiction in his own thought edifice. That is, Darwin traces moral behavior back to group selection. This shows, however, according to experience, a definite adaptive complexity. According to Dawkins, though, “cumulative evolution through natural selection is the only known explanation for adaptive complexity.” Thereby, cumulative evolution is, according to Dawkins, to be seen in contrast to one-step selection. To agree with Darwin that, “tribal selection of this kind very probably occurs,” but simultaneously to see one-step selection in this, is not mutually compatible.

Meanwhile, it will surely surprise no one that my ensuing considerations will again run close to Darwin.

There are very many differences between organic and cultural evolution, and most of them have already been mentioned at one point or another. Instead, however, of deriving one’s own theory of cultural evolution out of them, one usually is satisfied with having uncovered a few differences to which the potential is attributed to explain that cultural evolution occurs as one assumes it does – even when, at first glance, it doesn’t look that way.

The most fundamental difference from evolutionary-theoretical perspective relates to the type of transmission of cultural information. We have already seen that the type of transmission in organic evolution has led to meaningful consequences. Genetic information is stored in DNA. With the death of the individual, this information is also lost, unless the individual has produced replicas and transmitted them to new individuals through reproduction. The expansion success of a piece of genetic information is strictly coupled to the reproductive success of the individual – more precisely, to its total fitness. From this coupling results – and only based upon this – the known and well-proven assumption that genetic information is selected in order to optimize the total fitness of individuals.

Who, though, is the carrier of cultural information? It is not the DNA; that much is certain. Is it the individual, or perhaps the group? And how is this information multiplied and transmitted to other carriers? – There are now many channels of information through which cultural information spreads, and so the expansion success of cultural information is usually not coupled to the reproductive success of single individuals. And this is an elementary difference from genetic information with critical importance for the question of which cultural information increases in a population over the course of time.

There can hardly be a more fundamental difference from an evolutionary-theoretical perspective. Nothing exercises so great an influence on which genetic information increases in the course of organic evolution than the ways and means by which the genetic information is multiplied and transmitted. In light of this difference, it cannot at all be assumed from the beginning that cultural information is selected for over time to optimize the reproductive success of single individuals. This is not a further hypothesis on my part, rather simply a logical deduction. The burden of proof lies with those who postulate that human behavior, ignoring or even including cultural development, stands in the service of fitness optimization.

As mentioned above, the differences between organic and cultural evolution are thoroughly known. This naturally also applies to the fact that cultural and genetic information are stored and transmitted differently. To that, Wuketits (Wuketits; 1997):

> "A good conceptual differentiation was found by Christian Vogel (1986). He speaks of *biogenetic* and *tradigenetic* evolution in order to bring the differences between organic and cultural evolution to the point. Both rest, according to Vogel, upon the storage and transmission of information. But in organic evolution, information is coded in the form of genetic information (in the genes and DNA, respectively) and transmitted in the process of reproduction from generation to generation. In cultural evolution, information means ideas, knowledge, and is stored in individual brains, recorded on extra- corporeal material carriers, and thus transmitted to other individuals. If, then, a person has certain concepts or ideas about the laws of planetary motion, the evolution of organisms, the construction of devices, or whatever else, then in order to pass on these concepts, he need not reproduce, but rather express them verbally or in writing. Requisite for this is only that others can understand or read his speech or writing. Tradigenetic information transmittal is thus in a certain sense contrasted with biogenetic evolution. …"

This is, in my eyes, a wonderful text passage. An elementary difference between organic and cultural evolution is cleanly worked out. Therewith, the basis for a new research discipline is practically lain out, which sets for itself the task of treating cultural evolution as an independent research subject worthy of a thorough, evolutionary-theoretical investigation. This young, tender shoot, which carries within it the potential to grow into a mighty branch of the tree of knowledge, is however, immediately propped up with an argument already known to us in principle. The text, namely, goes on in the following way:

> "… But it remains, nonetheless, inseparably bound to it. After all, the culture-producing organ, the brain, is a result of organic evolution. In connection with some other, already mentioned in the last chapter, biological components (for example, freeing up the front extremities from locomotion), the brain development of the hominids presents an indispensable foundation for cultural evolution. Culture thus cannot play out outside of biological boundaries."

Even this passage I could agree to without objection; it is held generally enough for that and in principle surely correct. Behind it, though, stands a very clear concept of in what way cultural evolution is dependent upon biological boundaries. Wuketits' interpretation goes to support that cultural achievement, because of the "biological boundaries," in the end serves the purpose of increasing individual fitness, a purpose that in general is also achieved, whereby exceptions only prove the rule. I cannot recognize more in the biological boundaries, however, than boundaries that may limit the developmental lines of cultural evolution, but by no means can prescribe their "goals." Cultural evolution is an independent evolutionary process! Its course can no more be derived from the basis of the rules applicable to biological evolution than the course of organic evolution can be derived from the laws of atomic physics alone, although all organisms are of course composed of atoms and are subject to the physical laws.

In order to understand how cultural evolution really functions, one must build anew the entire thought edifice, from the foundation up. One must avoid simply taking on the dogma derived within the thought edifice of biological evolution – such as that of the maximization of fitness.

I would now like to try to take the subject of cultural evolution seriously, and derive some yet outstanding working hypotheses to the questions thrown out in the last chapter. I will not, however, attempt in doing so to master [lit.: "break over my knee"] a comprehensive theory of cultural evolution. Even the few considerations that I will employ are sufficient to assume that cultural evolution is even more complexly structured than organic. To erect a comprehensive theory of cultural evolution therefore presumably goes well beyond the capacity of a single person – it is a suitable goal for a research program.

As a main center of focus, I am naturally interested in the influence of cultural evolution on the course of the organic evolution of humans. It will thus be a primary concern in the following how cultural evolution worked before new media for the storage and transmission of cultural information, such as, for example, writing, were developed.

The only storage for cultural information under these circumstances was in the human brain. Understandably, with the death of an individual, the information stored in his brain was lost just as was that stored in the genome. Beyond the death of the individual, only that cultural information kept status that had been shared with other individuals during his lifetime. A decisive aspect of cultural information would therefore have been which cultural information individuals tended to pass on again and again, since the transmission of cultural information is subject, in contrast to genetic information, to conscious control. And only information that was passed on repeatedly could offer a point of attack for "cumulative selection;" only that thus brought with it the prerequisites for becoming a component of cultural evolution.

We are thus surely dealing with, for one, internal selection in the particular brains that took note of the cultural information and decided whether it should be passed on. The selection criteria in this internal selection were presumably strongly dependent upon the human psyche, which in turn was doubtless strongly marked by the organic evolution of humans. Does this now mean that cultural evolution was placed in the service of the genes through this internal selection, and only developed into a new, particularly effective instrument of fitness maximization?

Such an interpretation is, on closer inspection, hardly bearable. We have already had to note, in dealing with sexuality, that there are different perspectives for investigating the motivations underlying human behavior. The conscious level, at which humans explain their behavior to themselves, accepts, for instance, feelings as causes. The analytical level of sociobiology does not; much more, feelings are themselves interpreted as adaptive traits in the service of maximizing fitness. From this results, among other things, that humans do not understand what their feelings are for. They have always thought about this theme, but every sociobiologist will agree with me that such interpretations, before the introduction of evolutionary theory, did not have the slightest chance of approaching the truth. That upon which, in the opinion of humanity, things depended, was thus never that upon which they depended for organic evolution.

Fitness maximization operates according to the motto that the animal may think whatever it wants, as long as it consequently does what it is supposed to do. With the internal selection mentioned above in the framework of cultural evolution, however, directly the conscious and emotional levels come to bear. Thereby, of course, one's own interests play a large role – but just the self-interest one perceives, not the self-interest that one should really have from a sociobiological point of view. If we thus suppose a new, powerful tool behind cultural evolution, then it is sooner placed in the service of the psyche, and not in the service of maximizing fitness.

The psyche was itself of course originally developed in the course of organic evolution as an adaptation to very special selection conditions. Under these conditions, it had exactly the right amount and exactly the right kind of influence on human behavior in order to contribute its part to fitness maximization. Torn from evolutionary context and significantly strengthened in its effects through cultural evolution, the psyche could also extensively retain its genetically anchored structures – but its functionality vis á vis the maximization of fitness was necessarily lost. All of the structural commonalities in the behavior of humans and animals, which ethologists and recently also sociobiologists have observed, therefore do indicate the common roots of these behavioral paths, but they say nothing about their present function in humans. Human sociobiology can thus deliver, along with animal psychology, valuable contributions to the understanding of the human psyche and therewith to the discipline of human psychology. On this level, ultimate explanations can still apply, to the extent that the characteristics treated are genetically determined and can be addressed as products of genetic evolution. For what purposes these products were instrumented in the course of cultural evolution, however, and for what they consequently serve today – that is on a different page.

Interestingly, Edward O. Wilson interprets the effects of the entire process very differently (Wilson, 1980):

> “The individual itself determines the principles according to which it judges the group and the law. Rules for which one decides intuitively, on the basis of emotions, are of overwhelmingly biological origin, and merely strengthen the pretended social relationships.”

“Merely strengthen” is, from a sociobiological point of view, a contradiction in itself. When we observe a behavior from sociobiological perspective, we always ask ourselves whether it is optimized in a particular respect. An optimum is, however, usually a singular point upon which all of the variables are mutually determined in the right ways. If one changes only one variable – whether qualitative or quantitative – then one can no longer count on the system being optimized. Strengthening means, in this context, distorting and destroying. There can be no talk of “merely strengthening.”

In order to illustrate how optimization processes function, mountain landscapes are popularly referred to in teaching. A mountaintop is thus an example of a local maximum, finding which could be the task of an optimization procedure. Organisms have been optimized, in the course of their evolution, with respect to their overall fitness; their genetic code represents instructions for reaching the fitness peak upon which the particular species has specialized. Now imagine you are at a particular position in the Alps, and a direction sign tells you that you must march 3 km to the south in order to reach the next peak. Would you conclude from this that you could climb even higher if you hiked not 3, but 8 km in the same direction? – Hardly. – Wilson starts from exactly this conclusion, though, when he says that the pretended social relationships are "merely strengthened" through cultural rules.

The special thing about a mountaintop is the fact that every further step – no matter in what direction – leads downward. Of course, one can come to another, perhaps even higher mountain through pure chance if one walks further – the additional gain in height is then, however, purely a chance result and not the result of steering developed for it. There have been, for instance, in the known history of humanity, many men with reproductive success than exceeded the wildest dreams of every male chimpanzee by an order of magnitude. One Inca [leader], for instance, had 1500 women – but for every such Inca in human history, there were thousands of monks, whose equally "merely strengthened" social relationships practically ruled out reproduction from the start.

After having expressed my opinion and what I think cultural evolution does not do, it becomes time to think about what it could do. There are some interesting aspects there, pointing to which might be worthwhile. As mentioned before, the human psyche comes to bear in internal selection, but the same also applies to one's mental abilities. Humans distinguish themselves primarily through their highly developed ability to construct complex and internally consistent scenarios. This ability was developed further, according to the CTSW model, primarily in connection with visual sight and the distance estimation based thereupon in throwing.

Because of these biological points, humans tend to construct complex scenarios and repeatedly test their accuracy. In the area of cultural evolution, this presumably led to cultural information typically appearing not as small, independent units, but rather as components of larger thought complexes. New information is not simply noted, but instead placed in relationship to all existing knowledge, whereby perceived contradictions trigger mechanisms for their elimination. Humans construe a plausible cultural paradigm for themselves, just as they make a mental image of their visually perceivable surroundings. While visual scenarios are based on concrete environmental data taken from the eyes, cultural scenarios can develop a substantial life of their own and become as distant from reality as one wishes – similar to the realm of visual scenarios in dreams. A certain remedy was first provided by the scientific method, which consists of that theoretical constructions are based on observations of the environment.

When a worldview has become fixed, then new cultural information that contradicts this worldview has a very hard time in spreading. It is rejected, just as individual pieces of information are rejected in seeing if they do not fit into the overall picture. This procedure of the brain is known from many optical illusions, and is obviously (in the case of visual perception) adaptive. Even when the cogency of an individual argument ought actually to be classified as overwhelming in its cognotheoretical aspects, it must expect substantial difficulties in its integration into cultural tradition if it does not fit with the current worldview.

In the small, mutually warring groups in which the human population existed for the largest part by far of its history, a whole series of highly integrated cultural traditions surely arose based on human tendencies and abilities to construct complex scenarios, which could be identified as the cultural property of that **group**. This results simply from the following considerations:

- Information can be passed on very easily within the group, but could only be transmitted with great difficulty across the borders of the mutually hostile groups. The intensive exchange of information within the group led to the scenarios of the group members becoming attuned to one another. All members of the group possessed a great deal of identical information, since a constant exchange of information took place.
- In addition, there was also an exchange of opinions about how this information was to be interpreted. Through this exchange of opinions, the ideas of the group members were equalized even further. Often, the interpretation of a higher-ranking member of the group would surely have simply been taken on by the others.
- Deviant opinions of individual group members hardly played a role in the developing cultural property. They did not go into the cultural tradition, just because they were not taken up and carried on by others. Just like in organic evolution, functional complexity probably resulted in the framework of cultural evolution primarily through cumulative selection. Complex cultural thought edifices could therefore only grow out of information that was passed on again and again and thereby also developed further. For cultural evolution, therefore, just the ideas and information that were most widespread within the group were meaningful.

Since the transmitted information by no means always had to do with environmental data, rather often enough with purely mental ideas, the cultural traditions circulating in different groups diverged significantly from each another.

One can recognize very clearly in the development of languages that cultural evolution brings forth complex structures on the group level. Languages are quite obviously not individual characteristics, but group characteristics. They are also, however, products of cultural evolution. That this is a case of true cumulative evolution becomes very clear when one looks at, for instance, the work of Luca Cavalli-Sforza. He showed that comparative investigations of languages are similarly well suited for reconstructing lines of descent of human populations as are genetic investigations (Cavalli-Sforza, 1994). Surely, though, not only language belongs to the cultural property of a group. Equally group-specific from the start were also moral expectations, origin myths, and more of that sort.

The survival of such cultural traditions was primarily tied to the success of the group; the fate of individual group members was hardly relevant from their point of view, since they existed in substantially identical copies in all group members. If habits and usages possessed characteristics that promoted the survival of the group, then they were more likely to be retained by the group over longer periods. Because of this, the possibility then arose to be carried over to other groups (through the group-changing women), or at a successful group fission (from which both partial groups then continued to exist), to become part of the cultural property of two groups. To the already mentioned inner selection, which was primarily oriented to the mental achievements and the psyche of humans, was thus added yet an external selection, which was substantially a case of group selection.

The transmission of information through group-changing women would not have been especially effective in this, for many reasons.

The first reason we find already in quite distant ape relatives. High-ranking males do not appear all too willing to learn something from lower-ranking females. In this context, long-term studies of researcher-fed Japanese macaques have become famous. In the course of the observations, two discoveries were made by females in conjunction with feeding: the washing of sweet potatoes and the washing of wheat. Although both techniques are very practical, they were initially only taken over by low-ranking females and by children. High-ranking males never learned these techniques. Nonetheless, they came into common use over time, in that young males that had learned them as children rose to higher positions.

The second reason is typically human and was in principle already addressed above. Cultural development leads to that in every group, independent traditions and an independent worldview arise. Contradictory information from outside would encounter skepticism and refusal. One also speaks of how human societies tend toward “pseudospeciation.” The knowledge of how one produces a new tool, whose use is clear at hand, may pass over group borders quite rapidly. “Philosophical” and “religious” ideas in the broadest sense, on the other hand, run into clear resistance. These generally are also based, next to environmental observations, substantially on arbitrary assumptions, and different assumptions lead to mutually irreconcilable ideas. Strange ideas would be rejected as soon as they could not be brought into accord with one’s own ideas – which was the rule.

Under the circumstances for expansion that underlay cultural information, it thus truly makes sense to assume group selection. The derivation of the claim that we are dealing with group selection in the course of cultural evolution ought not particularly to estrange sociobiologists. In principle, the analogous principle to kin selection is postulated here. The units of cultural evolution, which Dawkins for example identified as memes in order to differentiate them from organic genes, were present in the original, small, ethnocentric societies in the heads of all group members as substantially identical copies. In the case of cultural evolution in small, extensively isolated groups, we therefore have, because of “kin selection,” to deal with a similar degree of cooperation and altruism as one would expect in a social band that consists of nothing but copies from a single egg, i.e., of individuals with identical genes, in the case of organic evolution. Moral expectations, religions, origin myths, and the like are, according to experience, not unique to single humans, but are components of the common cultural property of human social bands. Therefore, the assumption that the group members were culturally more closely “related” than genetically was actually already in the air from the beginning with the occupation of the sociobiologists with human behavior. It was thus also obvious from the start to assume that because of cultural development in humans, cooperation and altruism should be encountered more often than is to be expected from their genetic relationships. And this assumption could also have been proven from the start with a multitude of already-known observations. After all, human societies have been compared more than once with the colony-building insects. The high degree of cooperation in these animals results, however, from a very special reproductive system and is, in the end, to be traced back to kin selection. If cultural evolution had actually been taken

seriously as an independent evolutionary process, then it would have surprised no one that the behavior of humans often arouses the impression of being a product of group selection.
Group selection is exactly that which even Darwin saw at work in the development of human behavior. And also, such a renowned modern scientist as Irenäus Eibl-Eibesfeldt insists that human behavior can only be understood if one takes group selection as its basis. The opinion of this scientist on this point is, in my opinion, especially weighty. He concerned himself intensively with human behavior, and in doing so – just like Darwin in his time with evolutionary theory – pursued a very rewarding, because it is strongly descriptive, approach. Unfortunately, however, even Eibl-Eibesfeldt did not think to treat genetic and cultural evolution separately. He is trapped in the idea that culture is only the extension of nature by other means – not with other "goals." Because of this, he took part in an unnecessary discussion of principles with the sociobiologists around the question of on what level "selection" takes place. He primarily dealt with the culturally marked behavior of humans and therefore pleads – at least in the case of humans – for group selection (Eibl-Eibesfeldt, 1995). The sociobiological approach has proved fruitful primarily for animals, for whom, in light of the small extent of cultural tradition, organic evolution and therefore individual selection of course stand in the foreground.

Because of the habits and usages that came with the development of language, it was thus frequently selected for to use the group. Because of cultural evolution, at some point in the course of human history of the last 1.8 MY, we have increasingly to reckon with group selection. For this, the fitness of single individuals did not, by any means, have to stand in the foreground (of course, the group as a whole normally had to reproduce biologically in order to retain their cultural property, but it played a subordinate role which individuals took care of the reproduction – individual fitness maximization is not a requirement for [group] reproduction). The development of human behavior thus took place because of the development of language in a field of tension of in part different interests on genetic and cultural levels. How high the significance of cultural evolution was in this depended on language ability, group structure, group size, and the structure of the preexisting tradition, i.e., from prehistory. The following thoughts should show that cultural evolution possessed the long-term potential to dominate over biological evolution in its influence on human behavior, and why.

A critical aspect of cultural evolution for evolutionary kinetics is the ways and means for preparing variations. As we have seen, in contrast to genetic information, conscious control by humans underlies cultural information. This means that the mental ability of humans was instrumental in the course of cultural evolution, in order to produce promising variations. Humans have always given some thought to the development of their cultures. The status of a culture was coupled to the status of the group, consequent to which those cultures were selectively preferred which managed to harness the behavior of group members in the service of the success of the group. At best, this could happen when the members were indoctrinated in a way that led to them consciously making the interests of the group their own. From that results in humans – above all in traditional societies – altruistic behavior to such a great extent that it can hardly be brought into accord with fitness maximization.

Identification with the interests of the group led to humans trying to influence developments in such a way that the group would be advanced. Even more important was surely the introduction of new criteria for the judgment of the actions of individuals by the group members. Through that, the expressed motivation – primarily of the men – of standing out in the group, which in itself is a product of organic evolution and originally primarily served the cause of individual fitness interests, was placed in the service of the group. This led to suggestions for improvement or new interpretations of old ideas adapted to changed conditions. These in turn represented a part of the variations on which cultural evolution was based. The critical difference from organic evolution therein is that the application of the mental abilities of humans leads to such variations being anything but accidental. They are conceived from the start as – sometimes very extensive – measures, to which are attributed the potential to provide remedies to known problems. Of course, even here, errors were more common than truly progressive improvements, since human understanding left much to be desired. The probability of a leap-wise change being useful was so greatly increased in this, however, that these were able to make a substantial contribution in the case of cultural evolution.

After changes, humans are mainly distressed if they recognize that the group is endangered. Interferences with the cultural property of the group ensue, which one expects to provide remedies. If they prove themselves, then they become integral components of the cultural property; if not, then the danger remains and leads to further efforts toward change or to elimination of the group from the contest. Changes in the cultural property of a group thus occurred overwhelmingly “on the living object.” Less successful groups did not necessarily have to be exterminated right away, though. The group members would have noticed that their group was not among the best and worked to remedy this. Through this, the cultural property was subjected to selection due to the competition prevailing between groups, even before it got to the elimination of the group. Arms races are an example of this kind of cultural evolution, which have led to enormous functional complexity in the area of weapons technology. In this way, the human brain was applied to assist not only in the production of new variations, but also in the selection within cultural evolution. This is also not surprising. We always have access to our memes, and therefore also always have the capacity to change them. Opportunities for the variation of transmitted information are, in the case of organic evolution, strongly limited; there, they occur only from generation to generation; in the case of cultural evolution, that limitation is not present. Thus, Dawkins’s criterion (Dawkins, 1988):

> “As long, though, as there is no metapopulation of tribes within which these tribes produce daughter tribes that inherit their tribal features, there will be no true evolutionary selection on the tribal level.”

appears unsuited for the assessment of cultural evolution.

Because of its peculiarities – primarily because of the instrumentation of the human brain for the production of new, promising variations as well as for the improvement of selection – cultural evolution can bring forth adaptations much more quickly than organic evolution. The high speed of cultural evolution in modern humans is thus a point over which there has long since been agreement. From that, however, it becomes clear that cultural evolution in modern humans dominates over the organic. From the point of view of cultural evolution, the results of organic evolution are nearly unchanging environmental aspects to which there is always enough time to adapt. We truly are dealing with similar relationships as with the jet fighter introduced at the beginning of this chapter – it is certainly subject to the wind, but in light of the high speeds that it can develop through use of its jet engines, the wind is only a minor disturbance that can easily be compensated for and does not hinder the jet fighter in reaching its target, set independent of the wind. Since cultural and organic evolution pursue different goals in the creation of human behavior and cultural evolution goes substantially faster, it is to be assumed that our behavior stands more in the service of cultural evolution than in the service of organic evolution.

I do not want, however, to give the impression that I imagine to have sketched out by what criteria our behavior developed up to the present day. Group selection is, for example, primarily to be expected as long as humanity was organized in small, substantially isolated, ethnocentric bands. At any rate, this is still true for recent hunter-gatherer groups. In the higher civilizations, in contrast, the relationships became much more difficult, since the opponents are no longer killed and perhaps eaten but instead incorporated into society as cheap labor. Agriculture made it potentially worthwhile to let conquered enemies live because of their labor. Because of this, we had to deal with changed selection conditions in cultural evolution over the course of the last 12,000 years. Ever more frequently, the humans of an overarching political association did not belong to the same cultural tradition, but to different ones. Some barriers to the exchange of information therefore fell, which undoubtedly had influence on cultural development, although I by no means trust myself to plumb how this influence looked in its particulars. Much of what happened here could only be understood with knowledge of the historical context of the time. Some old traditions surely no longer served the political groups, rather endangered them, in that it led them to pseudospeciation within the bands and hampered their appearance as a unit.

Complex cultural products, such as religions, cannot simply be removed overnight when they are no longer needed. They have achieved in the course of their development a high plausibility value and a high affinity to their carriers, the human brains, and as a rule, the religion of the conqueror is no more plausible than that of the conquered. It thus came to a competition between fully developed religions over believers within political associations, whereby presumably internal selection came into use. One cannot expect of a religion other than a state religion that it develops to support the state. For the survival of a religion, it is solely important that the followers of this religion behave altruistically toward one another.

The presumably high importance of internal selection in the meeting of different religions makes it appear promising to me above all to keep a look out for “parasitic” or “symbiotic” adaptations to the human psyche, which acquired particular importance in this context. One must consider the religions here as independent “species” that came out of a long coevolution with humans. The role of humans in this scenario is that of the host and the carrier. So that a person can be won as a host, his “immune defenses” – the critical ability of the brain, already set contradictory cultural information, and surely other aspects – must be overcome, just as a virus must overcome the immune defenses of a body. Thus, successful religions are internally consistent and plausible. In order to move humans to make themselves serviceable as carriers, it made sense to reward them for this – similar to how flowering plants reward insects with nectar for carrying their pollen. The most important and irresistible reward that religions have offered the human psyche for its services is surely the promise of life after death – whereby it does not play the least part for the expansive success of a religion whether there is something behind this promise; it only matters that the people believe in it.

It would interest me very much whether the course of the spread of Christianity in the Roman Empire until its promotion to the state religion shows structural similarities to the course of a viral epidemic. Since early Christianity is to be addressed as a freedom theology, oppressed populations such as slaves and the inhabitants of occupied territories would then be seen as the "at-risk groups."

The confrontation of long-revered products of cultural evolution with other, competing cultural goods over the "territory" of the human brain was intensified in the recent past through a flood of new, natural-scientific knowledge that placed the old beliefs in question. Thereby, it was shown clearly enough how tough and long-lived long-revered ideas can be, regardless of their, from a cognotheoretical perspective hopeless, situation. It was also shown, however, that intelligence and curiosity, in principle, place in human hands the means to free themselves from the dictates of memes – to the extent that they are purely fantastical constructs – just as their behavior was "freed" from genetic imperative through cultural evolution (whether both are actually matching their (human) interests in the long term is another issue).

The selection processes underlying cultural evolution surely show – as already mentioned – a strong dependence upon the means of storage and transmission of cultural information. Precisely these degrees of influence are currently subject to enormous changes through societal change and even more through technological progress. Thus, the selection criteria of cultural evolution may also be in constant change. Just the influence that the Internet will exercise on cultural development is already enormous in itself.

Many, above all current, cultural developments are in addition presumably not at all traceable back to optimization processes of some kind, because cultural changes happen ever more quickly, so that many of them are to be addressed today as variations of which we do not yet know whether they will be retained or lost again. Since variations in the cultural arena are also much larger than in the genetic, in many areas of cultural evolution it can hardly come to fine adaptations, by which the effectiveness of this optimization procedure in the societal area is limited.

Human behavior presents itself as an extremely complicated research subject, which a multitude of degrees of influence underlies, of which some are themselves now in a state of dynamic change. Cultural development plays the critical role in that today and clearly shows its own dynamics. For humans, therefore, the rule that the behavior of organisms does develop such that the (genetic) overall fitness of the present individual is maximized, used for instance by Richard Alexander (Alexander, 1988 and 1989), doesn`t apply. This rule is in any case the "central paradigm of behavioral research" (Grammer, 1995). This paradigm is limited in its field of application to organisms for which the independence of cultural development can be ignored. Nonetheless, evolutionary-theoretical considerations can probably help us to a limited degree in understanding our behavior if cultural evolution is taken seriously as an independent process and subjected to a thorough investigation. Organic evolution also takes no trivial part here – its understanding is needed in order to reconstruct the starting and framework conditions of cultural evolution, which surely exercised and still do exercise a substantial influence on the course of this evolution.

Because of the ability to pass on extensive, detailed information to following generations, the development of human behavior in the end occurred under other rules of the game than applied to animals. In the course of human evolution, cultural traditions gained ever-greater influence on human behavior because of the development of language. Cultural and genetic adaptations could pursue common goals in human behavior and reinforce one another. They could pursue different goals that were not mutually exclusive, but also opposing goals. In the last case, it came to a competitive situation over the influence on human behavior. Genetic adaptations dominated at the beginning of the *erectus* phase, but by no later than the beginning of the Late Paleolithic, cultural adaptations surely stood clearly in the foreground.

New habits could arise, in contrast to genetic adaptations, quite spontaneously [and] in considerable complexity. This is due, among other things, to the ability of humans to construct mental scenarios and work through the consequences of new rules (in the head as well as in actual play), and ensures that cultural behavioral adaptations can evolve substantially faster than genetic ones. Elementary, preexisting, genetically anchored behavioral adaptations that opposed the goals of cultural adaptations could presumably hold on longer through this transfer of dominance from genetic to cultural evolution the more firmly they were anchored. A particularly strong anchoring is to be expected here in the area of sexual behavior, with its critical importance for fitness.

In areas of human behavior that today are strongly culturally regimented, humans may have behaved significantly differently before the introduction of these regimentations, since one does not need instructions for what happens anyway. From this alone follows that lifelong sexual bonds to one or a few partners cannot be essential to natural human sexuality, since one could otherwise dispense with the worldwide-spread, variously interpreted, expensive fuss over marriage and partner fidelity. The high cost that is carried on in this, however, leads us to conclude an important societal function of the lifelong commitment to a particular partner.

What chronological course the surrender of the leading role in influence on human behavior from organic to cultural evolution historically actually took is a highly significant question for the course of human evolution, to which an answer must be offered within an evolutionary scenario. And this answer comes exceptionally easily in the framework of the CTSW model of hominid evolution: the archaeological record indicates that the importance of cultural evolution increased downright suddenly at the transition to the Late Paleolithic.

It seems surprising at first glance, though, that this first occurred so late. I have no doubt that the mental and linguistic prerequisites for such a dynamic cultural development had already been present for many hundreds of thousands of years. Why, then, did it wait so long? My answer to this question goes: the special position of humans in the mental and linguistic area is certainly a prerequisite for a dynamic cultural evolution, but it is only **one** of the prerequisites and not simply **the** prerequisite.

Two other, closely related factors had, in my view, decisive influence on the course of cultural evolution – the size and the construction of the groups. What changes presumably took place here and how these changes affected cultural development I will address in the next chapter. Here, I would only like to anticipate some considerations that affect the influence of group size on the evolutionary kinetics of cultural evolution.

A particularity of cultural evolution that exerts an enormous influence on developmental dynamics is the possibility of the division of labor. The degree of the division of labor is in turn tied to group size. The larger a group is, the more strongly expressed the division of labor can be, which in turn can lead to a clear acceleration of cultural productivity. In very small groups, the opportunities for the division of labor are exceptionally limited, and the developmental dynamics of cultural evolution are thus clearly bounded.

Now, it is known that at the transition to the Late Paleolithic, not only cultural development experienced a substantial acceleration, but simultaneously, political associations also became much larger. It is thus to be expected that increasing division of labor contributed – perhaps prominently – to the acceleration of cultural development in the Late Paleolithic.

The world population has today passed the six billion mark – at the beginning of the Late Paleolithic, presumably ca. 70,000 years ago, it was lower by a factor of about 1,000. At the same time, the number of "political associations" – at that time hordes, today states – at the beginning of the Late Paleolithic was higher by about the same factor than today. The size of an average political association has thus grown over the last 70,000 years by a factor of about 1,000,000. And the opportunities that this opened in the area of labor division were also used – today, the division of labor takes place increasingly in many areas, even across the borders of political associations.

Because of the division of labor, many developments take place simultaneously in the framework of cultural evolution. Single developmental processes will certainly frequently take – e.g., right in the technical area, to which great attention is devoted in archaeology – a similar chronological course to that of organic evolution. They show a stormy beginning with rapid progress, and at the end, approach asymptotically the state of technical maturity. The dynamics of the entire cultural development, which is constituted of a multitude of parallel developments, are coupled, however, through the division of labor to the size of the political associations. This in turn has grown even significantly faster since transition to the Late Paleolithic than the world population. The developmental dynamics of cultural evolution will therefore have taken an exponentially growing course over large parts of this period. A course such as we also find again qualitatively in Schrenk's illustration (Chap. 61.). The bend he chose in the developmental curves for "important evolutionary features," in the case of cultural evolution, actually makes sense.

6.6 Natural limits on group size and their cultural conquest

Freeliving chimpanzees not only cooperate as groups against the members of other groups, they also build interest associations within groups that preferentially consist of the sons of the same mothers. With decreasing relationship, cooperation should after all be increasingly replaced by competition, since the success of the genetic material of cooperating males is based on the exclusion of less closely related males from access to reproductive resources. If the group gets too large, then relevant exclusion no longer takes place. Therefore, there is a stability limit on group size in chimpanzees. If the group gets larger, then the members become estranged, confrontations within the group increase, and it comes either to a division or to a violent reduction of the number of male group members. The conflicts at Gombe were the result of this kind of division. The killing of a male group member had previously only been observed once, and then in a zoo. The question of whether such things also happen in the free wilderness is still open (de Waal, 1991).

Now, of course no chimpanzee thinks about when the right moment has come to destabilize his own group in order to derive from it a long-term reproductive advantage. The cohesion of the group results much more from the closeness of personal contacts among the group members, and this is maintained through social activities such as delousing [grooming]. A certain role is surely also played by the fact that chimpanzee males cannot simply leave their bands, since they would then expect a serious attack when encountering strange males. Of course, the number of individuals tied together in this way cannot rise arbitrarily, since on the other side stands a healthy measure of inborn self-interest in questions of reproduction. While the social interactions within the group become progressively more complex with increasing numbers of adult males and their ties to one another decline on average, the number of possible coalitions for a power struggle increases.

The stability limit for the number of chimpanzees belonging to a group can obviously be shifted upward somewhat under intensive application of sexuality. According to Kano, bonobos are presumably presented with the task of strengthening group cohesion, since large groups are more able, in their habitats, to use food resources well. Their bands are larger, with up to 100 individuals, than common chimpanzees', whereby sexuality is primarily applied preventatively by the females in order to keep aggressions from appearing in the first place (Savage-Rumbaugh & Lewin 1995; de Waal, 1995). Bonobos resemble humans in many aspects of their sexual behavior, which has contributed to their preferential use as an ancestor model. Still, if the marked sexuality of bonobos is a developmental-historical answer to the requirements of food acquisition in their habitat, then it did not exist as such in the last Ice Age (see Chap. 2.4). That humans also were presented with the task of stabilizing the largest possible group associations is likely in light of the importance of conflicts between groups. And humans have apparently exploited the possibilities for this that sexuality offers for the stabilization of groups just as fully as the bonobos. This certainly did not lead to similar social structures, though, since their task was a very different one. The high positions that bonobo females take on in their groups were unattainable by female hominids from the start. Male hominids had to be ever more aggressive, and later, even warlike; thus, their internal cooperation always had a high survival value. They therefore had the best prerequisites for divvying up the top positions in the group hierarchy among themselves. Since in human groups the males had to remain exceptionally fight-ready, aggressive, and dominant, even through use of sexuality, such a large group probably could not be stabilized under precultural conditions, as can be observed in the exceptionally peaceable bonobos. It is more likely that a further reduction in group size because of the high aggressiveness required of the men could be prevented through the application of sexuality.

In chimpanzees, group structure is thus tightly interwoven with sexual behavior, and this in turn is surely effectively genetically ensured because of its elementary importance for reproduction. Precisely sexual behavior, and coupled to it group structure, were likewise emotionally tightly anchored and resisted for a very long time elementary interference by the cultural developments increasing because of the development of language. This became even truer when human sexuality had taken over a meaningful role in the stabilization of groups and thus possessed functions that strengthened the groups. Cultural interference in sexual behavior could easily lead to a weakening of the groups, and would thus have been counterproductive from a cultural perspective, since cultural evolution in small, ethnocentric bands would have been characterized by group selection (see Chap. 6.5). On the other hand, a limitation resulted from the natural group structure of humans, just like in chimpanzees, on the sizes and thus the fighting capabilities of the groups. A lifting of this limitation would have to lead to a considerable strengthening of the bands in the long term.

For the human developmental line, one should actually expect since the transition to *Homo erectus* that the groups became ever larger. The fighting strength of the groups, after all, was more prominently in the foreground than ever before. The question, though, is how much elbowroom a society structured in a chimpanzee pattern possessed for the enlargement of the group, since an enlargement of the groups collided on an emotional level with the most elementary adaptations from the reproductive area.

The limitation of group size immanent for a chimpanzee society, and its final conquest through cultural measures, represent, in my opinion, the key to understanding the processes at the transition to the Late Paleolithic. That the Late Paleolithic [people] appeared in larger associations than, e.g., the Neandertals they displaced in Europe is made clear through archaeological finds. In light of the high importance attributed to intraspecific confrontations by the CTSW model, the numerically superior groups of Late Paleolithic [people] suffice to explain their expansion success. The cultural conquest of the biological limitation of group size gave a relatively small human population the superiority that was necessary in order to crowd out all other, biologically extensively equivalent, human populations in a short time. At the same time, it paved the way from scavenging to large game hunting.

Despite their immense fighting strength, humans were miserable hunters, since it was plainly not possible for them to get mobile animals. This presumably led to the grotesque situation that a well-defended cave bear that faced its attackers made better prey for the Neandertals than a deer. Large groups at the transition to the Late Paleolithic opened the possibility of effective driving hunts. Humans, who were specialized for chasing away dangerous animals, were in larger bands downright predestined to drive their prey to its ruin. The transition to driving hunts is verified through fossils. Before the Late Paleolithic, animals butchered by humans were primarily especially young or especially old individuals. This corresponds to the composition to be expected of a scavenger. After the beginning of the Late Paleolithic, the bones found represent the age profile of the animal herds better – an indication of successful hunting (Lewin, 1995 a). Through cultural revolutions, a scavenger and miserable hunter became, within a few millennia, the most dangerous hunter in the history of the world.

Overcoming the natural size limits of human social bands made an extensive catalog of cultural measures necessary. This explains the dramatic changes at the transition to the Late Paleolithic as well as why this transition took place only so late and at such a high level of human mental development:

- Group cohesion was endangered by the men, since on the one hand they are naturally more aggressive than women are, and on the other hand, they stood in a reproductive race within the group. Preferred sex partners represented the most important apple of discord here, and a firm assignment of the women to certain men could contribute to stabilizing the group. As long as such assignments were founded only on agreements among the men, however, they reflected solely the power relationships within the group and could be called into question along with these. As women additionally were not always equally attractive in different phases of life, higher-ranking males often tended to change partners. A critical cultural breakthrough thus consisted in making permanent assignments of sexual partners the norm and placing them under the protection of unassailable forces (e.g., divine spirits or gods).
- Tribal associations first became possible when the exchange of women between different subgroups could be regulated by mutual understanding. In recent primitive peoples, the exchange of gifts plays a critical role in this. Presumably, such usages have their origins at the transition to the Late Paleolithic. Gifts were necessary, since there were not always young women in both subgroups that could be exchanged for one another, and even if there were, their "values" could easily be assessed differently. Objects to be given as gifts naturally possessed, next to their pure practical value, a high non-material value, since they should reflect the great respect of the giver. It was also always good to give something that the receiver did not possess. Thus, innovation and higher investment in manufacture entered material culture. New materials were used, and in part, substantial effort was made to get better materials.
- The close personal contact that mediated an intensive feeling of cohesion in original human associations could no longer fulfill this task in large groups sometimes divided for reasons of food acquisition. Increased importance thus came to habits and usages that mediated a feeling of cohesion. Spirit myths, common fests with synchronized activities such as dancing and singing, initiation rites characteristic of the political association, the exchange of gifts (Eibl-Eibesfeldt, 1995 and 1991), a purposeful politics of marriage, and the culturally nurtured consciousness of being a community of destiny in the fight against external enemies generated a feeling of community. Of course, a common language also played a large part. Some of these means for strengthening the group had already developed before the transition to the Late Paleolithic because of growing language

ability and contributed their part to the strengthening of the groups (habits and usages come into question here that in principle were compatible with the original group structure and the interests of dominant men).

- Rules are only necessary in order to influence the activities of humans where human nature makes them tend to behave differently. With the introduction of extensive rules, which primarily affected and canalized the very emotionally laden sexual behavior of humans, the necessity also arose to do away with transgressions of these rules. It thus also had to be determined how an evildoer could be brought to justice (for example, in the case of an escapade) without his closest followers protecting him and endangering the stability of the tribe (for corresponding customs among primitive peoples, see Eibl-Eibesfeldt 1995). Here too, higher interests had to be brought forth in order to move people to behave in contradiction to their nature. Fertile ground for intensive religious development was thus prepared.

The larger group associations that became possible in the Late Paleolithic themselves fertilized cultural development in manifold ways:

- Craft traditions did not only profit from the large demand for gifts. In larger associations, the division of labor and craft specializations could occur sooner. A gifted student also found a good teacher much sooner, and vice versa, an experienced craftsman could find gifted students much more easily.
- The division of labor allowed the uneven distribution of cultural knowledge among group members and thus allowed much more extensive information to be passed from generation to generation. One must not forget that cultural development before the development of writing was subject to clear limitations, since all information had to find "room" in the memory of the group members.
- Because of the division of labor, extensive information was also increasingly passed on from specialist to specialist (tool makers, shamans, artists, etc.). Thereby, more demanding information could also accumulate in the cultural property, since the loss of information through misunderstanding was decreased.
- The acquisition of materials was also facilitated in that the territories of political units were no longer so severely fragmented. The newly high importance of material culture also led, despite all obstacles, to the development of trade between neighboring groups.

- The size of political associations also depended upon the effectiveness of food acquisition, such that opening up new food sources reached high significance. And the shift to hunting and in part also to fishing as meaningful new sources for animal foodstuffs resulted in the development of many new tools.
- Overcoming the limits on group size at the transition to the Late Paleolithic set a cultural race between social systems in motion (or at least substantially accelerated it), in which it primarily mattered which system was able to realize the largest groups and the highest population density. From then on, the fighting capacity and the survival of entire political units depended primarily on these quantities. This was also surely the most critical driving force in the Neolithic revolution, since standards of living decreased with the transition to farming. Since the stabilization of larger groups was a purely cultural undertaking after the onset of the Late Paleolithic, customs and usages were subject to stronger selection than ever before. That all human bands that had not participated in the transition to the Late Paleolithic disappeared from the surface of the earth within a few millennia only marks the beginning of this rigorous selection process. It continues with the crowding out of hunters by herders, of nomads by sedentary farmers, and of tribal societies by state-level organized communities, which in turn became ever larger with time.

Genetic evolution in the sense of a further development of human abilities thus practically ended with the beginning of the Late Paleolithic. Apes are actually poorly suited, in light of their long generation lengths and low fertility, to achieve rapid evolutionary advances. The dynamic development of the line leading to humans was thus only possible because of their chimplike group structure. The marked sexual selection in a multi-male society was the most important driver of human evolution. Through sexual selection, the most imposing males of a multi-male group are preferred, and that on which the hominids specialized was in principle grand power displays in front of predators. The best throwers also automatically belonged among the most imposing males of the group, with correspondingly good prospects of high rank and above-average reproductive success. Intellectual abilities developed further because of the throwing adaptations also had, through their application in the "internal political arena," a direct high importance for rank and thus for reproductive success. After all, these already play a certain role

in chimpanzees, as determined by Jane Goodall, who attributes the rise to the top of the group of a chimpanzee she observed (Mike) in large part to his intelligence (Goodall, 1991).
Since at the transition to the Late Paleolithic the chimplike group structure was given up in favor of a firm assignment of sexual partners, sexual selection was also extensively repealed. This makes itself noticeable in that, among other things, the brain volume of *Homo sapiens* has decreased since then (Martin, 1995) – the high level could no longer be sustained without effective selection for the larger brain. The level reached in brain volumes before the beginning of the Late Paleolithic can be conceived as a dynamic equilibrium value – a level at which the costs and benefits of a large brain for the fitness of humans was in equilibrium. Because of the confrontations between the groups, this equilibrium slowly shifted over time in the direction of increasingly higher brain volumes, and this tendency would presumably have continued without the transition to the Late Paleolithic. Thus, benefits surely consisted in large part of better chances for intelligent men of a high rank in the group and the high reproductive success resulting for such men in a multi-male society. The costs presumably resulted primarily from the higher energetic demands, a higher parental investment in the "rearing" of the children, and a raised risk for mother and child at birth that a large brain brings with it. Since the benefits were closely coupled to the societal form, they decreased significantly after its change and the system sought out a new point of equilibrium (or is still on its way toward one). Most societies certainly offered high-ranking males the opportunity, even after the beginning of the Late Paleolithic, to take multiple wives and thus achieve above-average reproductive success, but because of the intensive cultural development, rank order depended ever less on the quality or kind of the [genetic] heredity of the particular man, since high ranks were inherited. The most thorough attempt thus far to end sexual selection is presented by the demand for monogamous marriage and marital fidelity propagated by, for example, Christianity (Eibl-Eibesfeldt, 1995).

The transition to the Late Paleolithic was perhaps a process that on the one hand was already possible in one way or another for many hundreds of thousands of years, but on the other hand could have had to wait further hundreds of thousands of years. Thereby, the actual point in time depended only trivially on achieved mental and linguistic abilities. Presumably, humanity found itself in a kind of vicious cycle before the transition to the Late Paleolithic. On the one hand, extensive cultural measures were necessary in order to stabilize larger groups; on the other hand, larger associations themselves were a requirement for the development and retention of the customs and usages necessary for their own stabilization.

In small bands, the influence of individuals is of course much larger than in larger groups. Cultural demands that went against the interests of the individual and provoked resistance could easily be ignored in small groups by especially dominant men. Under such circumstances, rules could only arise and persist under very special conditions that demanded neglect of the reproductive interests of individuals (above all the powerful ones) in favor of group interests. Even in culturally very far developed societies, dominant men still have always found a way to put themselves, without punishment, beyond the societal norms that forbid them to follow their sexual tendencies. In a group to which only a few men belonged, men regularly appeared who dominated the association so unequivocally that they not only ignored the corresponding rules, they could even abolish them. Thus, corresponding cultural innovations met a quick end and quickly passed into oblivion, since there was after all no writing with which to fix them.

In larger associations, the individual, with his selfish reproductive interests, was opposed by many more men and women who were prepared, under cultural influence, to defend the interests of the group against him. Therefore, in large associations, mechanisms for their stabilization could develop quite rapidly and were also retained more readily – the problem was only that human bands were originally small and that there were thus no large bands for a long time. Under such circumstances, the actual transition to the Late Paleolithic is probably only to be understood with knowledge of the actual historical processes. On the one hand, the vicious cycle could be broken at any time – on the other hand, quite unusual conditions had to come together for it actually to occur. Thus, though, the question also immediately presents itself of to what extent *Homo sapiens sapiens* was actually "destined" by its capabilities to crowd out all other humans. It is easily conceivable that the situation before the Late Paleolithic corresponded to that of a lottery. All human societies had been playing the same game for many hundreds of thousands of years – until a population of *Homo sapiens sapiens* ca. 70 K years ago got six [numbers] right, cashed in the main prize, bought all the real estate with it, and threw all the others out on the street.

Among the "others" surely belonged most members of their own biological category – whether one classifies them as species, subspecies, races, or however else. Biologically, anatomically modern humans probably developed in all of Africa and additionally also in parts of the Near

East. In this territory 70,000 years ago, there was presumably a population of *Homo sapiens sapiens* that included as many as several million individuals. According to molecular biological results, however, only ca. 10,000 of them have left offspring behind to the present day and thus became our ancestors (Stringer & McKie, 1996). All other lines of anatomically modern humans died out, just like all Neandertals and the local populations of Asia at the time. And I see no reason for seeking another explanation for that than for the disappearance of the Neandertals. We thus are probably dealing with a process of replacement, in whose course not only populations disappeared that clearly differed genetically and phenotypically from the conquerors, but also populations that were practically biologically identical to them. As an explanation for this process, therefore, biological approaches alone such as the development of language ability only in *Homo sapiens sapiens* hardly come into question.

6.7 Food sharing

In human populations, food sharing is usual worldwide. Hunter-gatherer peoples practice an express division of labor in seeking food. Men occupy themselves with hunting, while the women are active as gatherers. Thereby, the women often contribute the larger part of the food supply, but the men reap the laurels, since meat enjoys a higher status (Eibl-Eibesfeldt, 1991).

It would never occur to a chimpanzee female to take on several hours of additional food searching each day in order to provide for a male as well. In exchange for the exclusively male nutritional resource of meat, they can always trot out the limited female reproductive ability. For a hunting or scavenging and gathering society organized in chimpanzee style, one really should therefore expect the exchange of meat for sex, and not food sharing. Acquiring plant foods the men could please do for themselves. If one assumes that the natural group structure of humans extensively corresponded to that of chimpanzees, then the question presents itself how it could happen in human societies that women pass on a portion of their foodstuffs to men.

I assume that the transition to a food sharing society of the kind in recent hunters and gatherers was an accompanying effect of the shifts at the rise of the Late Paleolithic. Therefore, food sharing is to be seen, just like lifelong pair bonding, as a relatively new, culturally determined behavioral pattern that had no influence on hominid evolution. From a biological perspective, women are even much better able than chimpanzee females to get meat in the proven chimpanzee way. And they probably also did this over the majority of the 2 MY of human history. Concealed ovulation and the constant sexual attraction of women made it obvious for men to work constantly (more or less) for the favor of the women.

The decisive cultural achievement that made the transition to the Late Paleolithic possible was, however, the stabilization of larger groups. An important medium for this stabilization was the restriction of the sexual freedom of the women through culturally fixed dogma. Surely, men had tried even earlier, with varying success, to monopolize women for themselves, but now they were supported in their efforts by society. With the sexual assignment of a woman to a particular man, her most important article of exchange declined significantly in value, at least for this man. Accepting meat regularly from other men was now surely also taboo, since that smelled like a prelude to “adultery.” In this way, other, more unobtrusive gifts became established in extramarital sex as means for winning the favor of a woman. Since the women, because of the societal revolutions in connection with the transition to the Late Paleolithic, lost sex as an object of trade for meat, they had to make other concessions. They had already been gatherers before, but presumably had not provided for the men in that way. This now changed, foodstuffs were balanced with other foodstuffs, and societies arose with a marked division of labor in the acquisition of food. This division of labor became a characteristic of all Late Paleolithic societies. And since the Late Paleolithic [peoples] replaced all other humans, we find this characteristic today in primitive peoples all over the world.

6.8 Strategic thought

I have already pointed out that I hold the assumption, obvious at first glance, that the mental development of humans because of intraspecific confrontations was primarily driven forward through the requirements of strategic thought, to be false. After we have concerned ourselves with the particulars of organic and cultural evolution and with the transition to the Late Paleolithic, I am finally far enough along to be able to justify this standpoint.

First, a structurally similar consideration speaks against a high significance of strategic thought, as I have already drawn in the case of tool production and of geometric thought. In the past millennia, the requirements in the area of strategic thought have grown constantly. The size of the task forces employed grew just as the radius of action (this primarily presents logistic problems) and the number of different weapon systems did. If the mental abilities that humans applied in this area had only been made ready for the strategic demands of intraspecific confrontations before the Late Paleolithic, then they could not have been enough to satisfy the substantially higher demands of modern war-making. It is therefore obvious to assume, within the framework of the CTSW model, that abilities are used here today that were prepared in a different context in the course of evolution. Particularly the highly developed ability to construct complex scenarios, which originally stood in the service of evaluating distances.

In addition, I assume that the confrontations before the Late Paleolithic were structurally more similar to the relationships among chimpanzees than of recent primitive peoples, and therefore also placed no substantially higher demands on strategic thought than the conflicts among recent chimpanzees. Before the Late Paleolithic, group associations were not larger than in chimpanzees. From this resulted a whole series of important consequences for the ways and means by which confrontations between neighboring bands were carried out:

- In Chapter 4.3, I cited a passage from Jane Goodall, in which she wrote, among other things, the following (Goodall, 1993): "…attacking adult individuals of one's own species is always a dangerous undertaking; that's why it has been necessary in historical times for human societies to train warriors by means of culture, for example in that people glorified their role, condemned cowardice, rewarded bravery and skill on the battlefield, and highlighted the value of practicing 'manly' sports in childhood." In view of the considerations that I have presented on organic and cultural evolution, this reference appears in a new light. The cultural training of a warrior is not only a further development of a biological behavior pattern. Men are reared here to take on risks of a significantly higher degree than can be reconciled with their fitness interests. The origination of such cultural traditions thus presumably first occurred in a situation in which cultural evolution had already taken over the lead in influencing human behavior – i.e., in larger group associations after the transition to the Late Paleolithic.

- The confrontations were a direct result of the birth surplus and contributed to holding the size of the total population stable. In order to achieve this, in light of the low fertility of humans, it is sufficient in recent primitive peoples if 30% of adult men fall victim to conflict. A similar loss quota required, in the small bands in which humans were organized before the Late Paleolithic, less than one death per year per group.
- In smaller groups, the territories are also smaller. One thus comes very quickly to the borderlands. In addition, the ratio of border length to territorial area is larger for smaller territories than for larger ones. Therefore, a larger portion of the group's territory is to be considered borderland.
- Populations as small as the human group associations before the Late Paleolithic are too small to survive permanently without genetic exchange with other populations. Group changes thus surely happened regularly. These, however, probably had to be preceded by an initiation of a relationship in the border areas.

Because of the small group associations, the relationships before the Late Paleolithic were thus probably such that encounters with hostile neighbors happened quite often. These, however, could only have led to confrontations with fatal consequences in exceptional cases. Most encounters probably flowed into power displays in whose course it was made clear to the neighbors that the group would tolerate no injury of its territory. Today, one can observe structurally similar behavior between rival gangs of soccer fans prepared for violence. Whereby, though, the groups are ordinarily larger and the proceedings are thus less clear; in addition, bottles are more frequently thrown than stones.

Presumably, strange men before the Late Paleolithic, just as in recent chimpanzees, were only pursued and attacked when one found oneself in clear numerical superiority. For that, not least

because of the “romantic border traffic,” there were plenty of opportunities. Also here, we can unfortunately observe structurally similar behavior when a band of right-wing radicals “hunt” a foreigner. The whole thing is crowned when such an attack is explained with the witty remark, “they’re taking away our women.” Describing the perpetrators in such a case as “inhuman” or “sick” hardly applies to the facts of the case. We must unfortunately assume that that kind of behavior is all too natural for humans. This does not mean that it is justified, since the society in which we live is, fortunately, anything but “natural.” And we can and must demand of its members that they hold themselves to the “unnatural” rules of this society, because our own security can no longer be ensured if the functional arrangement of the society collapses.
Probably, we will have to pull out and polish up terms like “uncivilized” and “primitive” from the mothballs of history in order to condemn and deter such behavior in the future as well. We should avoid, though, viewing representatives of recent “primitive” peoples as prototypes for uncivilized and primitive people. Their societies and their behavior are equally culturally dominated to our own. Just like us, they are heirs of the great cultural revolution at the transition to the Late Paleolithic.

To the natural behavior of our ancestors before the Late Paleolithic also surely belonged that women and children, just like among recent chimpanzees, belonged among the preferred, because relatively non-dangerous, targets of attack.
Hostile encounters before the Late Paleolithic presumably primarily took place in borderlands. A coordinated advance to the center of a neighboring territory made as little sense as in the case of recent chimpanzees. In the center of the opposing territory, one had the best chances of meeting all the men of the enemy group together. And exactly in the center of their territory were they most highly motivated to defend their territorial claims. If, because of this, it came to a large confrontation, then the attackers would have to count on sensitive losses, losses that could place the continued existence of their group in question. On the other hand, they had little to gain. Even if they were able to eliminate the opposing group, their own territory suddenly grew to about double its size as a result. They were hardly in a position to defend such a strongly enlarged territory from other neighbors – certainly not if they had taken losses in the fight. There were therefore presumably no campaigns of conquest before the Late Paleolithic – at most, individual groups were regularly worn down over the course of years between their neighbors. In

this area also, the relationships changed downright suddenly at the transition to the Late Paleolithic:

- After the cultural conquest of the biological limits on group size, it would have come very quickly to the origination of tribes that were so large that, for reasons of food acquisition, had to split up into subdivisions. Only occasionally did tribal meetings occur; mostly, one only had anything to do with another subdivision of the tribe if one entered its territory.
- Simultaneously, the "romantic border traffic" collapsed, since the tribal associations were now large enough to be able to reproduce without genetic exchange with neighbor tribes. Of course, the tendency to prefer strange sexual partners did not dissolve with this. There were now, however, enough of these in one's own tribe to suffice, since one grew up separated from the majority of one's opposite-sex tribemates. It thus made little sense to take on the risk of advancing into foreign territory to find a sexual partner. The larger territories also stood in the way; it generally took longer to leave one's own territory and encounter a strange one.
- The larger territories had, relative to their area, shorter borders.

The relatively shorter borders and the removal of the opportunity to encounter individual strangers on "suitor's feet" led to the number of hostile encounters decreasing after the transition to the Late Paleolithic. Since the population surplus still had to be removed in these encounters, however, the individual encounters had to become bloodier. Cultural development provided the means by which the men, again without regard to the unclear personal risk, could take part in these fights. Since one typically encountered only a subdivision of the opposing tribe on a surprise advance onto foreign territory, it thus made sense to consolidate the forces of one's own tribe and carry out that kind of attacks. One thus had the chance to cause serious damage to the opponent with little loss because of the clear superiority. And only those tribes that understood such chances could survive the sustained competitive battle. First now did it increasingly come, in the framework of dominating cultural evolution, to strategic conduct of war – whereby abilities were used that had long since been made ready in the course of evolution. Next to the enormous capabilities in the area of scenario construction, fully developed language certainly also belonged to these abilities.

6.9 Damned to war?

At first glance, the CTSW model of hominid evolutions seems bleak and shocking. It certifies, after all, that the last 2 MY of human evolution were characterized by intraspecific confrontations that exercised an enormous influence on genetic evolution as well as on the course of cultural development. Men are born warriors, and social systems have developed so that they were able to outlast warlike conflicts.

From the point of view of this thought edifice, we have – to the extent that we desire peace – every cause not to trust our nature as well as our culture. Both are teeming with adaptive traits in the service of war.

Concepts that assume that humanity is "good" by nature and that "evil" first came to the world because of cultural development are plainly wrong. As long as humanity existed, it was territorial and conducted wars – it did not first have to develop sedentary farming or invent money for that. We tend, because of our biological foundations, to appraise enemies differently than friends. When once we become entangled in a conflict, our capacity for judgment and our sense of justice are absolutely no longer to be trusted, and escalation is difficult to prevent. In this, our cultures provide us very readily with the necessary prejudices in order to discredit and dehumanize our opponents; this effect is known only too well to ethnologists and confirmed under the terms of cultural pseudospeciation. In many cultures, for example, there is only one name for humans and the members of their own political unit. Members of other groups are plainly denied membership in the same species.

Does it follow from this that we are condemned to make war into all of eternity because this corresponds to our nature?

I think that this question can be answered very clearly, from the view of the CTSW model, with a **no**.

Certainly, we will hardly ever manage with condonable means to ban violence from our lives completely. What applies to the conduct of war, i.e., the organized violence of groups against other groups, however, seems hopeful from the developments of the last 40,000 years.

Of course, this time was marked by wars, but it was also characterized by a constantly increasing size of political units. And within the political units, cultural tools were developed for preventing internal warlike conflicts. This did serve, in the end effect, often enough only for the fortification of these political units in fights against external enemies, but in the end, this too is all the same. What counts is the fact that humans, who are biologically adapted to live in groups of ca. 30 individuals and to treat all strangers, with the exception of potential sexual partners, as enemies, can be taught to live together peacefully in a nation of umpteen million individuals of whom the vast majority are absolute strangers. This very clearly shows an enormous amount of elbowroom that we have culturally available for the design of our life.

If it is possible for the citizens of a state with multiple hundreds of millions of residents to live together peacefully, then it is also possible in principle for all of humanity. From the view of the throwing hypothesis, we definitely have reason for cautious optimism. Our ancestors lived under conditions in which fully 25-30% of the men lost their lives in warlike confrontations. For some tribal societies, these numbers still applied until recently. In comparison to that, the twentieth century went downright peacefully, even if this sounds sarcastic in light of the two World Wars.

What, then, is to be done if we want to make ourselves a peaceful world in the long term? In answering this question, it is less a matter of developing new approaches than of the evaluation of the long-available ones.

The elimination of state-level power structures is, for example, hardly the right way to make the world more peaceful. On the contrary, it was first possible for us through these structures, on the one hand, to develop in relative freedom, and on the other hand, to live in peace with each other after all. The state monopoly on violence that is imposed in order to punish offenses against a firmly written order of law is probably the most widely developed cultural instrument for the stabilization of a large group association. In principle, it even becomes possible through this for members of different cultures to live together peacefully – that this is not always easy need not surprise us.

Anyone who dreams of a multicultural society (this applies to me) should be aware that one must do some things toward that, and that living together can only go well permanently if, aside from the many cultural differences, there is an equally cultural common superstructure that should be most able to support a consciousness of true belonging together – at least, at any rate, the consciousness of a community of fate. The legal state is certainly able to intercept a certain amount of potential violence and prevent an escalation – but under difficult conditions, this could quickly prove insufficient.

The natural human answer to resource shortages is a sharpening of conflicts between competing groups. The civilized human no longer has a natural group, as whose member he could enter the fight – but he still tends to fight, and does not want to do it alone – on the contrary, if things become dangerous, he feels unwell left to his own devices and seeks out the protection of a group. He is clever and opportunistic enough in doing so to join the group in which he sees the best potential for gaining access to valuable resources. Such resources need not necessarily be of a material kind. Actual, or even just imagined, high rank is also sought (as a member of a "true" belief, one can feel superior to all non-believers by exceptionally frugal means, even if one is very unequivocally inferior in the division of material resources). If he is a group member, then the mechanisms of pseudospeciation engage. The more one speaks of one's own belongingness, the less critically are the thought edifices prevailing in the group taken on, and the more critically is contradictory information from the outside received. The world is observed through a polarized value filter, and the worldview is correspondingly skewed.

In principle, we know of suitable methods for ensuring peace on earth. We can also assume confidently, however, that it will be difficult to create a peaceful world order under application of these means. Since this task has a new quality.

Whoever imagines that humans struggled solely as free individuals and from wise decisions to stabilize their political associations through flawless cultural measures, errs terribly. Customs and usages often demonstrate impressive functionality without the humans that orient themselves to them being at all aware of this. Of course, humans have always "imagined something" in the development of their cultures. And that surely also helped to determine which cultural variations appeared. Which variations were also retained, however, was determined over long periods of our history by a selection process applied at the group level, to which equally great significance is to be attributed as in the case of organic evolution. And this selection process cared little about what the people thought.

Cultural achievements in the stabilization of large group associations were, over large stretches, a direct consequence of the competition, in agreement with cultural selection, between political bands encountering each other. The pressure from outside was always the decisive motive for ensuring internal order. And cultures that did best with this task succeeded in the cultural selection process and today help importantly in determining human behavior. It follows from this that, in the framework of cultural selection, we cannot expect without further ado the realization of a stable world peace order, since in this special case, the external enemy for the stabilization of that kind of order is missing.

If we want to achieve a world peace order, then we must depend on a different pillar of cultural evolution – on the critical abilities of our intellect, which come into play in the context of internal selection.

There are genes that make it easy for us to behave in a way that could have contributed 70,000 years ago to optimizing our fitness. There are also cultural traditions that make it easy for us to apply ourselves militantly toward a state, a religion, a tribe, or a political party. These quantities of influence, however, have always competed in steering our behavior with our intellect.

We perceive ourselves as individuals, and no one hinders us in making our well-understood individual interests be the guiding principle of our actions. We are capable of seeing through the ways in which genes and memes “try” to make us serviceable for their own purposes, and we can oppose these attempts when they work against our own interests.

7 A Story about the Development of the Human Brain

In conclusion, I would like to tell a story about when and because of what selective conditions brain development, in the view of the CTSW model of hominid evolution, could have run. This offers another opportunity to recapitulate the CTSW model of hominid evolution that is presented for discussion in this book.

We are now dealing with a story that begins with the common ancestor of humans and chimpanzees ca. 5 MY ago. The mental achievements of this ancestor can be estimated with the help of recent chimpanzees, which have gone through no continuing throwing adaptations and therefore even today predominantly get along with the brain capabilities that their and our common ancestor already had available. These ancestors were, like recent chimpanzees, quite heavy when one considers that they mainly nourished themselves with fruits that were to be found in the trees. Heavy climbers are especially endangered by falls, and one can observe often enough even today that a chimpanzee incurs dangerous injuries in a fall. In hunts for monkeys or flight from conspecifics, chimpanzees often jump from one treetop to the next and are accustomed to reaching a branch in doing so that is able to bear their great weights. Perhaps chimpanzees are therefore quite capable of estimating distances reliably up to ca. 10 meters and in this perhaps also call upon procedures that go beyond binocular vision. On the other hand, chimpanzees are obviously capable of combining up to two schemata sensibly in sequence, since they can construct two-word sentences (Savage-Rumbaugh & Lewin, 1995). Corresponding mental abilities may have been available at the beginning of hominid evolution. These abilities belonged to a chimplike ape, specialized to knucklewalking with stiffened wrists.
Now the throwing adaptations come in sometime, which at first were developed for defense against predators. 3.2 MY ago, the wrists were no longer stiffened, but no rotation of the upper body was yet possible. Since the inclusion of the upper arm movement in the acceleration process facilitates rather than complicates targeted throwing, I assume that the throwing procedure has always consisted of four component movements that had to be well tuned to each other (rotation of the upper arm, rotation of the forearm, rotation of the wrist, and the release of the projectile). In order to steer this already quite demanding coordinated motion, corresponding adaptations of the motor system must have taken place, with emphasis on an expansion of the capabilities of the prefrontal cortex and perhaps also a slight enlargement of the cerebellum.

Presumably, *Australopithecus afarensis* would therefore have been able to learn to combine up to four "words" into a sensible sentence under a suitable research design (in corresponding experiments with chimpanzees, symbols, so-called "lexigrams," are popularly used. Similar is to be imagined of the "words" I mention). Whether they could have learned significantly more "words" than a recent chimpanzee is, in contrast, questionable. The improvement of corresponding abilities in humans falls more into the area of constructing scenarios and was bound – according to my approach – to the improvement of distance evaluation. Chimpanzees can learn a few hundred symbols; educated Chinese, in contrast, manage a few tens of thousands of written symbols. The achievements of humans thus surpass those of chimpanzees here by a factor of a hundred.

For fending off predators, distances of less than ten meters were probably sufficient. The closer the predator came, the more surely it was hit; it was only important that the quite small distance was not passed at which the predator, even in the case of great danger, would stand and fight rather than flee. This does not stand in contradiction to the statement that, at the beginning of hominid evolution, adaptations took place in order to improve throwing qualities. The increase in maximal release speed that came with the adoption of new movement elements served to increase the kinetic energy of the projectile (this grows with the square of the speed), which is not necessary equivalent to an increase in range. Faster-flying stones could also lead to significant injuries even with lesser weight. Thus, smaller stones could come into use, of which in turn more could be transported at once. Of course, the higher speed also led to higher range – no one, however, required our ancestors to use this as well. If distance throws made little sense because of their lower accuracy, then they could simply be avoided. *Australopithecus afarensis* may therefore have been only equal to recent chimpanzees in the construction of scenarios, but on the other hand already clearly superior in the carrying out of complex motions. The very limited increase in the brain volume of *Australopithecus afarensis* compared to recent apes makes it obvious to assume that in them, no all too great expansion of brain performance had yet taken place.

Presumably, these animals were not yet right handed, but developed in their lives a very marked preference for the use of one hand, since throwing is an exceptionally asymmetric activity that requires thorough practice. It could therefore easily happen that, in learning to throw, one hand gained an advantage through more practice that was then strengthened, since this now more skilled hand was preferred from then on.

Perhaps there was also already a disposition toward handedness. In throwing, only one hand is always used, and very high demands were placed on the steering of this hand, with corresponding "costs" for the brain. The hand is not steered separately, however; its motion is only one part of a complex course of movement that must be very well coordinated. Here, a "higher authority" presumably had to be established that took over overall control of the course of movement. Now, the exchange of information between the brain hemispheres is quite slow and should thus be avoided, when possible, in the steering of a complex ballistic movement. Therefore, it was sensible to concentrate overall control of the course of movement in one brain hemisphere, from which in turn an advantage arose for the hand that was directed from this hemisphere. If overall control was developed in the right brain hemisphere of an individual, then it is usually a left-hander, since the motor steering of the left arm (like the whole left half of the body) also takes place in the right brain hemisphere. In the case of a throw with the left hand, the body parts could thus from here on be addressed that had to move most dynamically and the best attuned to each other. The location of overall control in the left half of the brain led correspondingly to right-handers. If there was already a tendency toward handedness in *Australopithecus afarensis* 3.2 MY ago, then this species might have been evenly divided into right- and left-handers.

This changed, however, in the next 0.7 MY. In this time – I assume – the upper body rotation was developed and integrated into the acceleration procedure. Now, the asymmetry of the upper body came to bear and preferred right-handers, as indicated by the oldest worked stone tools from the time of 2.5 MY ago, which were obviously finished by right-handers (Toth, 1987). Beside this, these tools presumably served for the butchery of carrion, which in turn indicates that the set of tasks in stone throwing had changed.

Now, predators had to be driven off a kill that they jealously guarded, or held off from a cadaver of which the hominids had already taken possession. Above all in the second case, range played an increased part. It was advantageous to hold the predators at greater distance, on the one hand so that their emotions were not churned up even more through the carrion, and on the other hand so that one could not be attacked all too surprisingly while cutting up the cadaver. The increase in importance of targeted throwing over larger distances caused a probably significant improvement in the ability to estimate larger distances well. In this context, the abilities for the construction of scenarios were expanded substantially. Also, the requirements on the motor system rose again clearly. This went along with a clear brain growth and led, ca. 2. MY ago, to *Homo habilis*, with a brain volume of 509-674 cc (Henke & Rothe, 1994). This [species] would probably already have been able to combine five “words” into a sentence in a corresponding research arrangement, since in throwing it already mastered the combination of five movement elements (the rotation of the upper body around the long axis had been added). It would also already have been able to differentiate substantially more individual meanings than a chimpanzee, since precise schemata of all possible objects were one of the foundations of its improved abilities for scenario construction in the service of evaluating distances. In its thoughts, it considered more components of a line of questioning and could weigh possible “answers” better – this, too, resulted from tighter requirements in scenario construction.

In the acquisition of carrion, it may also already have come to detailed “arrangements” among the participants through use of hand signs. After all, *Homo habilis* was, as a specialized thrower, expert in carrying out an intentional movement with a hand; thus, it had ideal prerequisites for the development of a sign language. The critical question, however, is to what extent a detailed language could have improved the fitness of the speaker at a given time, and in what relation this improvement stood to the necessary adaptations and their accommodation costs. In the end, chimpanzees are also capable to a notable degree of the exchange of detailed information, and are very fond of doing so once they have learned it (Savage-Rumbaugh & Lewin, 1995). Under natural conditions, though, these abilities do not unfold.

In actions against predators in order to acquire carrion, one can surely imagine that detailed arrangements would have been an advantage, but a speaking human can imagine that of nearly every activity carried out together. Chimpanzees, in contrast, achieve even quite complicated cooperation in hunting without having arranged it in advance. After all, one also gets quite far if one only observes the others and determines one’s own actions accordingly. Hereby, then, the capacity for foresight is more likely to play a role than language ability. And the capacity for foresight could already have been significantly better developed in *Homo habilis* than in a chimpanzee (see below). Thus, *Homo habilis* could have had quite good circumstances for effective cooperation in scavenging without language.

Foresight is closely tied to the ability to deduce rules in order to work with data on higher levels in constructing scenarios. In order to be able to foresee something, one must have dealt intensively with the appropriate problem circle and have recognized important connections. And one will normally only be able to make rational predictions in those areas with which one is familiar. Thus, neural machinery that makes possible the determination of a complex course of movement in advance is by far not enough to improve significantly the capacity for foresight in other areas.

Australopithecus afarensis could certainly already plan in advance clearly more complex ballistic courses of movement than recent chimpanzees, but this did not necessarily lead to a substantially improved capacity for foresight in general, since they were not aware of substantially more connections in their environment than a chimpanzee.

Homo habilis, on the other hand, presumably also already possessed a clearly improved ability to construct scenarios. In that, a multitude of connections known to it was also used. The known relationships could be called upon analogously to the process of advance planning in throwing and perhaps under use of the same structures in the frontal lobe, in order to plan other actions. Advance planning is thus perhaps a mixed use of the evolved thrower's abilities, primarily centered in the left brain hemisphere, to manipulate sequential data and the capacity, equally de rigueur for evolved throwers, for the construction of very detailed and complex scenarios. This ability is presumably based more on the performance of the right half of the brain. In the construction of visual scenarios, which was originally at issue, geometric thought played a meaningful role, and this was based in humans above all on the achievements of the right brain hemisphere.

A division of this kind of the tasks accumulating between the two brain hemispheres in throwing was obvious. The right half of the brain specialized on the preparation of background information; above all, distance was determined here. The extensive operations that had to be carried out for that took place internal to this hemisphere, and only the result was passed on to the left hemisphere. In it, the planning and steering of the actual movement took place.

The additionally accruing tasks on the brain in connection with the specialization on throwing could certainly be a sufficient explanation for the growth of the brain in the course of australopithecine evolution (including *Homo habilis*). The capabilities of humans, e.g., in the solution of geometric tasks, were surely not reached in the course of australopithecine evolution, however, since the selection pressure in the direction of such abilities clearly increased even more in *Homo erectus*. It is hardly to be assumed within the framework of the CTSW model, however, that the precision grip of the hand and right-handedness developed without parallel improvements in geometric thought, in the coordination of complex courses of movement, etc.

The next large step in throwing evolution is marked by the appearance of *Homo erectus* ca. 1.8 MY ago. It indicates that in the meantime, the application of throwing projectiles in confrontations between neighboring groups had taken over a decisive role in evolution. Now, throwers fought against throwers, and that means that the targeted throw over the greatest possible distance stood in the foreground. The estimation of large distances thus gained enormously in importance and with it also the ability to construct precise scenarios. On all levels of expansion, it came to the use of a larger number of detailed schemata, and higher levels of manipulation were additionally developed. This required a tremendous expansion of brain performance and numerous genetic adaptations, so that the adaptation of brain performance to the changed set of tasks surely required substantially more time than the physical transition from *Homo habilis* to *Homo erectus*.

In *Homo erectus*, two further movement elements came into the acceleration procedure (rotation of the entire body relative to the left foot and a jackknife motion in which the upper body was thrown forward). It could thus presumably have put together similarly complex sentences, in a corresponding experimental design and after many years of learning, to *Homo sapiens*. This does not mean, however, that it could actually speak at the beginning of its development, or had already spoken. Language ability presumably developed in the course, or even just at the end, of the *Homo erectus* phase, and probably reached its present level ca. 0.3 MY ago (see below). Much more belongs to language ability than the ability to combine elements into a sensible sequence. Specialized areas for the recognition of speech had to be prepared. Physical adaptations for the improvement of vocalization had to take place, since from the drawn-out calls of a chimpanzee one could at best have assembled a very slow language with a low rate of data transmission. Above all, though, suitable learning dispositions had to be developed and genetically anchored in order to turn use of language into a natural element of human nature. All of that surely required a further enlargement of the brain, since language ability was an additional, exceptionally demanding achievement. Because of this, it is hardly to be assumed that language was “granted” [implies given as a gift] to humans on the way to other adaptations. The throwing adaptations were, of course, certainly trailblazers of language development to a certain extent; this itself, however, took place because of an expensive separate developmental process. Since the brain increase in *Homo erectus* can already be explained by the high demands of intraspecific confrontations on a specialized thrower, it is obvious within the framework of the

CTSW model to bring language development into connection with the increase in brain volume by presapiens.

The throwing hypothesis indicates that intraspecific confrontations have contributed decisively to human development for around two million years. Of course, the development of language abilities also seems very plausible to us in the context of this kind of confrontations. Confrontations between enemy groups involving the use of stones applied as distance weapons might have rewarded strategic superiority more strongly than hand-to-hand combats involving the use of weapons inherent to the body, such as we overwhelmingly encounter in chimpanzees. In this, the coordination of the group could have acquired an entirely new priority and with it perhaps also the exchange of precise information. One must be aware, though, that such scenarios are predominantly oriented on the behavior of modern humans in warlike confrontations. And human behavior at the transition to the Late Paleolithic – the archaeological record demonstrates – was subjected to a deep-reaching change.

In addition, information could also be exchanged by signs, and I have already indicated that this was much more obvious for throwers than the development of a spoken language. Perhaps this was also preceded by a highly developed sign language; after all, this is preferable over a spoken language, e.g., in sneaking up in war or in hunting, even today.

Now, throwers often had their hands full right in critical situations, so that the use of an independent system for transmitting information may have offered clear advantages. A further advantage of language may have lain in that people could also be addressed that were not looking at one at the moment – if one can be thrown at by an opponent at any time, one should rather keep one’s eye on him. For such situations, however, a few warning calls would have been enough, as one also already finds them among meerkats in quite differentiated forms. More extensive exchange of information, as one would have needed, e.g., in the working out of a “campaign plan,” should actually have been quite easy to bring off with a sign language, since it requires anyway that one concentrate on it. In addition, I have already indicated that in my opinion, the strategic requirements of intraspecific confrontations until the transition to the Late Paleolithic presumably did not increase substantially. Why, then, should our ancestors have shifted the emphasis from sign language to spoken language?

Presumably, intraspecific confrontations definitely played a role in that, but one must refer to something further in order to clarify wherein its contribution consisted. Maybe the direct requirements of warlike conflicts did not play a direct role in the development of vocal communication, but rather the "education of a warrior." The growing boys did not only have to practice throwing. In order to avoid making a fatal mistake already at the first enemy contact, they also had to concern themselves promptly with how they had best to behave in the different situations of danger that conflict with strange conspecifics could bring. For that, though, they required information from the adult men that had corresponding experience. Since the men presumably strode about in a large area during the day like male chimpanzees and were not accompanied by children in this, opportunities for passing on information primarily occurred during communal overnights on the ground, to which our ancestors had presumably already switched ca. 2 MY ago. With the onset of darkness, a transmission of information through use of sign language – even if campfires already existed – became exceptionally difficult. Perhaps therefore, signs were increasingly accompanied by associated sounds in such "storytelling nights," and because of the increase in the volume of information that had to be passed on to the following generation, it came to a shift from sign language to the spoken word. In this scenario, the development of verbal language would not have taken place as a direct reaction to intraspecific confrontations. Language would first have been introduced when very large quantities of information had to be passed on within the group. And this could in turn have appeared right at the transition to presapiens.

The end of the *erectus* phase was obviously accompanied by a loss in importance of thrown stones in confrontations. Just as this previously dominant weapon had "normalized" the physique, it could also have limited significantly the range of variation in behavior. Additionally, the hominids were adapted to use of the stone weapon because of a throwing evolution of many million years' duration even before the appearance of *Homo erectus*, and knew "intuitively" how to approach it. The behavioral elbowroom was therefore subject to restrictions, and there were relatively few pieces of information whose transmission to the next generation would have significantly raised its fitness. If the possibilities of sign language sufficed for the transmission of this information, then perhaps the development of language in *Homo erectus* was not yet "worth it." As the stone decreased in importance, different other types of weapon came into use, and the confrontations became more unclear and also no longer ran according to schemata that had developed in the course of multiple millions of years of evolution. The transmission of experiences could thus have gained downright suddenly in significance. And this could have contributed to the development or at least the completion of verbal communication.

There is, however, yet another function of language, of which one should not lose sight precisely in respect to the high importance of intraspecific confrontations for human evolution. "Talking together" by no means serves solely for the exchange of information; it also has an important social function and demonstrates parallels to the social pelt care (grooming) of primates. Through grooming, primates free one another from parasites, and in that surely consisted the original function of this behavior. It was placed, however, in social context. The animals can express their esteem of a particular social partner through especially intensive grooming, and thus simultaneously give a signal to the rest of the group members. Grooming thus acquired central significance for social behavior. Coalitions are solidified through intensive mutual grooming. Lower-ranking animals can manifest their inferiority in that they groom the fur of the higher-ranking. Vice-versa, higher-ranking animals can also attest to their favor or disfavor toward lower-ranking [animals] by the amount in which they permit grooming, or even go over themselves to grooming the social partner. Meanwhile, the social function of grooming has acquired a much higher importance than the hygienic one.

In conjunction with languages, the roles are divided conversely. Here, the higher-ranking one is generally the one who becomes active – he gets to be the big spokesman. Talking, in itself, thus shows more similarities in a social respect to power displays than to grooming. On the other hand, lower-ranking ones can also become active here, in that they listen with interest or even express agreement through gestures, mimicry, and verbal insertions (and with that a certain degree of subordination). Language is also prominently suited for active appeasement. If a lower-ranking [individual] noticed that an action on its part threatened to result in an unexpectedly serious reaction, then it could still quickly moderate this action through an "amended" verbal interpretation and prevent escalation.

Language in general and storytelling evenings in particular may have taken on a significant role in the course of human development in the stabilization of group associations. All members of the group can participate in storytelling and derive a feeling of belonging from it. Lower-ranking [members] got an opportunity to re-cement a damaged relationship to those of higher rank. Higher-ranking [members], on the other hand, were offered abundant opportunity either to interfere in and settle conflicts of those of lower rank or to send soothing signals in the direction of individuals of low rank, to whom their relationship was presently perceived as tense.

The stabilization of group associations was very important to our ancestors in turn because of the intense territorial conflicts. And these may even have increased in our developmental line after the transition to presapiens – to the extent that our ancestors truly were "flatlanders," as I have already proposed elsewhere (Chap. 6.2).

I would in any case consider it unequivocally wrong, however, to see in the development of language solely a reaction to changes in the conduct of war at the end of the *erectus* phase. I have already indicated that evolution is an integrative process in which the sum of all effects of a variation on the fitness of its carrier determines whether this variation can prevail in the population. The benefits must exceed the costs.

In the case of the development of language, because of the already highly developed capability in planning and steering complex ballistic movements, we can count on a lowering of the costs of language development for evolved throwers in comparison to their chimplike ancestors (see Chap. 3.3.3). Simultaneously, a higher benefit of language is to be expected, since the cognitive abilities – primarily in conjunction with the estimation of distances – were clearly improved. Naturally, one gets more out of using language if one has a more intelligent conversation partner. It is thus entirely conceivable that among evolved throwers, language development was already worthwhile because of applications that we also find in apes without them having led to the development of language among these. Conceivable applications are found in social behavior or in food acquisition. And the effects of the development of languages on these applications of course went into the "calculation" of overall fitness that determined whether language would be developed or not.

It is only conspicuous that at the transition to presapiens, growth of the brain presumably associated with language development went along with the task of certain features of the physique that had been normalized by stone in *Homo erectus*. This makes the thought easy that alterations in the type of intraspecific confrontations contributed at least in part to the initiation of language development – although this could certainly have been a matter of the proverbial straw that breaks the camel's back [lit.: "drop that makes the vat overflow"]: of a possibly in and of itself low addend that nonetheless led to a change of sign in the result of the cost-benefit balance of language development.

Making out the beginning of the development of language abilities from fossils is very difficult. It is dangerous to conclude language development too quickly from similarities to modern humans in the construction of the brain, since here too, a pure adaptation to throwing may have played a significant role. Humans differ from all other mammals in the location of their larynxes. The case for language ability is unequivocal here, since humans thus accept the danger of choking. Laitman has carried out investigations that aim to reconstruct the location of the larynx in our ancestors (Lewin, 1992; Henke & Rothe, 1994). He concluded that the beginnings of human language ability already lay with *Homo erectus*. First, however, in archaic *Homo sapiens* (presapiens) 0.4-0.3 MY ago did the upper airway equal that of modern humans.

The Turkana Boy (*Homo erectus*, 1.6 MY) obviously lacked yet another requirement for highly developed verbal communication. In speaking, the airstream from the lungs must be modulated precisely; this requires a correspondingly demanding innervation of the responsible musculature. Therefore, in humans, the corresponding nerve is unusually thick. Since this nerve runs through the vertebrae of the spinal column, it leaves behind holes whose diameters permit conclusions about the thickness of the nerve. In the Turkana Boy, it was not yet thickened.

Presumably, then, it did not yet come to the development of a spoken language at the beginning of the *erectus* phase. In the development of the brain, which can be read from the increasing volume of the brain, the throwing adaptations probably still dominated. In the course of the *erectus* phase, the brain grew continuously, from 800-900 cc 1.8 MY ago to 1100-1200 cc 0.5 MY ago (Schrenk, 1997). Here, according to Aiello and Dean, a steady enlargement of Broca's speech center also occurred (Henke & Rothe, 1994). Perhaps a sign language was developed here on the foundation of the throwing adaptations, which then was gradually enriched with vocal sounds. In the transition to presapiens, it then probably came to a clear shift of emphasis in the direction of verbal communication. This again led to a phase of accelerated brain growth and to the completion of the vocal apparatus.

There are good reasons to assume that intraspecific confrontations do not suffice to explain the linguistic and mental capacities of humans. In particular, it is striking that in such a scenario again the men – as warriors – would have been the bearers of the development. If the evolutionary significance of language ability lay primarily in its application in conjunction with confrontations, then men should be as superior compared to women in speaking as in throwing and the accompanying performances of the brain. This does not agree, however, with observations; on the contrary, in certain linguistic tasks, women are actually superior (Kimura, 1992; see also Figure 7) and for the vast majority of tasks, one can reliably assume that women and men are equal.

And perhaps they had to be, since they were (and still are) reproductively tied to each other, but nonetheless each pursued their own interests. Maybe women had to be mentally equal to men in order to be able to pursue their own reproductive interests. I have already indicated in the discussion of natural human sexuality that women, for example at the very important and dangerous initiation of contact with strange men, had to avoid being deceived by them. Thus, a developmental model is conceivable in which the cognitive development of the last 2 MY was driven by intraspecific confrontations and in which the women participated in the areas where they could not tolerate male superiority with respect to their own fitness.

Possibly, though, this model is also still to simple. After all, it is to be assumed that the development of language led to shifts in the social behavior of the hominids and with that to altered requirements and selection pressures within the group associations. The mental demands on a speaking, social primate are, independent of the conduct of war, higher than on a non-speaking one. Above all, the very important area of reproduction was surely influenced by language abilities. And it is conceivable that here, further adaptive achievements were demanded of both sexes.

Our nearest living relatives, the chimpanzees, already count as the "lying barons" of the animal kingdom (Sommer, 1993). Through language, the opportunities for deception within the social band were expanded further in the course of human evolution, since one could, in the truest sense of the word, "tell a lot" (fig.: "make up a lot of stories"). Deception, however, was also made more difficult through the improved flow of information within the group. One did not only have to avoid being seen through by the object of the deception or being observed in the deception, rather also had to reckon with denunciation. Precisely in small human associations does gossip play a very important role in social life and also demand a very high amount of social competence from the members.

Language also permitted precise arrangements and the drawing up of behavioral reprimands whose disregard could be punished (in the end, this made possible the cultural breakthrough at the transition to the Late Paleolithic). It gave dominant men the tools in hand to rule the group and monopolize desired women (human sexual behavior, see Chap. 5.1 and following pages). Simultaneously, it facilitated concocting a plot to topple a chief who had taken too much for himself, or sowing discord between men who dominated the group together. Thus, an influence of language ability is also to be expected in the reproductive strategies employed by men and women in a multi-male group. Possibly, yet another expansion of brain performance beyond pure language development happened in this context. Although I doubt this. Precisely in the area of social behavior, recent apes seem exceptionally capable to us – perhaps the intellectual distance from humans is least in exactly this area. Yet, just the evolved abilities of humans in the construction of complex scenarios should also ensure a clear superiority of humans in this area. I assume that the social construction of human associations corresponded extensively to that of chimpanzees until the Late Paleolithic. The cognitive requirements of social life on the individual group members may have increased due to the development of language – cognitive abilities, though, had already done this in the context of throwing adaptations and thus were presumably entirely sufficient for social interests.

In any event, we must expect that a systematic error underlies our judgment of the importance of language for the course of human evolution. In my opinion, human behavior first becomes extensively culturally dominated after the transition to the Late Paleolithic. The enormous increase in the significance of culture for human behavior went along, in any case, with a corresponding increase in the significance of language – the medium with which cultural evolution serves itself. Because of this, our behavior and our perceptions today are insurmountably dominated by language – one need think only of the "word of God" or the "letter of the law." That could have been very different before the Late Paleolithic. The significance of language for the behavior of our ancestors may – measured against its importance for our behavior – have been downright ridiculously low.

Language ability placed a language barrier between groups. This was of particular importance to women who tried to change groups. Women who changed groups were required to learn a new language yet after puberty. Granted, the languages of neighboring groups before the Late Paleolithic may have been [kept] closely related to one another through the regular exchange of women. In connection with the group changes, as I have already presented, the express tendency of humans to fall in love is also to be seen. The superiority of women in linguistic tasks could be, in significant part, a result of the necessity of learning a new language at a relatively high age (after puberty). The physical superiority of men could also have played a nontrivial role in this. In order for their own interests to prevail against them within the group, the women may have needed a higher level of social competence supported by better-developed language ability.

Today, language plays an enormous role for the mental productivity of humans – this may have been very different before the Late Paleolithic. Language permits the transmission of explanatory concepts, through which improved "tools" for the manipulation of information on higher, abstract levels were placed at the disposal of following generations. A critical problem in operating on higher, abstract levels is the point that one must first prepare the necessary abstractions. As long as every individual was dependent on its own experiences in the development of overarching terms that represented connections among simpler terms, this "understanding pyramid" had to be built from the foundation to the tip, element by element, in the development of one's own mental abilities. Of course, in a relatively short life, one did not get far. The opportunity to learn entire explanatory concepts through language in childhood, without having previously had and evaluated the underlying experiences, gave humans the chance in the course of their developmental history to climb to progressively higher steps in the understanding process, and led to that in the course of the generations, they could advance to ever-higher levels of data manipulation.

One could imagine that it was therefore worthwhile to improve the biological foundations for the ability to work on ever-higher levels of abstraction as well. With that, though, we would have a scenario in which cultural development had helped to drive forward the development of the human brain. On the other hand, it is again thoroughly conceivable that the prerequisites for working on higher levels of abstraction had already been made ready in the course of throwing evolution and were only used by cultural development. I hold the second case to be more probable. On the one hand, it is better suited for bringing brain development and archaeological finds into accord. On the other hand, similar considerations also apply here as with geometric and with strategic thought, since the "understanding pyramid" mentioned above has been expanded enormously in the recent past. The cultural demands on operating at high levels of abstraction have surely increased enormously in this – far beyond the level that cultural development had demanded before. This increase in the level of demand occurred and still occurs so quickly that we cannot expect it to be accompanied by further evolutionary development of the brain.

We therefore use the performance potentials of the brain that developed sometime in the past and are much higher than was necessary for the cultural development of the time. This clearly contradicts the assumption that these performance potentials were prepared in the course of evolution specifically for cultural evolution. If, however, language ability and perhaps also the modern performance level in the exchange of information were first developed after the end of the *erectus* phase, and if this end was heralded by the introduction of new weapon traditions, then the capability of the human brain is to be traced back in part to cultural development after all. Not because these achievements were prepared just for cultural development, but because a critical cultural development led to shifts in the conduct of war, which in turn led to selective advantages for even more capable brains.

Today in the course of their development, children stuff themselves downright full of abstract terms. They constantly ask about connections whose understanding could make it possible for them to improve upon their worldviews. With their constant questions after the how and the why, which obviously come from their internal desires, they usually work out the existing explanatory pattern very quickly. Thus, they advance in a relatively short time to high levels of abstraction and then operate with concepts whose derivation on one's own would require more extensive experiences than a person in life – if only for reasons of time – would be able to collect. Language made possible the transmission of extensive detailed information to following generations and through that finally permitted humans, through use of an already highly developed brain, to become pronouncedly cultural beings.

After the transition to the Late Paleolithic, the mental capacity of each individual human became strongly dependent upon cultural aspects and thus can today no longer be described as a purely physical or purely biological feature. The biologically prepared performance potential is now only one of many quantities that decide how well a modern human is able to deal with the problems with which it is now confronted in the course of its life. It is therefore also not surprising that a purely biological quantity, such as brain volume, shows no correlation to IQ, which is more aligned to estimate how well a human can deal with problems that present themselves today.

With brain volume, a correlation is sooner to be expected with the volume of work than with the height of individual achievements. When we think about intelligence today, we primarily consider consciously conducted thinking tasks. In exactly these tasks, however, the quantity of manipulated information is exceptionally low. The amounts of data that we must manipulate in seeing are dissimilarly larger. Computers can help us develop a feeling for the orders of magnitude with which we are dealing. With graphic files, one can fill up a hard drive very quickly. In order to assess the contents of these graphics, a few minutes are sufficient for us. If, however, the same quantity of data is present in text, which we must take in consciously in order to assess it, then we are occupied for years. In conscious thought, we "pursue" a thought. The manipulation of visual information is supported by lots of processes occurring in parallel in the brain, and since these processes all run simultaneously, we cannot follow them consciously at all. Of course, for cultural development, conscious thought is of primary importance, since this is based above all on the transmission of information, originally above all through language. The importance of conscious thought has thus increased strongly because of cultural evolution, from which it does not follow, however, that the most complex or the most demanding achievements of the brain are to be sought in the area of conscious thought. Pioneering discoveries are also usually not derived – they occur to one. And this maybe simply means that our consciousness becomes aware that our brain has already solved the problem below the threshold of consciousness and perhaps under consideration of substantially more extensive information than we would consciously be able to manipulate simultaneously.

Just like the human body, the human brain is also viewed in the CTSW model not as exceptionally unspecialized, rather quite on the contrary, as specialized to the highest degree. The enormous versatility of humans does not result from an adaptation to versatility, rather from the enormous demands of their specialization. The abilities that were developed in order to meet these demands are therefore so highly cultivated and extensive that they make possible the mastery of a great variety of other tasks. However, none of these tasks, in the entire extent of its demands, approaches what was required of the human brain in the course of evolution. We must not allow ourselves to be deceived by what humans bring into being today through use of their brains. The enormous efficiency that characterizes our cognitive activities today in some areas of application is primarily a result of the many "thought tools" that were developed and passed on since the transition to the Late Paleolithic. One need only think of the limited possibilities for a further development of mathematics before the invention of zero, of the importance of a highly developed mathematics for the natural sciences, and of the importance of the natural sciences for the technical accomplishments of our time.

A correlation between brain volume and mental abilities will therefore soonest allow itself to be determined if similar is demanded of the brain as in the course of evolution. From the CTSW model, it results that the development of the human brain was driven through confrontations between groups involving use of thrown stones. Throwing in itself and the correct behavior in the course of confrontations between groups were the most important tasks in this context.

Because of this evolutionary development, humans today find great pleasure in sports that place similar demands on them. The reason for that is simple: the mastery of a difficult task requires a long learning phase. Learning takes place best in play. One plays what one enjoys. Therefore, children were preferred by evolution that enjoyed playing games in whose course they learned what they needed as adults.
We are direct descendents of these children, have retained their preferences and based upon them, have developed a whole series of modern sports whose construction allows glimpses at our evolution. Sports with high demands on team play, on the mastery of demanding ballistic courses of motion and emphasized participation of the hand, and the ability to estimate large distances well are, for example, baseball, rugby, volleyball, basketball, and handball. Top players in these sports must bring with them all necessary prerequisites, under which the corresponding potential of the brain also falls.

I would therefore like, in conclusion, to bet on the foundation of the CTSW model that top players of the listed sports present an above-average brain volume. This assumption should be relatively easy to test. The second prediction will be somewhat more difficult to test. This says that the brains of the female top players in these sports stand closer, in the characteristics in which male and female brains are different, to male brains than the brains of other females. This applies, in addition to size, also to the organization of the brain. It would be conceivable, for example, that in such women, linguistic functions are more strongly lateralized.

It would also be interesting to see how top players of both sexes came out in the tests in which Doreen Kimura determined performance differences between women and men (Kimura, 1992). If in the areas in which she determined a male superiority, this superiority results from the throwing adaptations, then especially good throwers, such as the aforementioned top players, should also be superior to average members of their sexes in the solution of these tasks.

It was obvious to conclude a new model of hominid evolution with such predictions. What a scientific model is worth is primarily determined in the attempt to derive from it predictions about as-yet unknown relationships. A new model of hominid evolution is always also an attempt to solve the puzzle of become human, a puzzle whose core is the high degree of mental ability that humans have achieved in the course of their evolution.

Acknowledgements

Rainer Knussmann was the first scientist who has taken my work seriously. His assistence in a critical developmental phase of this book was invaluable. Thanks also to Susan Way for the excellent translation of “The Age of Throwers” and Richard W. Young, who has arranged this translation. I`m waiting impatient for the publication of his own work on human evolution, it will be an important contribution to the questions I`ve dealed with in this book.

References

[TRANS. NOTE: German titles are translated here for convenience of understanding; obviously, the original book should be consulted when pursuing actual references. I have retained the original formatting, which is irregular.]

AIELLO, Leslie and Christopher DEAN (1990): An Introduction of Human Evolutionary Anatomy. Academic Press, London

ALEXANDER, Richard D. (1988): On the interests of humans and the evolution of life courses. In: The Challenge of Evolutionary Biology. ed. Heinrich Meier, Piper Verlag, Munich

ALEXANDER, Richard D. (1989): Evolution of the human psyche. In: P. Mellars & C. Stringer: The Human Revolution. Princeton University Press

ANGST, W. and Hans KUMMER (1975): Social organization of baboon groups. In: Hominisation and Behavior. G. Kurth & I. Eibl-Eibesfeldt (eds.) Fischer Verlag, Stuttgart

BAUERSFELD, Karl H. and Günther SCHRÖTER (1980): Fundamentals of Track and Field. Sportverlag Berlin.

BECKER, Peter-René (1993): Tool Use in the Animal Kingdom: How Animals Hammer Drill Paint. Hirzel – Wiss. Verl.-Ges., Stuttgart

BLUMENSHINE, Robert J. and John A. CAVALLO (1992): Early Hominids – Scavengers. Spektrum der Wissenschaft 12/1992

BOESCH, Christophe and Hedwige BOESCH (1984): Mental map in wild chimpanzees: An analysis of hammer transports for nut cracking. Primates, **25**(2), April, pp. 160-170

BRANDT, Michael (1995): The Origin of the Upright Gait. On the Locomotion of the Plio-Pleistocene Hominids. Hänssler-Verlag, Neuhausen-Stuttgart

CALVIN, William H. (1983): A stone's throw and its launch window: Timing precision and its implications for language and hominid brains. J. of Theoretical Biology **104**: pp. 121-135

CALVIN, William H. (1994): The River That Flows Uphill: A Journey through Evolution. Carl Hanser Verlag, Munich

CALVIN, William H. (1994a): The Emergence of Intelligence. Scientific American **10**: 101-107

CALVIN, William H. (1995): The Symphony of Thought. How Consciousness Arises. dtv-Verlag, Munich

CAVALLI-SFORZA, Luca and Francesco CAVALLI-SFORZA (1994): Different but yet the Same. A Geneticist Removes the Foundation from Racism. Droemer Knaur, Munich

CLARKE, Ronald J. and Phillip V. TOBIAS (1995): Sterkfontein Member 2 Foot Bones of the Oldest South African Hominid. Science, **269**, pp. 521-524

COPPENS, Yves (1994): Geotectonics – Climate and the Origins of Man. Spektrum der Wissenschaft 12/1994

DAMASIO, Antonie R. and Hanna DAMASIO (1992): Language and Brain. Spektrum der Wissenschaft 11/1992

DAWKINS, Richard (1988): On which units does natural selection direct itself. In: The Challenge of Evolutionary Biology. ed. Heinrich Meier, Piper Verlag, Munich

DESMOND, Adrian and James MOORE (1994): Darwin. Rowohlt Taschenbuch Verlag.

DE WAAL, Frans B. M. (1991): Wild Diplomats. Reconciliation and Relaxation Politics in Apes and Humans. Carl Hanser Verlag, Munich

DE WAAL, Frans B. M. (1995): Bonobos and their female controlled society. Spektrum der Wissenschaft 5/1995

EIBL-EIBESFELDT, Irenäus (1991): The Uniting Inheritance. Expedition to the Roots of Our Behavior. Kiepenheuer & Witsch, Cologne

EIBL-EIBESFELDT, Irenäus (1995): The Biology of Human Behavior. Outline of Human Ethology. Piper Verlag, Munich

FRANZEN, Jens L. (1997): A Grounded Reconstruction of the Evolution of Humans. Natur und Museum, **127** (8): 245-263, Frankfurt am Main. Current draft at http://senckenberg.uni-frankfurt.de/lecture/evome/evome.htm

GABUNIA, L. and A. Vekua (1995): A Plio-Pleistocene hominid from Dmanisi, East Georgia, Caucasus. Nature **373**, pp. 509-512

GOODALL, Jane (1986): The Chimpanzees of Gombe: Patterns of Behavior. Harvard University Press, Cambridge

GOODALL, Jane (1991): A Heart for Chimpanzees. My 30 Years on the Gombe River. Rowohlt Verlag, Reinberg

GOODALL, Jane (1993): Wild Chimpanzees: Behavioral Research on the Gombe River. Rowohlt Verlag, Reinberg

GRAMMER, Karl (1993): Signals of Love. The Biological Laws of Partnership. Hoffman und Campe, Hamburg

GRAMMER, Karl (1995): Biological Bases of Social Behavior. Behavioral Research in Groups of Children. Vol. 5 in: Dimensions of Modern Biology / ed. by Walter Nagl and Franz M. Wuketits. Wissenschaftliche Buchgesellschaft, Darmstadt

HAY, Richard L. and Mary D. LEAKEY (1982): The petrified footprints of Laetoli. Spektrum der Wissenschaft, 4/1982

HENKE, Winfried and Hartmut ROTHE (1994): Paleoanthropology: An Introduction to the Tribal History of Humans. Springer Verlag, Berlin

JOHANSON, Donald C. and Tim D. WHITE (1978): A new species of the genus Australopithecus from the pliocene of eastern Africa. Kirtlandia No. 28

JOHANSON, Donald and Maitland EDEY (1982): Lucy: The Origins of Humankind. Ullstein Verlag, Frankfurt

JOHANSON, Donald and James SHREEVE (1990): Lucy's Child: On the Search for the First Humans. Piper Verlag, Munich

JOHANSON, Donald and Blake EDGAR (1998): Lucy and Her Children. Spektrum Akademischer Verlag, Heidelberg

KIMBEL, William H., Donald C. JOHANSON, Yoel RAK (1994): The first skull and other new discoveries of Australopithecus afarensis at Hadar, Ethiopia. Nature, **368**, pp. 449-451

KIMURA, Doreen (1992): Female and male brain. Spektrum der Wissenschaft 11/1992

KIRSCHMANN, Eduard (1999): The throwing hypothesis and a new model of hominid evolution. HOMO Vol. **50**/1, pp. 80-85

KNECHT, Heidi (1994): Hunting spears of the later Paleolithic. Spektrum der Wissenschaft 3/1994

KUMMER, Hans (1992): White Monkeys on the Red Sea. The Social Life of the Desert Baboons. Piper Verlag, Munich

LEAKEY, Meave and Alan WALKER (1997): Early Hominids. Spektrum der Wissenschaft 8/1997

LEVAY, Simon and Dean H. HAMER (1994): Homosexuality: Biological Factors. Spektrum der Wissenschaft 7/1994

LEWIN, Roger (1992): Traces of Becoming Human: The Evolution of *Homo sapiens*. Spektrum Akademischer Verlag, Heidelberg

LEWIN, Roger (1995 a): The Origins of Humans. 200,000 Years of Evolution. Spektrum Akademischer Verlag, Heidelberg

LEWIN, Roger (1995 b): Birth of a tool-maker. New Scientist, 3/11/1995

LEWIN, Roger (1998): The Molecular Clock of Evolution: Genes and Family Trees. Spektrum Akademischer Verlag, Heidelberg

LOVEJOY, Owen (1981): The origin of man. Science **211**: 341-350

LOVEJOY, Owen (1981): The Evolution of the Upright Gait. Spektrum der Wissenschaft 1/1989

MARGULIS, Lynn and Dorion SAGAN (1991): Secret and Ritual: The Evolution of Human Sexuality. Byblos-Verlag, Berlin

MARTIN, Robert D. (1995): Brain size and human evolution. Spektrum der Wissenschaft 9/1995

MARZKE, M. W. (1983): Joint function and grips of the *Australopithecus afarensis* hand, with special reference to the region of the capitate. Journal of Human Evolution **12**, pp. 197-211

MEIER, Heinrich (ed.) (1988): The Challenge of Evolutionary Biology. Piper Verlag, Munich

MIYAMOTO Michael M., Jerry L. SLIGHTOM, Morris GOODMAN (1987): Phylogenetic relations of humans and African apes from DNA sequences in the Ψή-globulin region. Science **238**, pp. 369-373

Morin Phillip A., James J. **Moore**, Ranajit **Chakraborty**, Li **Jin**, Jane **Goodall**, David S. **Woodruff** (1994): Kin Selection, Social Structure, Gene Flow, and the Evolution of Chimpanzees. Science **265**, pp. 1193-1200

MORRIS, Desmond (1986): Bodywatching. A Field Guide to the Human Species. Heyne Verlag, Munich

MORRIS, Desmond (1994): The Human Animal. vgh Verlagsgesellschaft, Cologne

MÜLLER, Gerd B. (1994): Evolutionary Developmental Biology: Foundations of a New Synthesis. In: The Evolution of Evolutionary Theory: From Darwin to DNA. ed. Wolfgang Wieser, Spektrum Akademischer Verlag, Heidelberg

RIDLEY, Matt (1995): Eros and Evolution: The Natural History of Sexuality. Droemer Knaurs Verlag, Munich

ROCK, Irvin (1985): Perception: From the Visual Stimulus to Sight and Recognition. Spektrum Akademischer Verlag, Heidelberg

RODMAN, P. S. and H. M. MCHENRY (1980): Bioenergetics of Hominid Bipedalism. In: American Journal of Physical Anthropology **52**, pp. 103-106

ROTH, Gerhard (1994): Brain and Mind. In: Schiefenhövel et al. (eds.): From Monkeys to Demigods: The Path of Humans out of Nature. TRIAS Thieme Hippokrates Enke, Stuttgart

ROTH, Gerhard (1996): The Human Brain. In: Roth/Prinz (eds.): Head-Work: Brain Functions and Cognitive Achievements. Spektrum Akademischer Verlag, Heidelberg

SAVAGE-RUMBAUGH, Sue and Roger LEWIN (1995): Kanzi the Speaking Chimpanzee: What Differentiates the Animal from the Human Intellect. Droemersche Verlagsanstalt, Munich

SCHRENK, Friedemann (1997): The Dawn of Humans: The Way to Homo sapiens. Beck, Munich

SOMMER, Volker (1993): Praise of the Lie. Deception and Self-Deception in Animals and Humans. Beck-Verlag, Munich

SPOOR, Fred, Bernard WOOD, Frans ZONNEFELD (1994): Implications of early hominid labyrinthine morphology for evolution of human bipedal locomotion. Nature **369**, pp. 645-648

SPRINGER, Sally P. and Georg DEUTSCH (1995): Left-Right Brain. Spektrum Akademischer Verlag, Heidelberg

STANLEY, S. M. (1992): An ecological theory for the origin of Homo. Paleobiology **18**, pp. 237-257

STEITZ, Erich (1993): Human Evolution. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart

STRINGER, Chris and Robin MCKIE (1996): Africa – Cradle of Humanity: The Origin, Development, and Expansion of *Homo sapiens*. Limes Verlag, Munich

SWISHER III, C. C., G. H. CURTIS, T. JACOB, A. G. GETTY, A. SUPRIJO, WIDIASMORO (1994): Age of the Earliest Known Hominids in Java, Indonesia. Science **263**, pp. 1118-1121

TANNER, Nancy M. (1997): The Part of the Woman in the Origin of Humans. Deutscher Taschenbuch Verlag

TATTERSALL, Ian (1987): The Puzzle of Becoming Human: On the Track of Human Evolution. Spektrum Akademischer Verlag, Heidelberg

TITTEL, Kurt (1994): Descriptive Functional Anatomy of Humans. Gustav Fischer Verlag, Jena

TOTH, Nicholas (1987): The first stone tools. Spektrum der Wissenschaft 6/1987

TRINKAUS, Erik and Pat SHIPMAN (1993): The Neandertals. Mirror of Humanity. Bertelsmann Verlag, Munich

VOLAND, Eckart (1993): Outline of Sociobiology. Gustav Fischer Verlag, Stuttgart, Jena

WANPO, Huang, R. **Ciochon**, G. **Yumin**, R. **Larick**, F. **Qiren**, H. **Schwarcz**, C. **Yonge**, J. de **Vos**, W. **Rink** (1995): Early *Homo* and associated artefacts from Asia. Nature **378**, pp. 275-278

WILSON, Edward O. (1975): Sociobiology: The New Synthesis. Cambridge Mass., Harvard University Press

WILSON, Edward O. (1980): Biology as Fate: The Sociobiological Foundations of Human Behavior. Ullstein

WUKETITS, Franz M. (1997): Sociobiology: The Power of Genes and the Evolution of Social Behavior. Spektrum Akademischer Verlag, Heidelberg

WULF, Gabrielle (1998): Conscious control disturbs the learning of movement. Spektrum der Wissenschaft 4/1998

ZEKI, Semir M. (1992): The mental representation of the world. Spektrum der Wissenschaft 11/1992