Our Living Relatives: The Primates

(Adapted from Zihlman, 2000: *The Human Evolution Coloring Book*)

Charles Darwin brought the study of human evolution into the realm of science through his ideas that all life descended from previous forms and that the human family was but one branch on the tree of life. Darwin concluded On the Origin of Species with the statement "Light shall be thrown on man and his history." The clear implication was that the human species evolved through mechanisms similar to those of other life forms. In 1950, anthropologist Sherwood Washburn emphasized that the study of human evolution required comparison with living primates to demonstrate our biological heritage as primates. Indeed, humans have much in common with other life forms. Humans are at once vertebrates, mammals, and primates. We share fundamentals of physical development, brain anatomy, and ear structure with other vertebrates, and limb and dental structure with other mammals.

We will now learn about how we resemble and how we are different from other primates and mammals. The resemblances illustrate evolutionary continuity, and the differences show the divergence and adaptive radiation of life. The human species is but one of about 300 in the order Primates. A number of features distinguish primates from the other 17 mammalian orders and define a "primate way of life." The primates on earth today share an evolutionary history of more than 60 million years. Although one of the more recent arrivals, humans now occupy all parts of the earth. Most other primates live in tropical rain forests, three-dimensional high-rises where many species co-exist.

Primates live together in social groups that occupy a neighborhood, called a home range. Though these neighborhoods differ, forest-dwelling gibbons and savanna-living baboons must meet similar challenges in order to survive; they must get food and water, deal with neighbors, and avoid predators. Closely related species living together must find viable ways to divide available space. Three kinds of ground-adapted (terrestrial) African monkeys, each with its own food preferences, ranging patterns, and group size illustrate how space can be shared. Each species has carved out its own niche and learned to keep out of the others' way. Primates are generally omnivorous, although the size and shape of the dentition (teeth) reflect food preferences and dietary composition. Teeth help identify species and provide clues about their diet.

In terms of locomotion, primates climb, swing, and leap through the network of branches in the forest or walk, run, and bound on the ground. They differ from other quadrupedal animals, such as dogs, in having more muscle in their hands, feet, forearms, and legs, which gives primates considerable flexibility and mobility. During growth and development, the body proportions of infant primates shift as they make the transition from dependence on the mother for transportation to locomotor independence.

Primate hands and feet maintain a family resemblance. All are equipped with nails, sensory pads, and sweat glands. The human foot departs notably from the norm in shape and function. Primate hands are active in locomotion. In contrast to most other mammals, these hands are also adept at feeding, grooming, and object manipulation. Hand use promotes a vertical posture in sitting, and monkeys and apes stand, look, reach, carry object, and display bipedally, although only the human species maintains upright posture and bipedal walking.

Humans share with other primates and mammals a strong attachment between mother and infant; in primates, the initial social bond that an infant forms with its mother becomes the basis for the development of social relationships that persist throughout its life. Intimate face-to-face communication commences as infants feed at their mothers' breasts. The capacity for emotional attachment stems from a new part of the mammalian brain, the limbic system.

Smell is a vital modality for perceiving the world. This sense is well developed in prosimians and serves as an important mode of communication. The sense of smell is less sensitive in humans. Vision tends to be more acute in primates than in most other mammals. The overlapping fields that make possible stereoscopic vision improve primates/ judgment of distances and facilitate their acrobatic agility. Color vision enhances daytime (diurnal) activities such as locating brightly colored fruit, sighting members of neighboring groups, and spotting predators in time to avoid them. Visual acuity, together with an expanded cerebral cortex, sharpens the ability to interpret facial expressions and gestures, and essential aspect of getting along with one's social comrades.

Sensitivity to sounds is also vital to survival. Prosimians hear high-frequency sounds, whereas humans hear best in the lower ranges, which is optimal for spoken language. Distinctive vocalizations communicate an individual's location and emotional state to others. Some monkeys have special vocalizations for different predators, and they respond appropriately in reaction.

The body's great organizer is the cerebral cortex, with different regions controlling specific functions. Language centers control the articulation of sounds for human speech. Nonhuman primate vocalizations and even some human vocalizations, that are more emotional and less voluntary than normal speech, originate in the limbic system. New ways to study brain activity highlight the areas associated with perception and production of speech and language.

Primates live their entire lives in close association with other members of their species. Group size and composition vary between and within species, as does the strength of social bonds among different members of the group. This variation accounts for the flexibility that primates exhibit in surviving under a wide range of conditions. Primates mature more slowly and live longer than most other mammals. Like other mammals, they pass through defined stages from infancy to old age. The timing and duration of each stage comprise an individual's life history. Each species has its characteristic life history pattern that is not simply a reflection of the body size of the species.

When we take a closer look at different age-sex classes that make up primate social groups and populations, we see that female primates spend most of their lives pregnant and lactating. Long-term studies on individuals reveal what contributes to a female's lifetime reproductive success. Individual differences in physical condition and amount of body fat affect the time to conception, success of lactation, and ultimately, infant survival. A female's access to food and her activity level affect body mass and amount of body fat. These, in turn, affect her rate of physical maturation, age when she first gives birth, and the interval between births.

Life, from an infant's point of view, is about surviving. Infants are dependent and vulnerable during this time of rapid brain growth. From day one, infants are involved socially, reacting to their mothers and other group members, and learning the "primate way." Their survival depends a great deal on the health and well being of their mothers. As juveniles, they become more physically independent, foraging on their own and playing for extended periods, but they are still small and vulnerable, learning their place in the social group while relying upon its cohesion and protection.

The behavior and lives of males remains enigmatic. Male primates exhibit a range of behaviors—from nurturance to lethal aggression--and lead long and complex lives. Female and male primates differ from each other in a number of ways----coloration, vocalizations, and body and tooth size (sexual dimorphism). In species with pronounced sex differences, males grow for a longer time and reach physical and social maturity later then females.

When Jane Goodall began what was to become a long-term study on the lives of the Gombe chimpanzees in East Africa, she recorded events in individual lives. The skeleton of each chimpanzee tells its own story about the individual's life and death.

Primates have relatively large brains and seem "intelligent" by human standards. Primatologist Alison Jolly, who studied lemurs, points out that primate intelligence is manifested in meeting the challenges of social living and solving problems, not necessarily in tool using, which some people use as a definition of intelligence. Monkeys and apes show considerable ingenuity in solving their everyday problems and in communicating with each other. However, when attempting to solve nonsocial problems, monkeys and apes differ in their abilities.

Although other mammals use tools---sea otters use rocks to crack open clams, finches use cactus spines to probe for grubs, and monkeys occasionally use objects---only chimpanzees, gorillas, and orangutans approach the highly developed manipulative abilities of humans. For example, chimpanzees use a variety of objects for many practical purposes. These skills often require many years of learning and practice. Tool use among wild chimpanzees is now well known from several populations.

Long-term studies on wild chimpanzees also document the variation and individual character of behavior patterns among populations. Some of these behaviors become established traditions and are passed on to the next generation. Behaviors may also be transferred from one chimpanzee community to another, as was documented when an older female emigrated to a neighboring group, bringing her experience and memory with her. Social traditions are not unique to chimpanzees. Other

large-brained, long-lived social mammals can transmit information socially, thus enabling preservation of innovations that contribute to survival. Social traditions do not constitute culture in the human sense of the word, but they seem to be precursors to the arts and sciences which characterize the uniqueness of our own species.

Chimpanzees' struggle with the "Candy Game," which human children over the age of four can master, illustrates how abstract symbols may free one from the "biological destiny" of hard-wired reactions. Our facility for learning language—spoken, signed, and written—provides the basis of the cultural divide, the narrow but very deep gorge that separates us from the apes that are so closely akin to us on the genetic level.

As Darwin deduced, we humans are but one twig on the giant sequoia of life. The nearby branches are our primate relatives. The nearest of all are the African apes, so close that when we watch them in action, we often marvel at how "human" they seem. And yet the differences too are fascinating. Much light has been thrown on the ways that different primate species live, and the reflected light tells us a great deal about ourselves.

TRAITS THAT DEFINE THE ORDER PRIMATES

There are lots of physical traits that the 300 plus species of primates have in common with the other placental mammals:

- **Body hair**
- **Mammary glands**
- **Increased brain size relative to body size**
- **4 different kinds of teeth (incisors, canines, premolars, molars)**
- **Relatively long gestation (pregnancy) period followed by live birth**
- **Constant internal body temperature**

Primates also are built much like other tree-dwelling mammals such as squirrels, shrews and opossums. They have long, flexible backbones, five-fingered gripping hands and feet and forward eyes on a short, flexible neck.

Primates forearms are linked to the chest by a collar bone (clavicle) which allows them to hang without straining their shoulder muscles and provides a great deal of shoulder mobility (a useful feature for moving about in trees). Like many other tree dwelling mammals, most primates have long tails to help them balance, and some also have prehensile (grasping) tails. So how do we distinguish primates, as an order of mammals, from the other mammals?

Well, primates are much better adapted than other tree-dwellers at manipulating objects. Primates have hands and feet (not paws) that grasp, often with an opposable thumb or opposable big toe (these can press against the other digits). Primates have a well-developed sense of touch with many sense organs on the tips of their fingers and toes (tactile pads). Except for marmosets and tamarins (two types of New World Monkeys), all higher primates have flat fingernails and toenails instead of claws that serve to protect their tactile pads. They also have two separate bones on their forearms (radius and ulna) that allow them to rotate their hands (palm up and palm down). This is important also for primates that swing from branch to branch (brachiation).

Compared to their body size, primates have a bigger brain than other animals. This enlargement allows primates maximum use of their environment and to develop advanced forms of social behavior. Primates have a relatively larger braincase because of forward position of the eyes and reduction in the size of jaw muscles associated with an omnivorous diet. In addition, their brains are more complex. Those with the biggest and most complex brains are known as "higher primates" (the monkeys, apes and humans); the others are known collectively as "lower primates" (the prosimians).

The structure of the skull shows that the primates depend more on sight than on smell. All primates have both eyes facing forward, on the front of the face and enclosed in bony sockets, so that the view seen by one eye

overlaps that of the other. Called "stereoscopic" vision, this gives a clear, three-dimensional image. Thus, primates are good at judging distances, an important ability for life in the trees. Because the eyes of humans, apes, and monkeys are placed in front and parallel, the muzzle (snout) is shortened, reducing the volume available for the sense of smell. In the prosimians, especially the lemurs, the eyes are not completely frontal and the muzzle is still quite prominent.

The basic structure of the primate eye is similar to other mammals. But while most mammals have only black and white vision, color vision is the norm in primates which are active during the day (diurnal). Color vision is possible because the retina has special cells (cones) which are distributed towards the center. In humans, apes and some monkeys, these cells are highly concentrated right in the center of the retina (the *fovea* or yellow spot). Away from the center of the retina are different cells (rods) that are important in peripheral vision. These cells are sensitive at low light levels, but process only in black, white and shades of gray.

Like some tree-dwelling animals, some primates have developed prehensile tails. Truly prehensile tails are found in just two subfamilies of New World monkeys, the *Atelinae* (spider and woolly monkeys) and the *Alouattinae* (howler monkeys). Other primates can also wrap their tail round a branch whilst sitting at rest, but this is only to help them maintain their balance (capuchin monkeys). Prehensile tails allow them to reach ends of flimsier branches for fruits and newly sprouted leaves which other tail-challenged creatures can't reach. With the prehensile tail providing a secure grip, the animal can use its hands to reach out for fruits and newly sprouted leaves at branch tips. Studies showed that prehensile tailed primates have a feeding sphere 150% larger than those without.

What is a prehensile tail? Prehensile tails can curl around a branch and suspend the full weight of the animal from it, like a fifth limb. The tail is able to grip so well because up to one-third of the underside at the tip of the tail consists of bare skin, which looks exactly like the palm of a dark hand. There is even a pattern of tiny ridges, like a fingerprint, on this sensitive area. This gives the monkey a very firm grip when the tail is curled round a branch. The tail also has a lot of muscles, which makes it strong.

Prehensile tails are a heavy investment in muscles. A howler monkey's tails is 6% of its weight, about as heavy as one of its legs. In contrast, a kangaroo's massive tail is only 4% of its body weight. This heavy tail makes them less agile leapers. The tailless gibbon can brachiate much further than a spider monkey can leap with its prehensile tail. But the investment appears worthwhile as this special adaptation has developed in many primates.

The traits just enumerated, taken as a group, set primates apart from other mammalian groups. It's important to remember that no single trait makes a mammal a primate. Rather, it is a suite of traits that *tend* to set primates apart from other mammals. And since primates are generally **arboreal** (adapted to life in the trees) animals, many features of their anatomy are related to movement in arboreal habitats. To sum up then, primates can be distinguished by the following traits:

1. **Generalized skeletal structure with retention of some primitive mammalian skeletal structures (such as the clavicle; free rotation of the forearm due to the retention of two separate bones in the lower arm; a high degree of shoulder and hip mobility)**
2. **Trunk verticality (erect posture)**
3. **Prehensile (grasping) hands and feet made possible by:**
    a. **Five movable and separate digits (fingers and toes) on the hands and feet**
    b. **Opposable thumbs**
    c. **Opposable big toes**
4. **Nails instead of claws**
5. **Tactile pads with sensory nerve fibers at the ends of the digits**
6. **Generalized dentition (linked to the lack of dietary specialization in the order as a whole)**
7. **Color vision**
8. **Stereoscopic, binocular, 3-D vision (all primates have an acute sense of depth perception)**
9. **Eyes toward or at the front of the face**
10. **Decreased reliance on smell**
11. **Increased complexity and size of the brain relative to body size**