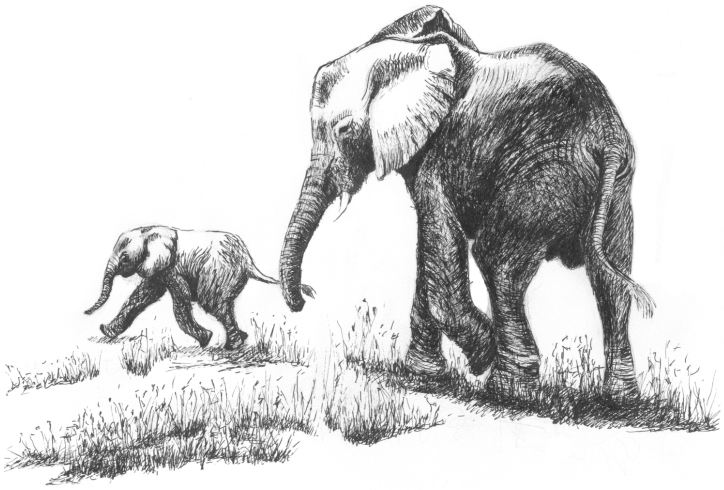
The Flexible Giant

Seeing the Elephant Whole



Craig Holdrege

Nature Institute
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The Flexible Giant

Seeing the Elephant Whole

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The Nature Institute
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1. Introduction: Portraying the Elephant

EACH CREATURE ON EARTH has its own unique character—the fluttering butterfly, the coiled rattlesnake, the sprinting cheetah, and, yes, the flexible giant, the elephant. Most of us are naturally attracted to the elephant—its magical trunk extending from the gigantic gray body, its big flapping ears and its loud trumpeting. The more we learn about its features, the more we stand in awe before this remarkable creature.

I have studied the skeletal morphology of the elephant and observed firsthand captive and, most recently in Africa, wild elephants. I have also drawn extensively on the work of other individuals (see bibliography). Especially over the last thirty years a wealth of knowledge about the behavior of elephants in the wild has arisen through the careful multiyear studies of researchers like Cynthia Moss, who has observed elephants for decades in the Amboseli National Park in Kenya. Without the painstaking efforts of the community of elephant researchers, it would have been impossible to present a living picture of elephant life.

My study of the elephant is guided by the desire to bring its unique characteristics to clearer expression. When the elephant captures our interest, we are experiencing it as a powerful unity. But it is one thing to feel this power and another to comprehend it clearly. That is what I have been attempting in my research.

When I ask students or participants in workshops what makes the elephant stand out—what makes it unique—a list comes together quickly:

- long, flexible trunk
- pillar-like legs
- big ears
- long tusks
- grey, almost hairless, but wrinkly skin
- roundish, softly treading feet
- loud trumpeting
- comparatively small eyes
- high intelligence
- complex social behavior

We can gain deeper and richer knowledge of the elephant by studying these characteristics in more detail, but in the process we run the constant danger of losing sight of the elephant in all its features. We may find ourselves on a path of endless analysis that leads us further and further away from the unity of the elephant itself.

The desire to see the unity of the elephant more clearly is not fulfilled by an encyclopedic compendium of facts about the elephant. The elephant is not its anatomy, nor its physiology, nor its ecology, nor its behavior; and it is not the sum of them all. The whole is not gained by piecing together parts. It is,

rather, the unity of the organism that expresses itself in each one of these facets of its being.

To keep analysis from taking on a life of its own, we can, while gaining knowledge of detail, continually return to the question, Who are you, elephant? The idea of the coherent organism, framed as a question, becomes the guiding light of inquiry. The challenge is to articulate this unity—to make it visible to our understanding. To do this demands a particular kind of attention and inner activity. First, when I have come to a certain grasp of some area of detail, instead of just progressing further in analysis I make myself—which is not easy—step back and ask, "How does this relate to the whole?" I may not yet have an answer, but by trying to place every detail into the larger context, I make sure I am not losing sight of the animal in all its parts.

Second, I try to withstand "explaining," by which I mean, in this context, finding a surmised single cause of the phenomenon I'm looking at. For example, I can look at the fact that elephants have very long straight legs. I may be tempted to "explain" this fact by saying it is an efficient construction that enables such a large animal to bear its weight with minimal muscular exertion. In Darwinian terms, this characteristic gives the elephant greater survival chances. But since I also know that the weighty hippopotamus has short angular legs, and survives in its way just fine, the "explanation" loses its compelling force. And this happens with virtually every single-cause explanation I have encountered. They just don't work. As far as I can tell, every biological fact has multiple relations that illuminate its function or form. Since monocausal explanations are usually false and tend to fix the mind in narrow pathways, I don't look for such explanations. When I find authors using them, I discard the explanation and let the phenomena stand on their own.

So with the iron will to always return to the whole and the discipline to hold back from short-cut explanations, I keep the path to the unity of the organism open. But to grasp this unity a third kind of activity is necessary. When I am studying a given phenomenon or reading what others have discovered, I make as vivid a mental picture as possible. I picture the exact form of the limb bones and how they articulate; I picture how the elephant feeds; I picture the formation of the teeth. Or when I have experienced a young bull making a mock attack, and am later writing down my observations, I make sure I build up anew a vivid picture of what I have seen. By utilizing imagination and staying as close to the phenomena as possible, I try to create an exact picture. The goal is to achieve saturated inner images of the elephant's characteristics.

The remarkable thing is that when one builds these exact pictures over and over, moving from one characteristic to the next, patterns emerge. You begin to recognize how the characteristics form a whole—the unity begins to reveal itself. When you go back to characteristics you have studied before, they may suddenly express the unity you have discovered through another part. For example, over time I have begun to see that the elephant not only has a flexible trunk, but that flexibility is part of its whole being—flexibility in feeding behavior, flexibility in social interactions, flexibility in learning overall, and even flexibility rooted in the anatomy of its immense feet. Characteristics such as the long phase of growth, the long period of social maturation, the virtually lifelong change of teeth, and the lifelong learning capacity no longer appear as separate traits, but as expressions of a unitary being. When I have begun to grasp the elephant in this way as an interconnected whole, I can then set about describing and characteriz-

ing it. My goal is, in Goethe's words, to "portray, rather than explain" (Goethe, 1995, p. 57).

For this reason this essay is not composed like typical biological descriptions of animals, which depict the different anatomical and physiological systems of the body (skeleton, muscles, digestion, circulation, reproduction, etc.), followed, say, by a consideration of ecology and behavior. Instead, it is arranged according to themes, sometimes taking a particular part of the body or function as the starting point, through which I try, from a somewhat different perspective in each section, to capture something of the elephant's unique character. It's a bit like hiking through a landscape and getting to know it from different vantage points. Every perspective takes in the whole, but does so by highlighting different aspects of it. In this way our own understanding is deepened. Through this activity—if it is successful—we can build up a picture of the elephant that expresses the unity of its different features.

Recognizing how every part of an animal manifests an underlying unity is an exhilarating experience. What seemed separate comes together and we sense that we are seeing the elephant truly for the first time. We have a nascent answer to the question, Who are you, elephant? Making even the smallest steps in this direction opens up a wholly new appreciation and understanding of the animal.

On this path of discovery, the wisdom of nature becomes more tangible. In getting to know this wisdom, our feeling of responsibility toward our fellow creatures on earth grows. We come to know ourselves as part of a world that is much greater than us. And when we learn from this world—when we glean something of its inner workings—we can also learn to care for it.

2. The Trunk and Flexibility

It is hard to imagine an organ more flexible than the elephant's trunk. The trunk sweeps to and fro along the ground and then stretches high into the air. It curves up and back, making undulating movements while spraying sand or water over the body. Bending around full-circle, it brings food or water to the inconspicuous mouth at its base. When two elephants meet, they often intertwine their trunks with beautiful spiraling movements.

No bone or cartilage hinders this fluid motion. The trunk is muscle through and through. Anatomically, the trunk is the elephant's extremely elongated upper lip and nose. As a nose it contains two nostrils, air passages that extend up into the head and are separated by a wall (septum). While in other mammals this septum consists of cartilage, giving the nose rigidity, the septum in the elephant is muscular, becoming cartilage only at the base where it is rooted in the skull. The trunk can bend and stretch in all directions. The body of the trunk consists of a complex fabric of lengthwise, crosswise, radial, and diagonally spiraling layers of muscle. These layers are in turn differentiated into countless subunits (fascicles) that allow such fine and smooth muscular coordination (Shoshani, 1997).

The tip of the trunk is especially dexterous, the elephant using it as we do our fingers for the sensitive exploration of objects, and also to pick up and manipulate them. (The African elephant has a two-tipped trunk, while the Asian elephant's trunk has one tip.) Elephant researcher Joyce Poole observes,

> In studying the behavior of elephants, I have found watching the tip of the trunk to be highly informative. The tip of an elephant's trunk is almost never stationary,

> moving in whatever direction the elephant finds interesting. An elephant's attention usually is stimulated by what other elephants are doing, and by observing the trunk tip I often have been alerted to subtle behavior that is taking place in the group that I might otherwise have missed. (Poole, 1996, p. 138)

The physical flexibility of the trunk finds its functional expression in an astounding repertoire: picking, grabbing, enwrapping, reaching, lifting, and pulling—all while gathering food and putting it in the mouth; sucking in and spraying water into the mouth to drink; smelling with probing, searching motions; breathing, including use as a snorkel in water;

Figure 1. A group of young male African elephants drinking in the Zambezi River (border of Zimbabwe and Zambia). (Photo C. Holdrege)

spraying mud, or sand onto the skin (or onto other elephants in play); caressing, slapping, nudging, lifting, shoving, or trumpeting in social interaction.

Since it can carry out so many functions with one organ, the elephant can at any given moment shift rapidly from one activity to an entirely different one. It drinks, then sprays, then trumpets, then rubs and sniffs, and then pulls down a branch and feeds. This remarkable functional diversity is an expression of the elephant's behavioral plasticity—it doesn't get stuck in its ways. The trunk embodies physical, functional, and behavioral flexibility.

Therefore, it is not surprising that young elephants must learn to use their trunks. As elephant researcher Cynthia Moss describes:

> A calf will frequently try to grasp with and manoeuvre its trunk, even a very young one like Ely whose trunk resembled a wobbly, out of control rubber hose. He spent a lot of time wiggling the trunk up and down and around in circles, or sticking it in his mouth and sucking on it. Now the two "fingers" on the tip of the trunk pulled and pushed the stick, until he finally managed to pick it up. He waved it aloft like a baton and, having accomplished that feat, dropped it and wandered away. (Moss and Colbeck, 1992, p. 90)

When observing a larger group of elephants it is easy to pick out a young calf, not only because of its size. Its trunk seems to flail about and the end appears limp—it lacks the muscular control and dexterity so evident in the trunk of older animals. The trunk is clearly a tool to be mastered. But just as it never becomes physically rigid, so is the elephant always able to learn new tasks with its trunk.

3. Variety and Versatility in Food and Habitat

> In addition to their staple foods—grasses, bamboos, legumes and the bark of selected plants—elephants have an amazing variety in their menu. Climbers, creepers, palms and succulents are eaten. The leaves of various fig trees are much sought after. Fruits of the tamarind, the wood apple [and] the wild mango are seasonal delicacies…. No other land animal is able to exploit such a wide range of plant resources. This is made possible by that unique organ, the trunk, whose finger at the tip can delicately pick up a tiny object and whose reach extends to a fig tree five meters high. (Sukumar, 1995, p. 52)

While the trunk is certainly essential to the elephant's ability to access such a variety of food, the versatility it exhibits is in fact inherent in the whole animal. The elephant's great height—increased by the trunk—gives it the ability to reach into trees. It can expand this already large feeding zone even more by shaking a tree, which makes the fruits drop off, or by pushing over a whole tree to get at fruits, leaves, and bark. Here its bulk and strength come into play. The elephant breaks branches with its feet and tears bark off of trees with its tusks. The mobile lips and tongue are also essential for the deft way it is able to manipulate its food:

> The sheaf of grass is placed crosswise in the mouth, with the basal root part projecting from the lips on one side and the tips of the blades on the other, then the

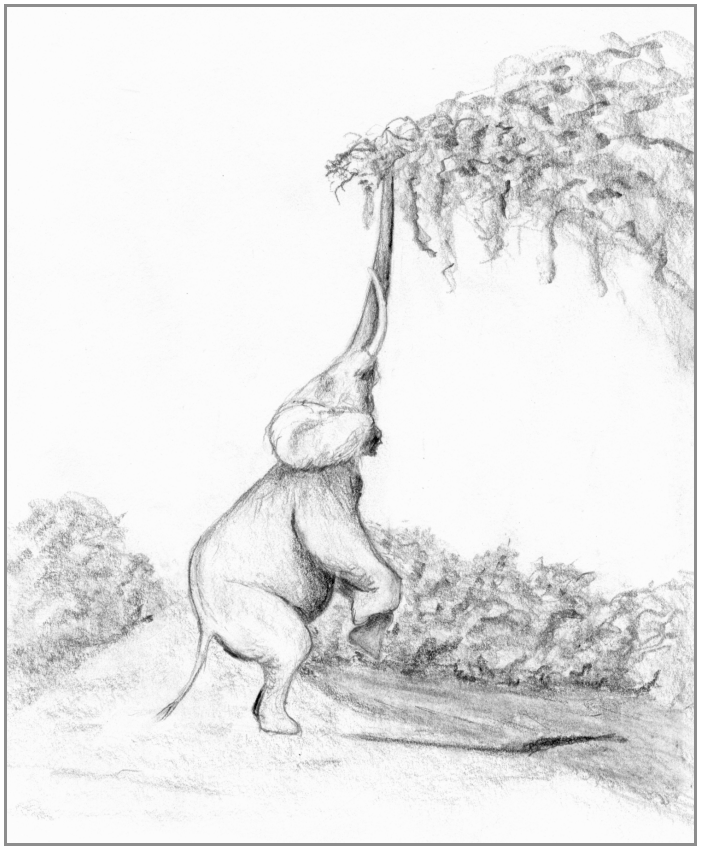


Figure 2. An African elephant standing on its hind legs to reach fruits in a tree. (Drawing by C. Holdrege after a photo in Sikes, 1971)

projecting parts of the sheaf are bitten through and allowed to fall to the ground, and the rest is masticated and swallowed. When the grass is tender, the blades are consumed and … the rejected parts of sheaves consist largely of the basal stalks and roots; when the blades are mature and hard, but basal culms are succulent, the apical part of the sheaf is rejected and the culms (with

> only the roots bitten off) consumed. The placing of the sheaf in the mouth, and the consumption of a part of it, is a selective action and not purely mechanical. (Krishnan in Daniel, 1998, p. 75)

We see not only how the elephant seeks out different kinds of food but how once the food is in its mouth, it can sense the food's quality and select what it desires. The food is ground between its massive molars, the jaws moving to and fro in rhythmical action. That the elephant can not only access a large variety of food from ground to tree canopy, but also digest this variety, shows that it has, compared to most herbivores, an unspecialized digestive system. The stomach and intestines are not specialized to digest primarily hard grasses, soft leaves of broadleaf trees and shrubs, mineral- and fiber-rich bark, fruits, or flowers. It can digest all of these, depending on their availability. Given the possibility, the elephant chooses variety.

In his well-known experiments with a captive Asian elephant, Benedict found that the elephant digested only about 44 percent of its food, in contrast to 70 percent in the cow (Benedict and Lee, 1938). More recent observations on two African elephants suggest that the elephant may only digest as little as 22 percent of the food it takes in (Rees, 1982). Food passes through the elephant quickly, staying in the body only for 20 to 46 hours in contrast to six days in the cow. These observations suggest—not forgetting the small sample and the question of the relevance to conditions in the wild—that although the elephant takes in large quantities of food, it does not put as much physiological activity into digesting the food as does a ruminant like the cow with its four-chambered stomach.

The elephant's ability and tendency to feed on a variety of food is mirrored in its capacity to thrive in a variety of habitats: tropical rain and montane forests, all types of savannas, which are a varied mosaic of trees and grassland, and even the desert. This is another sign of its versatility.

Rain-forest elephants, which have ample food throughout the year, have small home ranges, while the elephants in the Namibian desert have huge home ranges and can cover between 25 and 70 kilometers per day. In the African savanna or the Asian monsoon climates, the food an elephant eats, and therefore the degree to which it moves around, depends on the time of year. Cynthia Moss writes:

> One of the things to emerge was the intriguing ability of elephants to change their behavior under various ecological conditions. The second thing to draw my attention was an overall change in migratory patterns of the elephants in the previous five years. (Moss, 1988, p. 210)

This behavioral flexibility is related to the elephant's ability to find food even when it is scarce. In a year when rainfall had been very low and food resources scant, Moss observed how

> the elephants spread themselves throughout the park and surrounding areas, with each family returning to its clan's dry-season home range and tending to move on its own. During the severe drought months of 1976 even some of the family units broke down, with a single female and one or two of her offspring forming a subunit. (Moss, 1988, p. 217)

Elephant ecologist Philip Viljoen writes that

> during a recent five-year drought period more than 80 percent of the other 'desert' mammals like gemsbok and springbok died. As far as could be ascertained, not one of the desert-dwelling elephants died during this period. (in Shoshani, 1992, p. 132)

These examples illustrate the elephant's resilience, its ability to change with changing conditions.

Not only the elephant's use of the pliant and strong organ of the trunk, but also the way it applies its massive body and tusks, as well as its dexterous lips and tongue, reveal its flexible and unspecialized nature. In feeding, the elephant thrives on variety and at the same time can respond to inadequate or imbalanced food supplies by finding new sources of food and different areas to feed in, and by adjusting its social behavior. In its anatomy, physiology, and ecology, the elephant is a flexible creature.

4. Lifelong Change and Social Interactions

Elephants live remarkably long lives, up to about sixty-five years in the wild. This long life includes an equally untypical long period of growth and development. Most large mammals enter sexual maturity when they are a few years old and stop growing soon thereafter. Not the elephant.

Females enter puberty and begin mating at around twelve years of age. The gestation period is long, about twenty-two months, so that a female becomes a mother of a single calf at fourteen. (Occasionally twins are born.) She gives birth every four to eight years or so until she is in her fifties. Since the oldest

females are the largest, they evidently continue to grow throughout life, although growth after twenty-five years is imperceptibly slow. Such lifelong body growth is not typical in mammals.

In males, adolescence is long and drawn out. They start producing sperm at around fourteen years. At this time the two temporal glands, located between the eye and ear on each side of the head, begin to periodically secrete a fluid that smells like honey and even has some chemical resemblance to it (Rasmussen et al., 2002). These pubescent males don't begin mounting until a few years later and even then they usually back off when older males appear. Males go through a secondary growth spurt after puberty, so that a nineteen-year-old male will be larger than an adult female.

In his early twenties, a male finally becomes sexually active and, except during mating, associates only with other males. Full maturity in males is marked by the onset of musth between twenty-five and thirty years of age. "Musth" is the term used to describe the periods of heightened sexual activity and aggression in the adult male's life. During musth, foul-smelling fluids stream from the temporal gland, a stark contrast to the sweet-smelling secretions of younger years. These secretions are not only an expression of a physiological state, but are also important in social interactions. When young males smell an older male in musth, they tend to recede and avoid getting too close to him. Older males have regular musth cycles and most probably remain sexually active until death. Males continue to grow, if ever slower, throughout their lives.

The extended period of physical development is one facet of an overall pattern of lifelong change that is also expressed in the rich and changing social relations an elephant experiences in the course of its life. This is especially true of females, who live in extended family groups their whole lives and are scarcely

Figure 3. Mixed age group of African elephants at a watering hole; Chobe River, Botswana. (Photo C. Holdrege)

alone for a single minute of the day. In contrast, males become independent of family groups and tend to be more solitary the older they get.

A family group consists of grandmothers, mothers, sons and daughters, aunts, cousins, and nieces and nephews. A family group interacts periodically with other family groups, such meetings varying on a daily and seasonal basis. In this way an elephant is embedded in a relatively stable, but slowly changing familial environment woven into a larger context.

With each stage of maturation an elephant's life changes. Young elephants always remain in close physical proximity to their mothers and can often be seen standing under the mother's body, between her legs. Often, just before the mother gives birth to a new calf, her behavior changes and she weans her four-year-old. While the connection to its mother remains preeminent, the weaned calf spends increasing amounts of time playing with other calves.

Young females seem to have an irresistible urge to be around, play with, and care for infants. Eight-year-old females will often be seen near their own or another mother, interacting with their younger siblings or cousins. With puberty, mating, and pregnancy, the female's life changes radically, but she is not suddenly an adult. As Cynthia Moss observed, a young, first-time mother appeared "upset and apparently confused about what to do" when her baby was born, while an older mother, who had given birth several times, appeared "relaxed and competent from the moment the baby was born" (Moss, 1988, p. 152). The young mother receives help from other adult females, and sisters and nieces will begin looking after her calf, as she had done a few years previously.

Her calf grows and she will give birth again and again. All this time the female elephant matures behaviorally, her position within the family group gradually shifting. New interactions arise as her daughters give birth and her care extends to her grandchildren. At some point her mother will die and she, or perhaps an older sister or cousin, will become the family matriarch.

Each family group has one such dominant female, who is usually between forty and sixty years old. While continuing to gain experience, the matriarch still retains the flexibility to revert, when needed, to previous forms of behavior. So if one of her daughters or nieces dies, she once again becomes the protecting, care-giving mother. When a group led by an older matriarch comes into contact with other family groups, it discriminates clearly between little-known and better-known groups (indicated by bunching and smelling behavior; see McComb et al., 2001). In contrast, a group led by a younger matriarch does not make such distinctions between groups. Is this an elephantine version of the wisdom of old age?

Recent observations concerning "rogue" African elephant bulls show in a vivid way how essential interaction is between elephants of different age groups. Between 1992 and 1997 young elephant bulls in musth killed more than forty white rhinoceros in a South African national park (Slotow et al., 2000). These bulls were orphans that had been introduced into the park. They were survivors of elephant kills ("culling operations") to reduce the numbers of elephants in another national park. The young males were less than ten years old when they were introduced into the park. At this stage of development they would normally still be part of a family group and then, when older, would be associated with other younger, but also older bulls. All this contact was missing, and precisely these bulls carried out the abnormal rhinoceros killings.

These young males had musth periods that lasted much longer than normal, which is one sign of their overt aggressiveness. Park officials then introduced six older bulls into the park. The musth periods of the orphaned males—who had had no contact with older males up to that point—shortened significantly. The rhinoceros killings ceased. This remarkable change shows the power of inter-elephant contact. It is astounding that the physiological changes correlated with musth can be altered by the presence of another, older male. The younger males displayed abnormal behavior due to the lack of contact with family group and older bulls, but this behavior could also be transformed when contact was normalized. The young bulls—they were now around twenty years old—remained impressionable.

The elephant's long life is marked by lifelong change, physically and behaviorally. This means that an elephant also remains behaviorally flexible throughout its life. In mammals generally, behavioral plasticity is most pronounced in childhood, before

Figure 4. Young bull, with ears spread, makes a mock attack after having loudly snapped off a tree branch; African elephant, Moremi Wildlife Reserve, Botswana. (Photo C. Holdrege)

sexual maturity and the cessation of bodily growth. After sexual maturity, behavior becomes more rigid, which is why animal trainers work with very young animals, when their behavior is still open to outer influences.

One would expect that with their slow maturation, elephants would retain a more open and flexible learning capacity for a

longer period of time. And this is the case. In Asia, for example, it was a widespread practice *not* to train work elephants at too young an age. The elephants (of both sexes) were allowed their extended childhood and only *after* puberty did training slowly proceed (Williams, 1950). Only at about the age of twenty has the Asian elephant matured enough to become a full-working animal. It is also possible to capture adult elephants and train them, something one never does with other large mammals.

We associate playful behavior primarily with the behavior of young mammals, but, as Krishnan writes:

> Elephants are among the few animals that play even as adults. When bathing in company in a forest pool, it is not only the juveniles that revel in play: even the adults bump into, push down, and roll over one another with abandon—perhaps they find the sudden lifting of their ponderous weight off their feet by the water exhilarating. On land too, adult bulls may indulge in a long bout of play with their trunks, not in a tug-of-war so much as a pushing match, or in chasing one another. (Quoted in Daniel, 1998, p. 73)

In the context of lifelong flexibility we must not forget the trunk. As we have seen, the trunk is an unspecialized organ that allows the elephant to explore and interact with its environment in the most adaptable and diverse ways. Putting it simply, having a trunk, the elephant can't stop being flexible, even after sexual maturity. The elephant's overall openness and adaptability in behavior throughout the course of its long life expresses itself at any given moment in the activity of the trunk. The trunk, like the human hand, makes visible what open, explorative learning behavior is all about.

5. Teeth Reveal the Whole

Being the hardest, most crystalline part of the animal body, teeth are not only well-defined structures, but their size, shape, number, and position are characteristic for each species of mammal. If you ask zoologists or paleontologists what small part of the body they would like to have in order to identify an animal, it would be a tooth.

By all accounts, elephants have strange teeth. Let's begin with the tusks, which are modified teeth. All elephants are born with small deciduous ("milk") tusks that fall out after approximately one year. The permanent tusks then erupt. The tusks are deeply

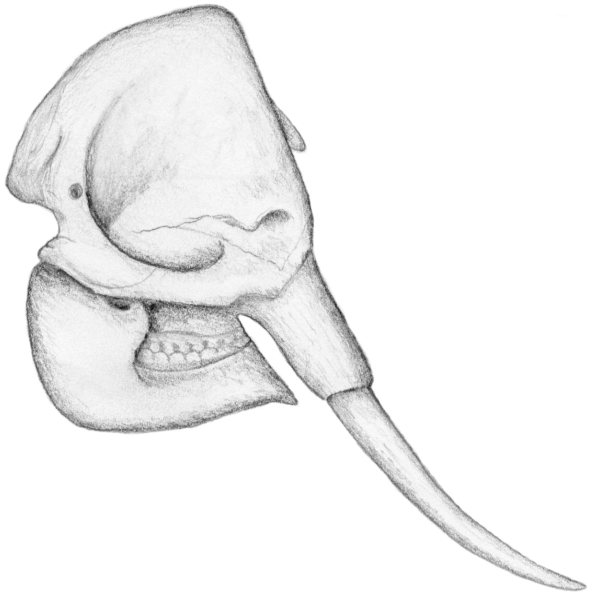


Figure 5. Skull of an adult female African elephant. (Drawing by C. Holdrege)

rooted in the upper jaw, with about one-third of the tooth being hidden in the jawbone (see Figure 12, p. 35). This part of the tusk has an inner pulp cavity from which growth originates.

Tusks grow throughout the elephant's life, becoming longer, thicker at the base, and ever more deeply rooted in the upper jaw. (Outward growth is balanced by inward anchoring.) Old African elephant bulls have the largest tusks, which can be over ten feet long, weighing more than two hundred pounds. Only in the female Asian elephant do the tusks remain, as a rule, small.

In general, the tusks grow downward and then curve upward. An individual elephant can often be identified by the unique curvature of its tusks. The tusks are used to dig, carry, and cut through tree bark. They are also wielded as gouging weapons. An elephant often employs one tusk more than the other, and this tusk then grows thicker and heavier, while the tip becomes more blunted (Sikes, 1971, p. 82). This extra growth is evidently induced by the stresses and strains met in using this "appendage."

As the tusks grow, so does the skull. It becomes higher and wider. The neck muscles holding the ever weightier head continue to enlarge, as do the spines of the thoracic vertebrae, to which these muscles attach. This increased weight is, in turn, supported by the growing leg muscles and thickening leg bones. From this we can see how the growth of a single feature is related to the whole body. The lifelong growth of the body that was described in the previous section now shows its concrete relation to the growth of the tusks.[1] But this is not all.

1. Tuskless elephants exist. One author comments that tuskless males "seem to make up in size of body and trunk for the lack of tusks and are generally enormously powerful elephants" (Evans, quoted in Daniel, 1998, p. 61).

Because of their position in the front of the upper jaw (in the premaxillary bones), the tusks are considered to be incisors, although they have the conical form of canine teeth. The elephant has no lower incisors and no canine teeth at all. The remaining teeth are the molars in the rear of the jaw. Just as the elephant's incisors are atypical for mammals, so are its molars.

When an elephant is born, it has two to three molars in each lower and upper jaw half. In the course of time these teeth wear and move forward in the jaw. The roots then begin to be reabsorbed and pieces of the teeth break off. As one molar is being lost in the front, a new one begins to erupt from the back of the jaw. Each new molar that comes in is larger than its predecessor (see Figures 6 and 7).

This means that the jaws also grow, mirroring the continuous growth of the tusks and with them influencing the growth and transformation of the rest of the head and body.

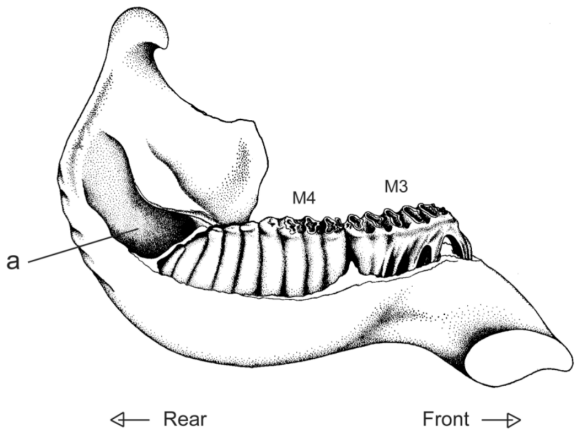


Figure 6. Left half of lower jaw (mandible) of the African elephant; medial view. The third molar (M3), partially broken off and strongly worn, is being replaced by the fourth molar (M4). Behind M4 is the space (a) in which the fifth molar was developing. (From Hanks, 1979)

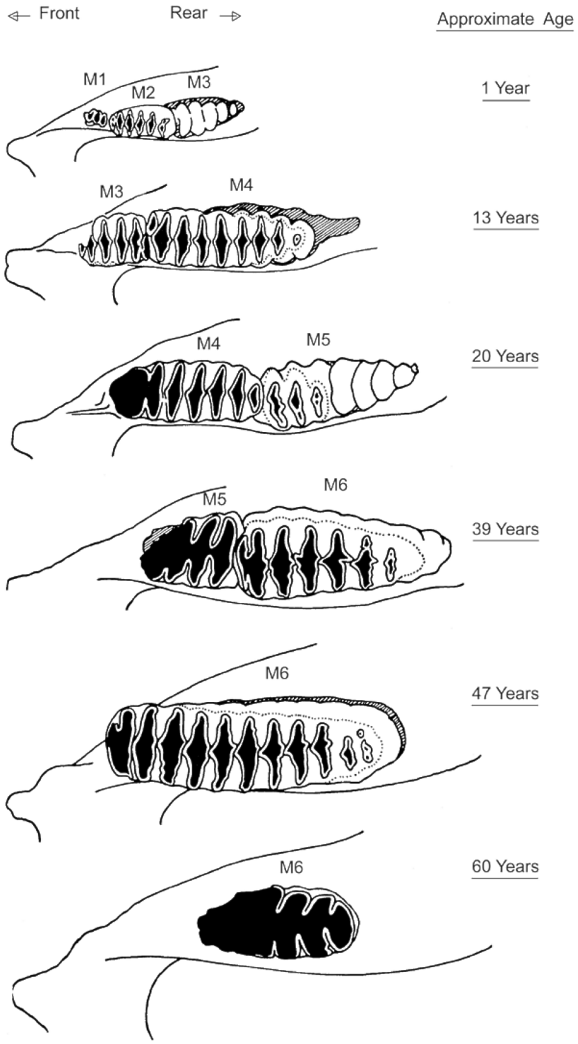


Figure 7. Tooth development in the elephant. This figure shows the right half of the lower jaw of the African elephant, viewed from above. Each of the six molars (M1 to M6) forms in the rear part of the jaw, gradually erupts and moves forward, wears due to usage, and then breaks off as it becomes fully worn at the front of the jaw. Note that the teeth become progressively larger. At approximately 60 years only part of the last molar still remains. (Modified after Laws, 1966)

During the course of the elephant's life, a total of six molars pass through each side of the upper and lower jaws. At any given time an elephant has parts of one or two molars (one coming in from the rear and one being worn down and breaking off at the front) in each half of the upper and lower jaws. Natural death in old age is connected to the wearing and loss of the sixth and last molar. When an elephant is between forty and fifty years old, the fifth molar is lost and the large sixth molar, which has been emerging over a decade, is the only tooth remaining in each half of the upper and lower jaws. Over the next fifteen to twenty years it wears to the gums. Old elephants can be observed eating soft swamp plants, since they can no longer grind harder plant fibers. Death will soon follow.

Other animals die due to tooth wear, but in the elephant this is the last phase of a lifelong process of new tooth production and ensuing wear. Most mammals go through a change of teeth in the first few years of their lives. The permanent teeth are in place not long after sexual maturity and remain there until death. The phase of tooth change is therefore concomitant with rapid body growth and intense learning. The completion in the change of teeth marks the end of an animal's youth.

From this perspective, an elephant's youth extends through most of its life, just what we have seen from other points of view (cf. Schad, 1977, pp. 248 ff.). The physiological processes involved in tooth formation—the ever growing tusks and the prolonged formation of new molars—continue into old age. What typically comes to rest in the head of a mammal at an early age stays in process in the elephant. Isn't this a "tooth-appropriate" expression of flexibility, of staying-in-flux?

So the elephant's singular dentition now appears as an integral feature of its overall character, as expressed in the qualities of sustained change, learning, and flexibility.

6. *Flexible Ideas*

In trying to understand an organism, ever-new perspectives open up as one contemplates its characteristics, moving from one to the next. In this way we have been able to see that such seemingly disparate features as learning and tooth development are connected.

But not all features of the elephant are adequately illuminated through the qualities of flexibility and constant change. In fact, there is a danger of letting the richness of such qualities die into abstract concepts under which we then subsume all other phenomena. As Goethe put it, the human tendency to take "pleasure in a thing only insofar as we have an idea of it" can become tyrannical as "thought forcibly strives to unite all external objects" (Goethe, 1995, p. 14). Ideas then become "lethal generalities" (ibid., p. 61).

We are never freed from this problem. But if we take it seriously, we will strive to form our ideas in the course of intense immersion in the concrete phenomena. These ideas then have a proximity to the phenomena that makes them vibrant. Discovering flexibility in the trunk and then in behavior is very different from having preconceived notions like "animals are machines" or "animals are survival strategies" that do *not* arise out of a consideration of the animal itself, but are brought in as presuppositions. These latter may be powerful explanatory constructs, but, since they are imposed from without, they always give a very limited and thereby skewed picture of the actual phenomena, especially when they are mistakenly understood as encompassing the *whole* animal.

Once we have gained an idea through a study, we can also illuminate new phenomena with it. The elephant's change of

teeth appeared in a wholly new light after we had seen how in other respects it remains an animal in transition throughout its life. By returning again and again to the phenomena with an interest to discover *new* features, we can temper the tendency to fall in love with an already formed idea and in our passion tyrannize the phenomena with it.

In this dynamic process, our approach to phenomena and concepts becomes fluid. The more we can make our ideas like the trunk of an elephant, enwrapping an object and thereby taking on its form and taking in its qualities, the more what we find will be the object and not our own predilections.

7. The Sensitive Giant

An adult African elephant bull can weigh over 10,000 pounds and needs to eat around 400 pounds of food per day. The legs must be strong and stable to carry such an enormous weight. In contrast to the legs of other weighty (graviportal) mammals like hippos and rhinos, the elephant's legs are long and straight (see Figure 8). They actually resemble a human leg more than that of other large four-legged mammals (see Figure 13, p. 44). The bones are embedded in thick layers of muscle, giving the legs their massive, rounded, columnar appearance.

The bones of the legs are themselves exceedingly heavy and have no marrow cavity—a long, tubular space normally running the length of the shaft of long bones in mammals. The larger a mammal, the greater is the portion of its total body weight made up by the skeleton. An elephant's skeleton makes up about 25 percent of its total body weight, whereas a lion's skeleton only makes up 13 percent of its total body weight (Flindt, 1986, p. 23).

The elephant's relation to weight comes into view more clearly when we discover that even a fast-moving elephant will have at least one foot on the ground at all times. It never runs, which involves all four feet being in the air simultaneously for at least a short time, although when moving at fullspeed (up to 25 km per hour), the hips and hind limbs make motions similar to those other quadrupeds make when they run (Hutchinson et al., 2003). The elephant also cannot jump.

Though in this sense bound to the ground, the elephant does not strike one as being overly encumbered by the weight it carries. The long, pillar-like legs appear as sturdy supports for the raised, voluminous body. Moreover, the way the elephant moves its bulk is special. In a detailed analysis of animal movement, Gambaryan (1974) describes "the smoothness of all movements" as one of the salient features of elephant locomotion. (He is not thinking of the trunk in this context, although it is the epitome of smooth motion.) The body makes almost no vertical movements in walking. The massive frame seems to glide almost weightlessly forward, since no weighty up-and-down thrusting accompanies its motion.

An elephant's feet rest on the ground on large, roundish-to-oval surfaces and at first sight appear only to confirm the impression of rounded massiveness that characterizes the whole body. But when the elephant moves, we can see how carefully it can place its feet and how the pliant soles roll around any uneven hard surface they tread upon. The elephant can also, despite its bulk, move very quietly. While camping out in a wildlife reserve in Botswana, I was awakened in the night by a solitary elephant loudly breaking off tree limbs. I could follow its movement because of the cracking branches, not because I heard *it*. The moment the branch breaking stopped, I heard nothing and lost track of its movement. The next morning I discovered tracks just

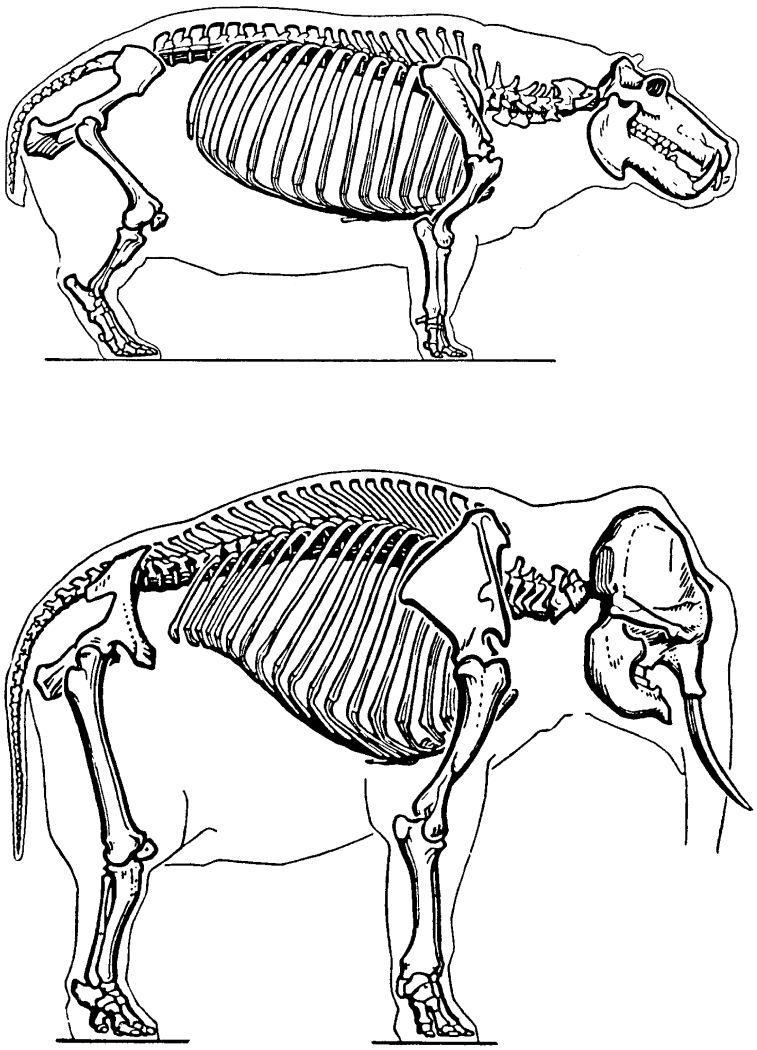


Figure 8. Skeletons of the hippopotamus and the Asian elephant (not to scale). (From Tank, 1984)

ten feet in front of the tent—the elephant had moved silently right in front of me and wandered off into another area.

This pliancy is related to the internal structure of the foot. Although one might not expect it, the elephant has five toes in the bony skeleton of its foot. The bones of the foot do not rest on the ground; instead, they are held at an angle and the tips of the toes carry the brunt of the animal's weight. Supporting the toes and foot is a cushion of fat embedded in elastic fibers (see Figure 9). In walking, this cushion continually changes shape, compressing and broadening when the foot bears weight, rebounding to a more columnar form when the foot leaves the ground.

As Sylvia Sikes points out, "It is the possession of this shock-absorbing, internal cushion, and self-adjusting sole, that enables this enormous animal to walk over rough terrain and be inaudible to human ears" (Sikes, 1971, p. 32). This cushioning action is not merely a passive effect, since muscles of the legs and feet modulate every movement. The feet, especially the forefeet, have many muscles that allow extension, flexion, and lateral movements of the toes, giving them an unexpected internal mobility. In addition, the bones of the lower leg—ulna

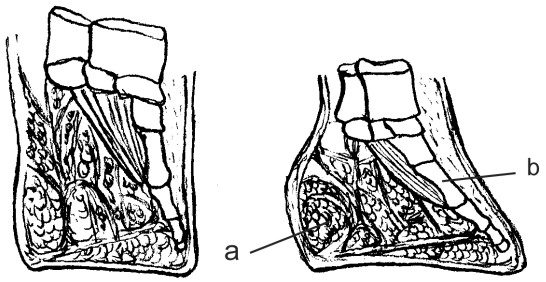


Figure 9. Diagram of the elephant's foot, longitudinal section. Left: foot lifted. Right: standing; when bearing the full weight of the body, the fat cushion compresses. a: fat cushion; b: toe bones. (Redrawn after Gambaryan, 1974)

and radius in the forelimb and tibia and fibula in the hind limb—are "well developed and distinct bones, thus allowing the feet to achieve considerable rotation without loss of supportive strength" (Kingdon, 1989, p. 32).

While most of the elephant's tactile exploration of the world occurs through its trunk, the feet are also used as tactile organs. Joyce Poole describes the outcome of throwing a rubber flip-flop sandal to a teenage male elephant as follows:

> He first stabbed it with the tip of his tusk and then used it to scratch the underside of his trunk…. Finally he put it in his mouth and chewed it gently, turning it round and round slowly with his large tongue. After several minutes of such examination he tossed the shoe up in the air behind him…. He reversed several steps and reached out to touch it gently with his hind foot. [He] touched it carefully from all angles with both hind feet. (Poole, 1996, p. 156)

This example illustrates beautifully how the elephant immerses itself in tactile experience, all the way from trunk and tongue to the soles of its immense feet.

This same elephant could, in the next moment, tear off a large branch with its trunk, then use both trunk and feet to position, step on, and break the branch, enabling it to tear of pieces of bark to eat. Both trunk and feet are strong, yet sensitive and agile. These contrasting abilities deeply impress everyone who observes elephant behavior. As Sylvia Sikes writes,

> The rapid alternation between movements of fastidious delicacy with which tiny berries and buds are selected

> and eaten, and movements requiring tremendous brawn that send gigantic trees crashing to the earth, is always astounding. (Sikes, 1971, p. 78)

8. The Head in the Context of the Whole

A standing elephant makes a self-contained and calm impression. There are no small, nervous movements. While the trunk may be moving back and forth and the ears flapping, the head is held high and still. In fact, the elephant can hardly sink or raise its head at all, being the only four-legged mammal that in standing cannot lower its head to the ground. The elephant's neck is very short so that the back of the head nearly touches the shoulders. Externally, head and torso meld into each other, giving the elephant a compact appearance.

In other long-legged mammals (antelope, zebra), a long neck facilitates the movement of the head to the ground for feeding. At the same time the skull lengthens, with the jaws working as appendages to gather food (see Figure 10). By contrast, in the elephant the neck is short, as is the skull, while the trunk lengthens as the organ used to gather food. This is a wonderful example of what is known in comparative morphology as compensation or the correlation of parts. One part of an animal doesn't just develop on its own; when one part changes the whole animal changes. The characteristics of an animal are finely interrelated.

The elephant has a remarkable head. Externally we notice this immediately in the unique appendage of the trunk, in the tusks, and in the large ears. With all these organs the elephant

extends out into the environment and, with trunk and ears, takes the environment into itself.

The elephant's overall gestalt is characterized by two primary qualities: the compact body and the columnar verticality of the limbs. In both, rounded forms dominate. When we

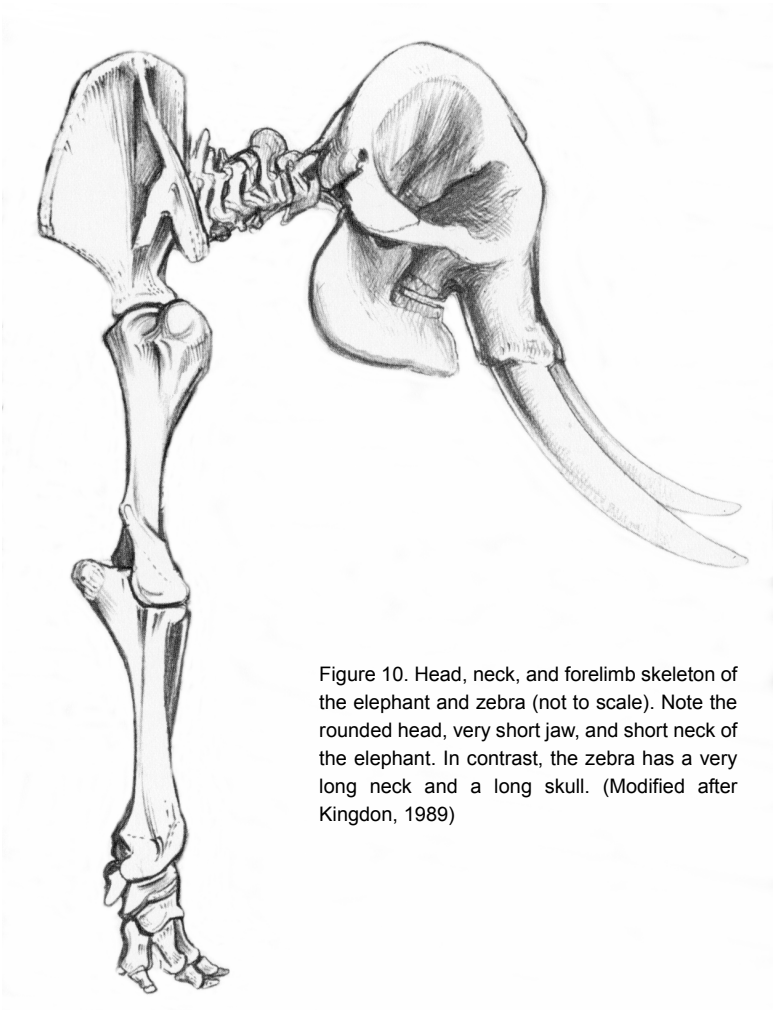
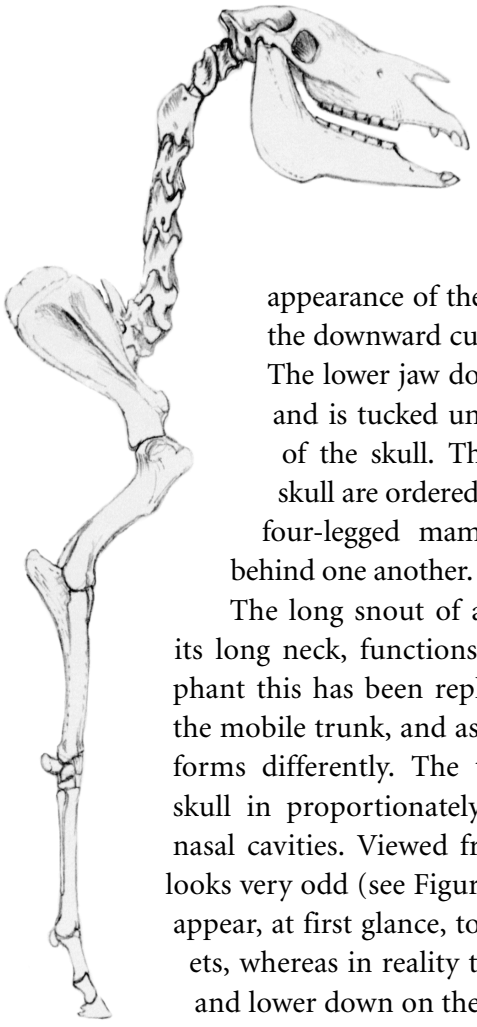


Figure 10. Head, neck, and forelimb skeleton of the elephant and zebra (not to scale). Note the rounded head, very short jaw, and short neck of the elephant. In contrast, the zebra has a very long neck and a long skull. (Modified after Kingdon, 1989)

look at the skull, we find these qualities again (see also figure 14, p. 45.)

While the skull of most four-legged mammals is long (front-to-back) and narrow (side-to-side), the elephant's skull is high (top-to-bottom) and short (front-to-back). It is much more compact and rounded, mirroring the overall bodily form. This self-contained appearance of the skull is pierced only by the downward curving and pointed tusks. The lower jaw does not protrude forward and is tucked under the high upper part of the skull. The parts of the elephant skull are ordered vertically, while in other four-legged mammals they are ordered behind one another.



The long snout of a zebra, extending from its long neck, functions as an arm. In the elephant this has been replaced, so to speak, with the mobile trunk, and as a result the whole skull forms differently. The trunk merges with the skull in proportionately very large and broad nasal cavities. Viewed from the front, the skull looks very odd (see Figure 11). The nasal cavities appear, at first glance, to be closely set eye sockets, whereas in reality the eye sockets are small and lower down on the sides of the skull.

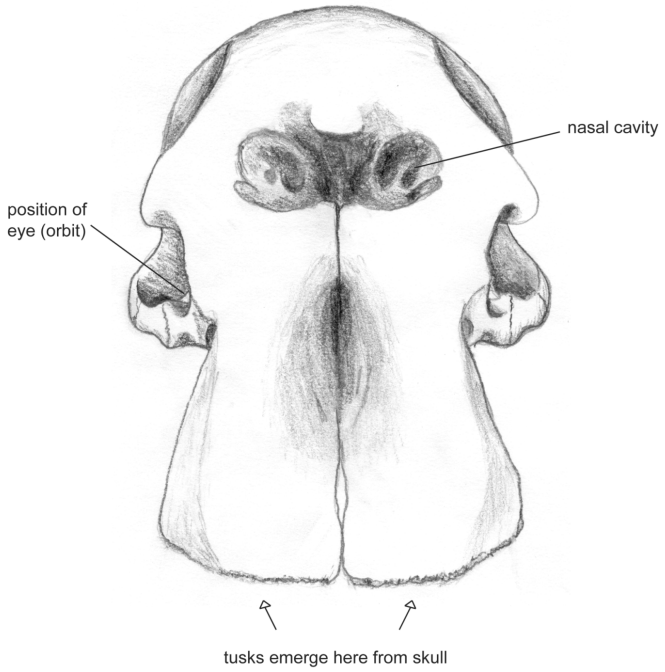


Figure 11. Frontal view of the skull of an African elephant without lower jaw and tusks. (Drawing by C. Holdrege after Figure 5 in Van der Merwe et al., 1995)

The nasal cavities, the bony and air-filled extension of the trunk, dominate the upper front part of the skull.

Behind and above the nasal cavities rises the high and pronounced forehead—another unique feature of the elephant skull. One would assume that this dome, which increases the overall rounded appearance of the elephant, houses the brain, but it does not. The brain cavity takes up only a comparatively small space at the rear of the skull. The forehead is, surprisingly, filled with an intricate network of air cavities, which is anatomically comparable to our frontal sinuses (see Figure 12).

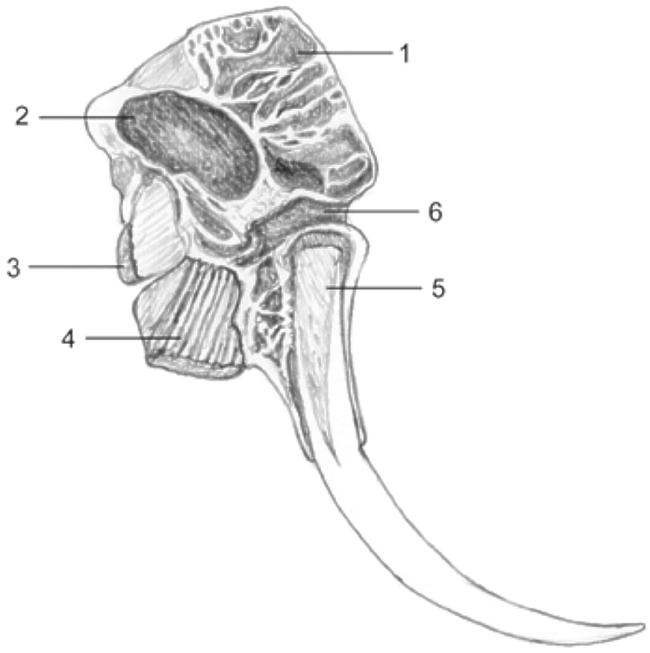


Figure 12. Median section of an Asian elephant skull. 1: air cavities (sinuses) in the frontal bone; 2: brain cavity; 3: forming molar; 4: molar in use; 5: pulp cavity of tusk; 6: nasal cavity. (Redrawn after Owen, 1866)

In the elephant these cavities have expanded to a remarkable degree. If we think of the air-filled trunk as a huge nose extending into the world, leading into the air-filled nasal cavities of the skull, which ultimately lead down to the proportionately large lungs, then we realize the intense relation the elephant has to air (Kranich, 1995, p. 161). And now we find an air-filled vault resting above the nasal and respiratory part of the skull!

The sinuses of a newborn elephant are very small and develop gradually throughout life. Virtually every bone of the skull forms smaller or larger air-filled sinuses over time. The

result is that, despite its immense size, the upper skull of the elephant is comparatively light. Elephant biologist Sylvia Sikes noticed that when an elephant walks on the bottom of a lake or river, or swims, its head is held higher, apparently floating through its buoyancy (Sikes, 1971, p. 54).

Like other parts of the elephant, the sinuses certainly have multiple functions, although biologists often have a strong urge to "explain" them in terms of one particular function. In addition to making the skull lighter, the air-filled spaces create a large outer surface on the skull to which jaw, neck, and trunk muscles attach. And, as we will see later, they play a role in transmitting and perceiving sounds.

9. The Sensitive Boundary

Its deeply wrinkled, nearly hairless skin encloses the elephant's voluminous body. The elephant looks ancient from youth on. The skin is thick—over an inch on the rump—but it is not an inert covering. The skin is imbued with fine tactile responsiveness and mobility. An elephant can twitch the skin muscles back and forth to cause a fly resting on its skin to move away.

But the skin is also sensitive and demands care. Pooling observations made by researchers on captive and wild elephants, Chevalier-Skolnikoff and Liska found that over 80 percent of tool-using behavior carried out by elephants, like scratching themselves with a stick held in the trunk, were in the context of body care (Chevalier-Skolnikoff and Liska, 1993). If conditions allow, an elephant will bathe and wallow in mud daily, finishing its bath with a shower of mud, soil, or sand. This natural garment clothes the skin until the next bath or rain. As a result, elephants carry the hue of the soil of their region.

That the elephant covers its skin by means of its environment may not seem astonishing inasmuch as it lacks the protective fur of other animals. The elephant actively augments its sensitive boundary to the environment by means of its own activity. At the same time, in the activity of bathing and covering the skin, we can see the elephant's tendency toward tactile contact, which we saw also in the trunk and feet.

It is interesting that elephants show an additional form of "covering behavior," as Jonathan Kingdon calls it (Kingdon, 1989, pp. 46 and 58f.).

Two descriptions:

> On one occasion I came upon the carcass of a young female who had been ill for many weeks. Just as I found her, the EB family, led by Echo, came into the same clearing. They stopped, became tense and very quiet, then nervously approached. They smelled and felt the carcass and began to kick at the ground around it, digging up the dirt and putting it on the body. A few others broke off branches and palm fronds and brought them back and placed them on the carcass. (Moss, 1988, p. 270)

> I have known cases, where upon running away from an elephant, the people have fallen down and, expecting to be crushed at any moment, have found to their surprise that the elephant stops near to them and proceeds to cover them with mud and leaves. (Sukumar, 1995, p. 100)

Elephants also cover up the remains of animals (lions, for example) and human beings they have killed. This kind of behavior is, to my knowledge, unique to elephants. The question

arises whether it represents a form of burial. Whether or not this is the case, elephants do have a very special relation to their dead and to bones of dead elephants. Elephant researcher Joyce Poole captures this relation and at the same time the remarkable behaviorial sensitivity of the elephant from one more vantage point:

> There is something eerie and deeply moving about the reaction of a group of elephants to the death of one of their own. It is their silence that is most unsettling. The only sound is the slow blowing of air out of their trunks as they investigate their dead companion. It's as if even the birds have stopped singing. Just as unsettling is the way elephants back into their dead. Although elephants use their front legs for killing, by kneeling on their victims, they have a way of walking backward and using their sensitive hind feet surprisingly delicately for waking up their babies and touching the dead. Using their toenails and the soles of the feet, they touch the body ever so gently, circling, hovering above, touching again, as if by doing so they are obtaining information that we, with our more limited senses, can never understand. Their movements are in slow motion, and then, in silence, they may cover the dead with leaves and branches. Elephants' last rites? A wake, a death watch, the calling up of the elephant spirits? Elephants perform the same rituals around elephant bones. They approach slowly and silently, and then the touching begins, slowly, as they deliberately, carefully turn a skull over and over with their trunks, touching, hovering over the long bones with their hind feet. (Poole, 1996, pp.159f.)

10. A Further Dimension of the Elephant's World: Hearing

Through its fine sense of touch the elephant experiences its world in immediate bodily contact. It takes in a larger sphere of its environment through its discerning sense of smell. An elephant usually notices you with its sense of smell and not with its eyes. It raises its trunk, sways the tip back and forth, and then comes to orient it in your direction. Close your eyes and wave your hand slowly through the air, imagining that your fingers are smelling, and you can get an inkling of what it might be like when an elephant's undulating trunk embraces the scents wafting in the air.

The elephant has another sense that allows it to spread out over still larger spaces—its sense of hearing. The large size of its ears (pinnae) already indicates the prominence of hearing in elephants. The moving surfaces help elephants locate sounds and direct them to the inner ear. (As with so many features of the elephant, the external ears are multifunctional. Large amounts of blood flow through them, and the blood cools down in the process, so that the earflaps are also organs of temperature regulation.) The elephant also has unusually large and heavy ossicles (hammer, anvil, and stirrup) in the middle ear that conduct vibrations to the inner ear.

Scientists have discovered that elephants hear and emit very deep tones that are inaudible to the human ear (Payne et al., 1986). Katherine Payne describes her discovery of the phenomenon of low frequency sounds and hearing in the Portland Zoo:

> While observing three Asian elephant mothers and their new calves, I repeatedly noticed a palpable throbbing in

> the air like distant thunder, yet all around me was silent. (Payne, 1989, p. 266)

Since then extensive observations and experiments in Africa have shown that, depending on the atmospheric conditions—which vary with the time of day and season—elephants can communicate with each other via low-frequency sounds over distances of several kilometers. Although groups of elephants may lose visual contact, they don't lose auditory contact. When a female is in estrous, for example, she makes deep rumbling sounds, attracting males that are dispersed in the area.

Low frequency sound communication makes understandable a phenomenon that had long puzzled elephant researchers. Viewing from the air, researchers observed how groups of elephants that were clearly not in nose range or sight of each other seemed to make coordinated movements, and, for example, all make for the same watering hole. While listening, the elephants "hold perfectly still, raising and stiffening their ears and slowly swinging the head from left to right as if to localize the source of a call" (Katherine Payne, quoted in Ben-Ari, 1999).

Recently scientists discovered that these low-frequency sounds, as well as reverberations from elephants stomping their feet during a mock attack, travel through the ground for even larger distances than through the air (O'Connell-Rodwell and Arnason, 2000). It may be that these massive creatures are also using the earth's mass to communicate over large distances. Not only may the large middle ear ossicles play a role in mediating these vibrations, but also "the elephant's body with a massive skeleton and pillar-like bones might be suitable for conducting the surface waves to the inner ear" (Reuter et al., 1998). It is impressive to think of the elephant's entire body as an organ of hearing.

The deep, low-frequency sounds that travel long distances through the air can only be produced and emitted by a large animal in which the body acts as a voluminous resonator and transmitter for the outspreading vibrations. (Think of a bass compared to a violin.) As in hearing, so also in the production of sound: the whole animal is involved. The large air-filled sinuses in the head can be viewed as part of the elephant's resonating body when it emits sounds.

When we try to imagine the elephant in its world, we first focus on the trunk as the center of its tactile and olfactory experience. Through these senses the elephant actively explores and takes in the qualities of the world it lives in. Through its large and uniquely framed body and its ability to hear low-frequency sounds, the elephant in the savanna lives in a sea of deep tones and vibrations, its boundaries stretching over kilometers. This large animal embraces through its rumblings a large environment.

But low-frequency sounds do not encompass the full range of elephant hearing and vocalization. In her book *Elephant Memories*, Cynthia Moss describes the impressive array of sounds made by elephants: bellowing, clicking of tusks, cracking of ears, groaning, growling, humming, moaning, rasping (of ears), rumbling, screaming, sluffing (of feet), snoring, squealing, and trumpeting. Virtually all of these sounds are related to communication between elephants; they are contact calls, alarm calls, and so on.

The variety of sounds an elephant can make has a correlate in its fine ability to distinguish between different sounds. Elephant trainers make use of this capacity, and a fully trained work elephant in Asia can respond to dozens of whispered commands from its mahout.

As we saw in the manual flexibility of the trunk and in the

variety of diet and habitat, so now we find in the elephant's hearing and vocalizations a remarkable array of possibilities. This spectrum extends from the outspreading rumblings resonating in the large and voluminous body to the close-up, fine receptivity for whispered tones, revealing from one more side how the elephant unites contrasting features: voluminous bulk and sensitive discrimination.

11. Comparison and Contrast to the Human Being

The last thing you would think of when you begin to study the elephant is to find similarities to the human being. But when I discuss the elephant with students over the course of a few classes, they invariably remark upon the numerous features that elephants and human beings have in common, despite glaring external differences. Various authors have been struck by such common characteristics (see, for example, Schad, 1977, pp. 248–251). Wildlife biologist Douglas Chadwick summarizes:

> In fact, humans and elephants are together at the extreme end of the scale in terms of the number of years during which offspring are carefully tended by their parents. Both have young that mature only in their early teens, and both continue to care for them until that time. This derives from another basic shared quality: we are both unusually long-lived as mammals go. Such lengthy nurturing also presupposes a good deal of intelligence…. In terms of learning abilities, we and elephants are once

> more together at the extreme end of the scale…. The majority of what [other] animals need to know to survive is already built in, largely instinctual…. Like humans, elephants are designed to learn most of what they need to know. The extended period of nurturing is part of that process, and they continue learning throughout their long lives. (Chadwick, 1992, pp. 77f.)

Related to all these qualities is the fact that both elephant and human being have flexible prehensile organs—the trunk and the hands. (But how different it must be to have only one such limb, which extends out of the head and at the same time has the ability to smell!) The freedom of movement these organs enjoy is made possible by the weight-bearing legs that elevate and support the rest of the body. We have already seen that the elephant's straight legs resemble in overall structure those of the human being more than they do those of most four-legged mammals (see Figure 13). But we should not forget that the elephant has four such columns, and not just two, to give stable support to its massive frame.

Interestingly, the female elephant has two mammary glands that are situated between the forelegs, that is, in the same position as in humans. This is unique among four-legged, non-arboreal mammals.

The elephant carries its head high off the ground and cannot reach the ground. Like our hands, the trunk functions as a limb to bring food and water to the mouth. As we have seen, the elephant does not have the horse's long bony snout; this front part of the skull is short and what extends to the fore is the muscular trunk (see Figure 14). The elephant's skull is not only short, but it also has a high forehead and the relatively small lower jaw (mandible) is tucked under the cranium. The

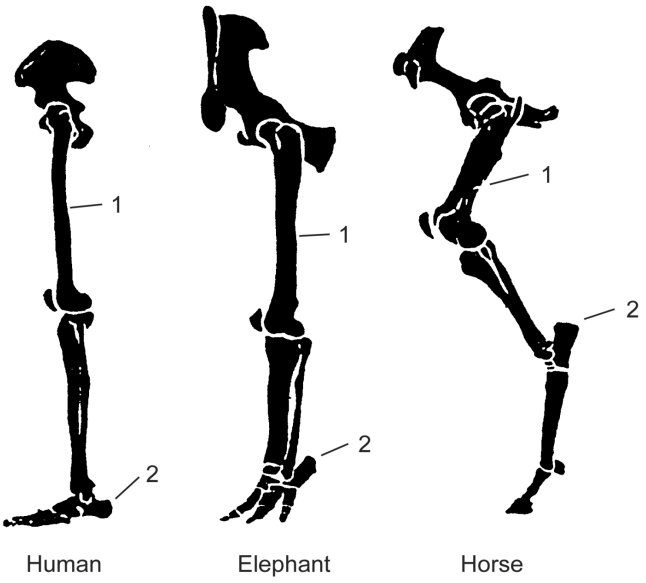


Figure 13. Leg of the human and hind limbs of the elephant and horse. Both the human leg and the elephant hind limb are very straight and the proximal (body-near) bones are the longest, while the bones of the feet are short. In contrast, the more angular leg of the horse has very long bones in the feet (the heel bone [2] is high off the ground) while the proximal leg bones are proportionately short. 1: femur (thigh bone); 2: calcaneus (heel bone). (From Carrington, 1959; reprinted with permission)

upright orientation of the skull is accentuated by the nearly vertical premaxillary bones, which carry the tusks. The skull as a whole is large in relation to the rest of the body. All of these features resemble a human skull more than they do a typical four-legged mammal's. In both legs and skull the elephant shows a tendency toward verticality, a tendency that dominates human morphology.

It would take a whole other essay to show how everything in the human body is configured according to the upright posture and to show its relation to the psychological and spiritual nature of being human.

Figure 14. Comparison of the elephant (African, male, tusks missing), horse and human skull; not drawn to scale. (Drawing by C. Holdrege)

Let one quote suffice. Johann G. Herder, a friend and colleague of Goethe, had a keen sense for how uprightness is a holistic quality that infuses all aspects of human life. He wrote:

> Because the human being has to learn all things, because it is our instinct and calling to learn everything like our upright gait, we learn to walk by falling and come often to truth only through error. The animal is carried forward securely in its four-legged gait; the more strongly expressed proportions of its senses and drives are its guides. The human being has the advantage of a king to look to far horizons, upright and with head held high. Of course, we also see much darkly and false. We forget our steps, only to be reminded when stumbling on what a narrow basis the whole head- and heart-edifice of our concepts and judgments rests…. The human being is the first to be set free in creation. We stand upright. The balance of good and evil, of false and true hangs in us. We can search, we shall choose. Just as nature gave us an overviewing eye to guide our gait, so also do we have the power, not only to place the weights, but—if I may put it this way—*to be the weights* on the balance. (Herder, 1982)

Herder captures in a beautiful and concise way the gifts and predicaments of being human—the ability to gain distance from the web of natural workings and to make free decisions using our own capacity of judgment. But we also err and wreak havoc in the world when we act out of ignorance. We must find our balance, our own moral relation to the world, just as we continually balance our body on the "narrow basis" of our two feet.

The elephant, in contrast, is embedded in its world in a harmonious way. It has the gift of being an animal. Yet, with its long

columnar legs, shortened and upright head, its flexible trunk to interact flexibly with the world, its long development and lifelong learning capacity, it has much in common with us, while remaining more embedded in a natural ecology. As outwardly dissimilar as elephant and human being may first appear, the more we get to know the elephant, the more we get to know—if not in an evolutionary sense—one of our closest relatives on earth.

12. Elephantine Intelligence

The elephant is well known for its intelligent behavior. Let's look at various examples of non-trained elephant behavior that the people making the observations considered intelligent:

> If he cannot reach some part of his body that itches with his trunk, he doesn't always rub it against a tree: he may pick up a long stick and give himself a good scratch with that instead. If one stick isn't long enough he will look for one that is. (Williams, 1950, p. 78)

> On many occasions I have watched an elephant pick up a stick in its trunk and use it to remove a tick from between its forelegs. I have also seen elephants pick up a palm frond or similar piece of vegetation and use it as a fly swatter to reach a part of the body that the trunk cannot. (Poole, 1996, p. 139)

> If he pulls up some grass and it comes up by the roots with a lump of earth, he will smack it against his foot until all the earth is shaken off, or if water is handy he will wash it clean before putting it into his mouth. (Williams, 1950, p. 78)

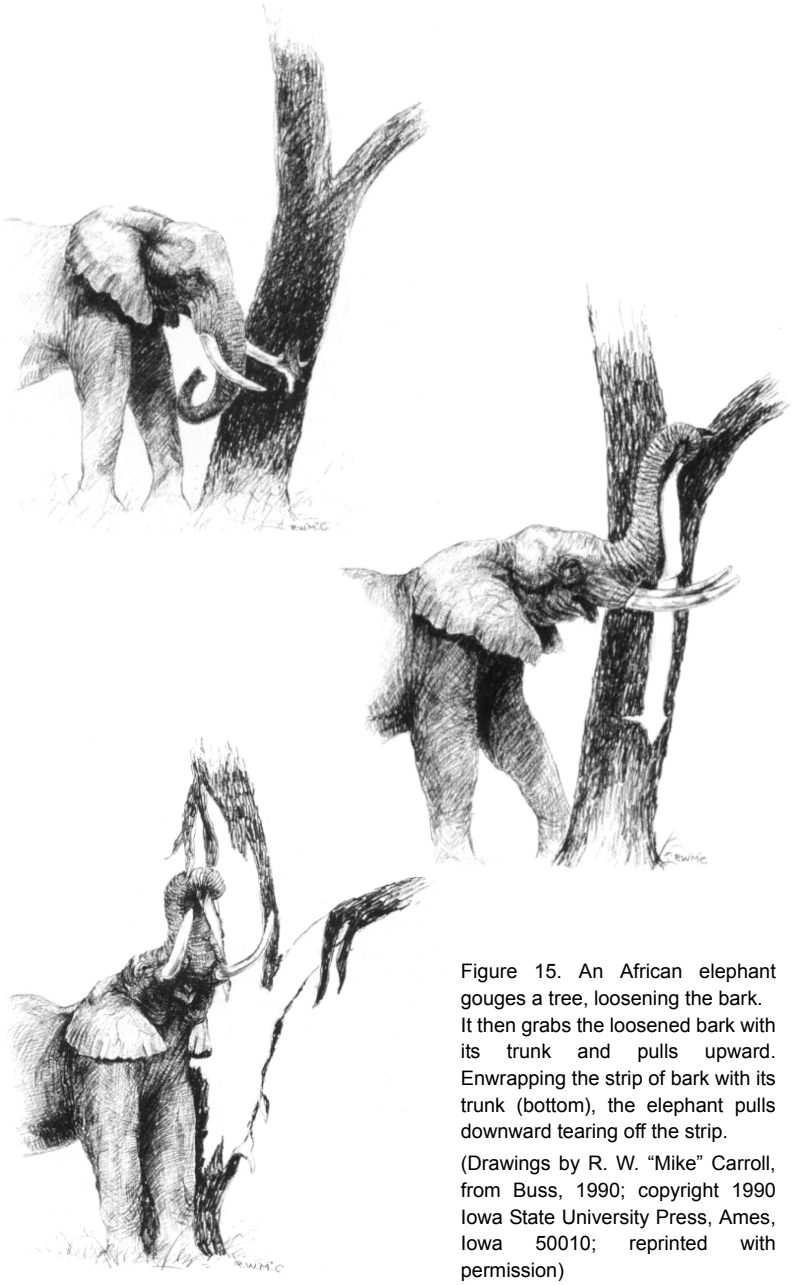


Figure 15. An African elephant gouges a tree, loosening the bark. It then grabs the loosened bark with its trunk and pulls upward. Enwrapping the strip of bark with its trunk (bottom), the elephant pulls downward tearing off the strip.

(Drawings by R. W. “Mike” Carroll, from Buss, 1990; copyright 1990 Iowa State University Press, Ames, Iowa 50010; reprinted with permission)

Elephants have picked up objects in their environments and thrown them directly at me, undertrunk, with surprising, sometimes painful, accuracy. These projectiles have included large stones, sticks, a Kodak film box, my own sandal, and a wildebeest bone…. Elephants have been known to intentionally throw things at each other in the same circumstances: during escalated fights and during play. Elephants have been known to intentionally throw or drop large rocks and logs on the live wires of electric fences, either breaking the wire or loosening it such that it makes contact with the earth wire, thus shorting out the fence. (Poole, 1996, p. 139)

[In India an] elephant was following a truck and, upon command, was pulling logs out of it to place in pre-dug holes in preparation for a ceremony. The elephant continued to follow his master's commands until they reached one hole where the elephant would not lower the log into the hole but held it in mid-air above the hole. When the mahout approached the hole to investigate, he found a dog sleeping at the bottom; only after chasing the dog away would the elephant lower the post into the hole. (In Shoshani, 1992, p. 137)

Many young elephants develop the naughty habit of plugging up the wooden bell they wear around their necks with good stodgy mud or clay so that the clappers cannot ring, in order to steal silently into a grove of cultivated bananas at night. There they will have a whale of a time quietly stuffing, eating not only the bunches of bananas but the leaves and indeed the whole tree as well, and they will do this just beside the hut occupied by the

> owner of the grove, without waking him or any of his family. (Williams, 1950, p. 78)
>
> [In South Africa] it was observed that an elephant, after digging a hole and drinking water, stripped bark from a nearby tree, chewed it into a large ball, plugged the hole, and covered it with sand. Later he removed the sand, unplugged the hole, and had water to drink. (In Shoshani, 1992, p. 137)

As we can see from these examples, intelligent behavior allows the animal to deal with a concrete situation in a flexible and non-schematic manner. Or as Shoshani and Eisenberg put it, intelligence is "the capacity to meet new and unforeseen situations by rapid and effective adjustment of behavior" (in Shoshani, 1992, p. 134). Intelligence presupposes an ever-present ability to learn. Not unexpectedly, many of these examples show that the elephant's intelligence often manifests through the activity of its trunk: breaking off sticks that are then handled as an extended limb for scratching or swatting; throwing with the trunk; stuffing a bell with the trunk. With such a flexible and dexterous prehensile organ, how could an elephant not be intelligent?

At the same time, these activities involve the whole animal in the coordinated use of different body parts and senses: sight and trunk are used in throwing, while foot and trunk coordination allows cleaning clumps of grass. Raman Sukumar, who studies the Asian elephant in India, describes a scene that clearly illustrates the elephant's complex behavior:

> Vinay [a solitary adult Asian bull] poked at the *bendai* tree with his left tusk, thrusting it up into the gash and splitting the bark. He grasped a portion with his trunk and tugged

> expertly with an upward flick, tearing off a four metre long strip. Another tug and the strip broke loose from the tree-trunk and came down. Vinay now began eating the bark, skillfully using his forefeet and trunk to break off small strips before transferring them to his mouth.
>
> After feeding for some ten minutes, Vinay did something that only an elephant can do so effortlessly. He turned towards the tree, and using his forehead and trunk, pushed the tree over. In a minute or so the tree was cleanly uprooted. Vinay tore just one more strip of bark from the tree and then turned away. Almost nonchalantly he began to pluck green grass that sprouted profusely from among burnt clumps. As he wrapped his trunk around a clump and pulled, the tender leaves came off quite easily from their dry bases. Stuffing one trunkful after another into his mouth, Vinay ambled along at a gentle pace. (Sukumar, 1995, p. 50)

The elephant's behavior flows from one activity to the next, engaging its brawn and dexterity as needed. The key to such actions and their sequence is that they are not automatic and prescribed. Intelligent behavior embodies plasticity—flexible interaction with experience. The elephant cleans off the dirt by smacking the clump of grass against the foot, but if it also perceives water nearby, it can then take the clump and submerge it in water to clean it further. It does not have just one "built-in" way to carry out tasks.

All of the above examples reveal what we would call purposive behavior. We have to be very careful, however, not to anthropomorphize an animal's behavior. We would clearly be anthropomorphizing if we imagined an elephant scheming about how to steal bananas and coming up with the idea of

plugging the noisy bell. That is just putting a human mind in elephant skin. We also need to be careful in the case of the elephant that did not put the log on the dog; we should not immediately assume that the elephant took pity on the dog or had a conscious awareness it was about to kill it. This caution does not detract from the impressive act itself. Rather, it leaves us more open. We erase the possibility of understanding the elephant's unique kind of intelligence if we too easily transfer our experience to it. When we stay close to the perceived situation and restrain judgment, the unique and fascinating qualities of the animal become *more* vivid than if we make life too comfortable for ourselves and imagine it seeing the world through our eyes. After all, we want to see more than ourselves in the animal.

The scientist Herbert Haug carried out a detailed comparative study of the anatomy of elephant, dolphin, and human brains to see if he could find out how the brains might relate to the intelligent behavior of these creatures (Haug, 1970). The brains differ distinctly from one another, but all are large (see Figures 16 and 17). The elephant has the largest brain of all land animals; an adult elephant's brain weighs on average between nine and twelve pounds. But, of course, the elephant also has the largest body of all land animals. The elephant's brain makes up about 0.08 percent of the total body weight, while a zebra's makes up about 0.25 percent of its total body weight. The human brain weighs three to four pounds and is also relatively large, making up two percent of our body weight (Flindt, 1986, p. 108).

The brains of elephant, dolphin, and the human being are all highly convoluted, a characteristic that increases the surface area. These brains exemplify the well-known correlation between the degree of brain folding and the degree of intelligent, flexible behavior found in mammals.

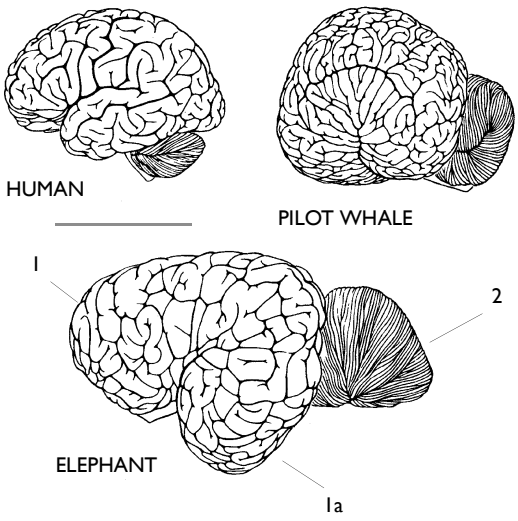


Figure 16. Brains of human being, pilot whale, and elephant, viewed from the side. Drawn to scale (bar = 10cm). 1: cerebrum; 1a: temporal lobe of cerebrum; 2: cerebellum. (From Haug, 1970; copyright 1970 Springer-Verlag; reprinted with permission)

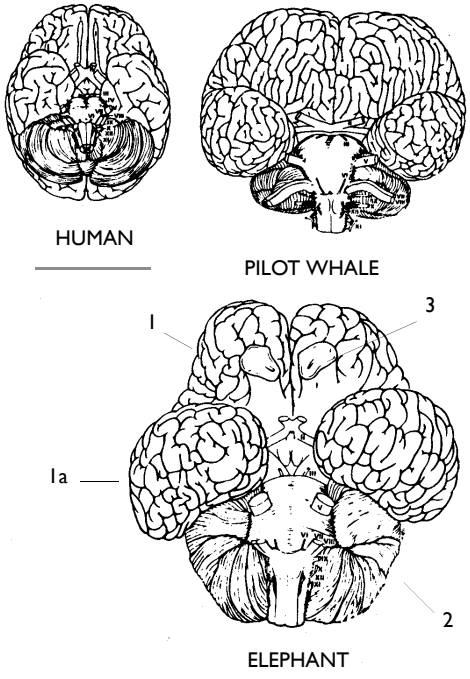


Figure 17. Brains of human being, pilot whale, and elephant, viewed from below. Drawn to scale (bar = 10cm). Note the very large temporal lobe (1a) of the elephant brain. The olfactory nerves leading to the trunk (3) are especially developed in the elephant. 1: cerebrum; 2: cerebellum. (From Haug, 1970; copyright 1970 Springer-Verlag; reprinted with permission.)

But what is specifically elephantine about the elephant's brain? Three areas of the brain are noticeably enlarged relative to the other parts of the brain: the olfactory lobe, the cerebellum, and the temporal lobe of the cerebrum. Enlargement of part of the brain usually means that there are more neurons in that part. These neurons are connected to other parts of the brain and to the rest of the body via nerve fibers.

The enlargement of the olfactory lobe is clearly connected to the fine innervation of the trunk with its refined sense of smell. The cerebellum has been found to be related to muscle coordination in other, better researched mammals. Since the nerve pathways in the elephant are not that well known, Haug can only make the clearly reasonable suggestion that the cerebellum's high degree of development is related to the highly coordinated trunk and limb movements. It is not surprising that the elephant's trunk-imbued intelligence, the focus of so many of its activities, is mirrored in the enlargement of parts of the brain connected to the trunk.

Why the temporal lobes are so large (proportionately larger than in any other mammal) remains a riddle. The temporal lobes are, among other things, related to hearing in mammals (and speech in the human being), so it does not seem too far off to conjecture that the elephant's ability to distinguish and communicate through a variety of sounds (including infrasound) may well be connected to the differentiation of the temporal lobes.

Haug's study led him to be skeptical about any claims that correlate intelligence and the brain too closely:

> From a qualitative point of view, the human being does not possess—compared to elephants and dolphins—a particularly high grade of cerebral differentiation that would provide the morphological basis for such a great

> difference in intelligence as is actually present…. The question must be asked, whether brain differentiation must necessarily be equated with human productive intelligence. (Haug, 1970, p. 56)

There is a strong tendency in our times to want to localize intelligence—and other capacities—in the brain. It is a very unorganismic way of viewing that leads us to seek for a "command center" in the brain. Intelligence resides just as little (or just as much) in the brain as it resides in the elephant's trunk. It would be just as correct (or incorrect) to say that the elephant has its center of intelligence in the trunk as it would be to say that it is in the brain. If the elephant's trunk becomes lame, some of its intelligent behavior will be missing—just as, if part of its brain is dysfunctional, some intelligent behavior may also not be possible. In either case it could compensate for such injuries to a certain degree by engaging other body and brain parts. Intelligence resides everywhere and nowhere. Perhaps it is best to say we discover it in the intelligent activity itself, which is carried out and made possible by the *whole* animal. And in the elephant this whole is most vividly displayed in the use of the trunk.

13. Summarizing Picture

The massive and voluminous elephant stands firmly in the world, carried by its long pillar-like legs. The short, high-browed head connects to the torso with a very short neck that is hardly visible behind the large ears. This compact appearance is accentuated by the nearly hairless, gray and fissured skin. Internally, the elephant's weighty being finds expression

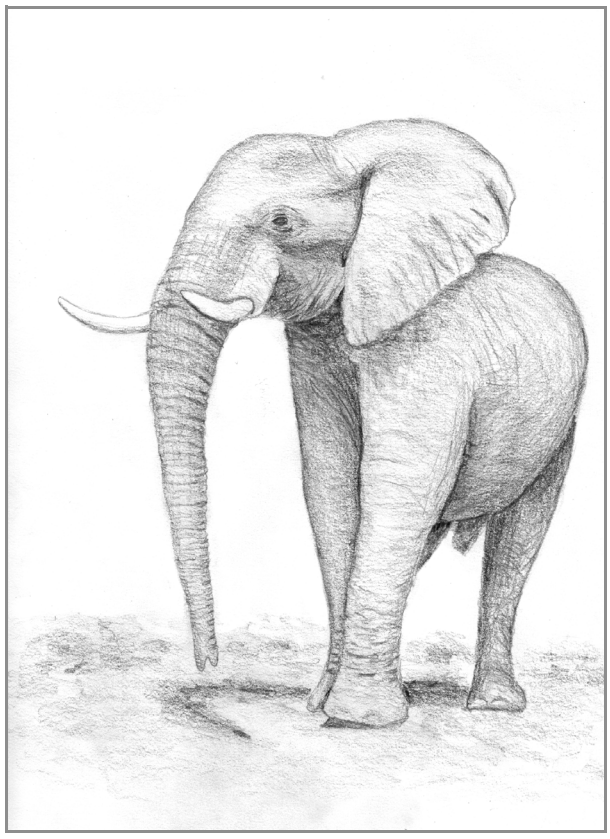


Figure 18. African elephant bull. (Drawing by C. Holdrege after front jacket photo of Shoshani, 1992)

in the high density of its limb bones and in the continuous production of dentine and enamel in the tusks and molars.

The head is not only uniquely shaped for a four-legged mammal, but from it emerge the most characteristic elephantine organs: trunk, tusks, and large ears. These organs reinforce the elephant's enormity. When you view from the front an adult African elephant with its ears spread, the animal appears as a massive wall, as broad as it is tall. But trunk, tusks, and ears

Figure 19. Nursing infant African elephant; Chobe River, Botswana. (Photo C. Holdrege)

also have a very different character from the rounded, self-contained head and torso. They radiate outward as organs of activity and expression. While the tusks protrude in rigid radiance, the trunk and ears move almost continually. Their large, sweeping motions, which lack any hint of nervous haste, heighten the elephant's grandeur.

Interestingly, the center of glandular expression in the elephant—the temporal gland—is also located in the head. Through its secretions, the elephant expresses something about its age and current state that is finely perceived by other elephants. We also find a "headwards" movement of certain physiological functions and organs. While other four-legged mammals have the mammary glands between the hind legs, the elephant has one pair of mammary glands between the forelegs. The position of the vagina has also shifted forward—it does not lie directly below the anus, but has moved down

and forward, being situated between the hind legs. It seems that the elephant's center of gravity, physically as well as functionally, has shifted headwards.

The elephant lives through trunk and skin at its body's boundary in intensive tactile contact with its surroundings. Watching a herd of elephants you see continual interaction—caressing, pushing, slapping, probing. Through its keen senses of smell and hearing, and its trumpeting calls and infrasound rumbles, the elephant enters into a truly expansive world.

The trunk unites power and agility in singular fashion. We find this unity of largeness and delicateness, of enormity and sensitivity, in modified ways in nearly all elephant characteristics. With its finely modulating feet, a soft-treading elephant has little trouble moving silently through a forest, but it can, in another moment, crash through the same forest, bowling over trees or crushing a lion under its foot. The thick, leathery skin that appears so tough is also extremely sensitive, warranting continual care. The large, constantly moving ears are ideal for taking in and locating tones coming from afar, but the elephant can also hear the quietest tones and distinguish between subtle modulations. The elephant's unified being speaks through contrasts.

There is no more physically flexible organ in the animal kingdom than the elephant's trunk. While the trunk is clearly the elephant's focal instrument for living out its flexible nature, this paramount elephantine feature in fact expresses itself in the whole animal—physically, physiologically, and behaviorally. The elephant does not have to eat food of one type, it can shift from one food source to another; when given the opportunity it goes for variety. The elephant can live in different types of habitats—from the climatically uniform

Figure 20. An example of cooperative elephant behavior. The elephant on the right had just used its bulk and a sidewards thrust to push the elephant on the left up and out of the mud in which it was stuck; Chobe River, Botswana. (Photo C. Holdrege)

and food-rich rain forest to the extremes and dearth of the desert. But most elephants live in the more rhythmically changing savanna and monsoon climates, where they move with the changing seasons and the changing sources of food the seasons bring.

An elephant changes throughout its long life. Its primary growth phase lasts around two decades, but it continues to grow slowly until death. The tusks grow lifelong, and, like no other mammal, the elephant's change of teeth in the molars never stops. There is an ongoing development of the new and discarding of the old, continuous physiological renewal. At the behavioral level we find this characteristic mirrored in the elephant's pronounced and lifelong learning ability. At any moment the elephant can adjust to new situations with its own unique form of intelligence.

Summarizing Picture

In their family groups, elephants have intense contact and learn from one another. They go through a long phase of maturation and then develop different relations within the group as they grow older. The life of a young mother is very different from that of an older female or of the group matriarch. Or think of the orphaned, aggressive young bulls that altered their behavior soon after older bulls entered their home range. In the elephant, the ability to change never ceases.

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