Chimpanzee Foodways

Overview

We arrive at our ultimate primate: the chimpanzee. Previously, I have been devoted to outlining some of the correlations in primates, especially as they pertain to food, digestion, territory, encephalization and other factors; then we covered the specific adaptation of certain primates and most of all the other Great Apes--but all of this really was to show the various contrasts to the most important of our primates for our purposes--the Chimp. As we shall see, the chimp conforms to many of the correlations we have already established but from there, he has many characteristics that make it shockingly similar to humans--way more so than other primates. Initial studies showed that chimps are ninety-nine percent identical to humans and later studies showed that we are ninety-five percent similar. Of course, we are radically more developed than the chimps in certain characteristics, such as encephalization and tool-use, but we can explain this by the fact that small differences in DNA can result in sizable, morphological changes. Also, in terms of our evolutionary story, we are most similar to the Chimpanzee--that is, both of our species branched from our common ancestor about six million years ago.

In any case, we are considering the chimp as the model for our common ancestor, especially since the Chimp is so similar to the first Homo in our line, Australopithecus, in morphology, encephalization and other characteristics. As we shall see in the next section, it appears that the Australopithecus was basically a chimpanzee with certain adaptations around upright walking and teeth and jaws suited for more abrasive foods. When we use the word 'chimps' below, you can see that in many cases we could easily supplant the word human.

Of all the primates, we are most similar to the chimpanzee in our evolutionary heritage, our DNA, as well as our foodways. For the purposes of this project, we consider the chimpanzee as the model of the universal, hominoid ancestor that seven million years ago started the evolution of hominoids. In other words, the chimp is quite similar to our greatest of grandfathers.

Firstly we have more common DNA with chimps than any other species on earth, at over ninety-eight percent. Secondly we are closest to them in evolutionary narrative. Accordingly, the chimpanzee and the first of the hominoids, Australopithecus, shared many commonalities, suggesting, of course, that the first hominoids evolved from something similar to the chimpanzee. For example, they are close in stature and encephalization and even look similar with the exception that chimps are better designed for climbing and Australopithecus for walking. Thirdly, the chimp and our common ancestor inhabited jungles because that is about all that existed back then in Africa. Fourthly, we ourselves are similar to the chimps in both our morphological and encephalized. While peeling away the cultural and cognitive skein of humanity, we will see that, at the instinctual and primal level, we are amazingly similar to them. Although that thought may be uncomfortable for some, we should be comforted because chimps are such beautiful creatures in all ways: loving, loyal, devoted, intelligent, playful and gentle--even as they sometimes succumb to the same atrocities that afflict humans such as war, infanticide and rape.

(I would imagine that, in many ways, chimps are actually probably more humane than we are. Mary Midgley- a philosopher- writes a lot about humans' desire to distance ourselves from the rest of nature and to not consider ourselves 'animals', but something other, better, etc. Konrad Lorenz also wrote about this, and the idea that human culture mistakes human dignity as something distinct from our animal nature. Dichotomizing man from animal, human from chimp, is an oversimplification of nature and the world, ignoring life's complexity, something with which Mary Midgley made a great effort to correct in her writings. Here is a quote from her autobiography that I love and could be appropriate here: "On one side there were the people who said there was no such thing as human nature, that was the social scientists and also the existentialists, and on the other, people like Desmond Morris, who said there is such a thing as human nature and it's brutal and nasty. And I thought we do have nature and it's much more in the middle. And the other animals are not as beastly as was suggested nor are we so unlike them").

Finally, we use the chimpanzee as the model for our common ancestor for practical reasons: all of our prior hominid ancestors are extinct, while chimps are alive and scientists have thoroughly studied many aspects of their foodways, giving us important data about the origins of our own foodways. In conclusion, we use Chimpanzees as the model of our common ancestor because we have multiple reasons to believe that the two were remarkably similar and because we have so much data on the Chimpanzees. In fact, for the purposes of this book, we look deeply at the foodways of Chimpanzees and then even more strongly at the foodways of Paleolithic humans; and then note the differences, and then show that those explain the ways that we hominids evolved over seven millions years ago. From now on, whenever referring to Chimps as the model of our common, human ancestor, we will call them "our theoretical ancestor."

In the second part of this book, we will delineate the similarities and differences in the foodways between chimps and Paleo Humans as one of our tools to trace the evolution of our foodways. For now, I will give you an overview and then delve further into the details later. In our sensing, we are similar to chimps because we are both less good at hearing and smelling, as compared to many other mammals, and way better at seeing. We both possess binocular and trichromatic vision that allows us to see wider spectrums of color in complicated environments. We also taste all five or more of the same flavors, which we use to help us sense and consume certain nutrients in our environment--although we have reasons to believe that our sense of taste has also changed significantly from chimps due, in part, to our cooking.

As for locomotion, we share some similarities and differences. We both can locomote on land and in the trees, but we humans are obviously way better on the land and the chimps in the trees. As we hominoids evolved from our theoretical ancestor, we became increasingly capable of travelling efficiently over the land--while continuing to be able to access trees for various foods like fruit and honey. For capture, both share similar arms, hands and fingers, making us both one of the most dexterous animals, great at manipulating foods and creating and using tools. We even create many of the same tools: straws, sponges, spears and rock hammer and anvils. We also share similar hunting strategies, involving surrounding prey, blocking escapes and corralling. Although the origins of our locomotion and capture is found with the Chimps, we obviously advanced well beyond them.

Our teeth are quite different from chimps', showing our further evolution from them in pertinent ways. The earliest hominids, Australopithecus, evolved larger, flatter teeth as compared to chimps, to ostensibly crack and grind tougher foods found on the plains (Estebaranz 2009; Ryan and Johanson 1989)--but then our teeth became much smaller once we started grinding and cooking our foods outside of our bodies (Cartmill et al., p.597). For digestion, we possess the same basic anatomy and function as the chimps, having three separate parts: the stomach, small intestine and colon but we also evolved differently from them: as we evolved to eat more refined foods, including animals with less fiber, and process our foods outside of our bodies, our overall digestive systems became smaller relative to the size of our bodies, and our colons especially became smaller.

In the metabolism of underlying nutrients in food, we all possess the usual underlying Eukaryotes that all have the same or similar metabolisms and nutritional needs. For example, like the Chimps, we also need glucose for brain catabolism; and amino acids and fatty acids for anabolism throughout all our cells. However, we humans have also evolved to be different from the Chimps, especially in our greater catabolism of fatty acids as compared to organic acids, as well as our greater need for glucose for even larger brains; we have also additionally evolved to have higher, overall body metabolisms as compared to the Chimps, and especially in relation to the overall size of our body.

We can also see the origins of our diet with the Chimps, as well as the ways that we evolved from them. While many animals specialize in a narrow range of foods, most humans and chimps are both diverse and omnivorous feeders, eating many different kinds of plants and animals. When our environment allows, we humans will feed on both plants and animals. And we both like to get all or most of our macronutrients from our diet---although, as already mentioned, some humans in extreme locations eat only animals--and therefore do not receive ample sugars in their diet.

We also tend to feed on various kinds of sugars to feed our more encephalized brains. While chimps focus more on fruit, which accounts for about eighty percent of their diet, humans focus first on starch, then on fruit and honey. We both feed on fatty acids to feed our muscles and heart, although humans evolved to consume way more fatty acids than chimps. Like all animals, we both focus on foods rich in amino acids. While chimps get most of theirs from tender leaves first and then from seeds and various animals, humans focus more on animals first and different seeds second. We both draw nutrients from fiber, but chimps draw more due to their greater intake and larger colons.

Compared to the Chimps we are three times more encephalized. However, we can clearly see the origins of our encephalization in them, specifically as related foodways. Both chimps and humans use their intelligence for knowing large and complex territories and the location and behavior of food. We share many cultural similarities: for example, we both live in larger groups that tend to sleep together. We also share the same division of labor: female Chimps gather plants and raise their children to the age of three while men also gather plants but also hunt and protect their territory. Chimps and humans both communicate the whereabouts and types of predators and food. And we both use tools to capture and refine our food. While the origins of our encephalized behaviors are found with Chimps, we have clearly evolved well beyond them in all ways of intelligence, culture, communication and tools.

DIET

As we have seen, chimps inhabit various ecosystems. Whether they are in one ecosystem or another, they are usually focused on fruits where they get about eighty percent of their calories; even when fruit is not abundant, they will take extra effort to find it. Most of the rest of their diet comes from young leaves, buds and blossoms--with the remainder consisting of seeds, nuts, honey, bark and resin. (It is suggested that their diet is: 65% fruit, 30% leaves and shoots, and 5% animal matter). (Stanford & Nkurunungi 2003) Chimps also eat animal foods, about 5% of their diet is animal matter (Stanford and Nkurunungi 2003). Milton states they likely consume about 48g of protein per day (Milton p.16) and Stanford reports that Gombe chimpanzees may eat was much as 65 grams of meat per day (Stanford, Craig B.). In the form of termites, bugs and other small mammals, which they acquire through hunting. Instead of focusing on one particular plant food, they will consume as many as eighty different plant foods (can be up to 200 species in a given group), to avoid overloading their bodies with too much of any one particular toxin; furthermore, plants are not typically available year-round. As Jane Goodall, further writes: "For berries, chimps generally eat straight off the vine but, with fruit, they generally pluck the fruit with their hand and then feed into their mouths. They devote nearly all of their time to feeding, especially when certain foods need longer time to process, either through chewing or the use of tools, and the remainder of their time moving through their territory; they do not nap as much as other primates, perhaps due to the superior energetics of their diet. When encountering novel foods, chimps have been observed cautiously eating only small amounts at any time, evidently for fear of poisoning themselves. After the initial experimentation, however, they will then begin to feed on the food more vigorously." (Goodall 1986)

Note: Chimpanzees' diets differ according to changing habitats and to the culture of a specific group of chimpanzees.This results in chimpanzees from different areas and groups to eat different species of plants, or to eat plants in different ways. Culture seems to be the primary influencer; however, when fruit is scarce, oil palm is a key food, with Bossou chimpanzees spending 23.9% of their feeding time eating oil palm parts. Nuts are also consumed.

Since chimps eat mostly fruit and young leaves, it may be tempting to think that their plant foods taste something like what we encounter at the salad bar--but that is evidently not the case at all; as most of their food, to our own tongue, is quite foul and even toxic-tasting. For example, Richard Wrangham reports that while chimp food is better or more refined than monkey food, it nonetheless is foul: for example, one of their foods, Warburgia Salutaris, tastes like mustard oil which in small quantities may be good on your salad--but he reports to eat just one is difficult while the chimps will eat lots of them (Wrangham p.51). He also reports that much of their food tastes astringent and others leave the tongue feeling numb (Wrangham). It's likely that these off-flavors and effects signify toxicity--but chimps, unlike humans, possess the biochemistry to detoxify these plants, therefore making them edible. (Astringency doesn't signify toxicity per se, though too much astringency (i.e. too many tannins) could be problematic from a nutrient digestion and availability stand-point.)

Note: Chimps spend up to 80% of their time feeding. (Tweheyo, Lye, & Weladji 2004). They consume fruit early in the day, and leaves later in the afternoon. Chimps' tendency to feed on leaves at the end of the day may be due to a significant increase in the sugar and starch content, and a decrease in the harder to digest fibers in leaves from morning to late afternoon (Carlson 2013).

PLANT FOODS

Fruit specialists—regardless of habitat type and the fruit supply, chimps focus diet on fruits, mainly from trees, especially figs (the most important staple food in chimp diet) and drupaceous fruits with large seeds (e.g. cherries, peaches, apricots are ex's of drupaceous fruits in modern human diet); fruits range from tiny, seeded figs to large, sweet and pulpy fruits, also latex-filled fruits that pass largely intact through gut; young leaves and leaf buds account for most of the rest of dietary intake; blossoms, seeds, nuts (panda, coula, oil palm nuts), stems, pith, bark and resin consumed in smaller amounts; roots/tubers, sap, rotting wood (licked for salt), mushrooms, algae may also be consumed on occasion

Chimps will cover large portions of their home range in search of ripe fruit. When staple foods are more limited, chimps will forage in smaller subgroups. Chimps forage in larger groups when ripe fruits are abundant.

ANIMAL FOODS

As we have noted, chimps do not devote that much time to hunting while, at the same time, animal foods do indeed seem essential to their diet. Generally they devote only about ten percent of their time per day to foraging for animal foods. Or said another way: although animal foods only account for about three percent of their calories (5% of diet is animal matter (Stanford & Nkurunungi 2003); however, meat specifically accounts for only about 3% of chimps' eating time (Stanford, Craig B.)), chimps will devote way more percentage of their time feeding to acquire them, suggesting that they need them for some purposes apart from calories and bulk alone. Some chimps have been observed as devoting thirty-seven percent of their time foraging to attain four percent of their calories in the form of termites (Bogart & Pruetz 2011). In other words, chimps spend only small amounts of time acquiring animal foods relative to plant foods--but, at the same time, they spend a tremendous amount of time foraging for animal foods relative to how many calories they actually provide.

Since chimps get so few of their calories from animal sources--but evidently regard them as highly important--researchers speculated that they acquiring meat for social, not nutritional, needs--and as such, developed some theories around the idea that meat-eating evolved as a way to form alliances between males and establish leadership or otherwise acquire sex from females--behaviors which we have already addressed.

Note: Stanford attributes some theories originally to Geza Teleki (1973) who originally argued that chimps hunt for social reasons, and states that Kortlandt (1972) argues that male chimps hunted to show their prowess to other chimps. In contrast, and in accord with your statements below, Stanford says that Wrangham (1975) concluded hunting was nutritionally based, though not all hunting behaviors were well-explained by nutritional needs, leading Nishida et al. (1991) to conclude that the alpha male capture meat as a political tool and McGrew (1992) concluding that female chimps give ex for meat. Overall though, Stanford rejects the social angle, sthat that "My own preconception was that hunting must be nutritionally based. After all, meat from monkeys and other prey would be a package of protein, fat, and calorie hard to equal from any plant food" (Stanford-http://www-bcf.usc.edu/~stanford/chimphunt.html)

However, in my mind, these theories are problematic due to the fact that, as we have already seen, animals, including chimps, just do not eat for calories: they eat to acquire the specific spectrum of nutrients they need for energy and building-blocks. For this reason, while chimps may or may not need to hunt for calories, they may need animal foods for other nutritional purposes, such as amino acids, unique fatty acids needed by their body but not found in the rest of their diet, macro and trace minerals and even vitamins; for example, while protein can be converted into calories; it generally is not unless an animal is deprived of either sugars or fatty acids which is rarely the case.

So it's possible to assume that chimps are hunting, not for calories which they can easily acquire through fruit, nuts and palm oils--but for amino acids--which raises the question as to whether chimps can't get enough amino acids from plant foods alone.

Protein Intake

"Although wild fruits as a class are low in protein, fruits average 6.5 +/- 2.6% protein dry weight (range, 3.2% to 12.6%). An 8-kg wild howler monkey is estimated to take in about 300 grams dry weight of plant foods (leaves, fruits, and flowers) per day. Let us assume that a 41 kg adult chimp, which is about five times larger than an adult howler monkey, takes in an absolutely greater amount of food, or 1,5000 gram dry weight per day. This is a crude approximation, but it will serve to make my point. If this food were all fruits with a protein content of 3.2% per gram dry weight, which is the single lowest protein content in a sample of 18 fruit species from Panama, this chimp would be taking in approximately 48 grams of protein per day. That amount, given an estimated requirement of approximately 1 gram of protein per kg of body weight per day, could at face value, cover its estimated protein needs if the protein was sufficiently high-quality.

In addition, it is certain that fruit protein is not digested with 100% efficiency; ca. 50% efficiency is probably more realistic. But most wild fruits have protein contents higher than 3%...Also, there are other protein-rich foods in the forest, including young leaves, some mature leaves, some nuts and seeds, and some flowers, that could help make up any amino acid deficits. Common chimps, particularly females, also often "fish" for termites and ants, sometimes devoting hours per day to this activity. This suggests that although termites and ants are small, the nutritive benefits they provide are worth this considerable investment in time."
(Milton, K. "Hunter-gatherer diets..." p. 16).

"In the wild, many primates take in more grams of vegetable protein per day than seems necessary based on body weight. This probably reflects that vegetable protein, even high-quality protein, shows a lower digestibility than animal protein. Assimilation studies have indicated that 20% or more of the total N concentration in wild plant parts is not available to the primate feeder." (Milton, K. "Back to Basic...").

"Most primates relish meat and will eagerly consume it when available in the wild or offered in captivity. The barrier to greater meat consumption by wild primates appears to be its patchy distribution and high cost of procurement in the natural environment rather than any physiologic or gustatory barrier to animal foods."
(Milton, K. "Back to Basics..." p. 482).

"In the wild, chimps are estimated to ingest an average 10 grams meat/day/chimp, [which] as a dietary protein complement, is of little importance (less than 0.5% of the diet), compared with the other types of animal foods, especially ants & termites." (Lang, C. Max, Curt H. Barthel).

Milton 2003-States that meat digestion in captive chimps was well digested, both in cooked and in raw form. Tappen & Wrangham 2000-Also found no evidence for poor meat digestion in captive chimps, similar passage time and digestion to wild chimps. Milton & Demment 1989 also found no problems in captive chimps. Also, in the Milton & Demment article, they do say that only 6 of the 72 chimpanzees offered raw beefsteak actually took it, and 11 of 80 took chicken when it was offered; however, I can't find any other evidence that captive chimps are reluctant to eat meat. So, I'm not sure if it makes sense to say that captive chimps are reluctant to consume meat.

Mammal prey: medium-sized mammals (including other primates) (Goodall 1986; Boesch & Boesch-Achermann 1989; Isabirye-Basuta 1989). Their most common mammalian prey is the red colobus monkey (Procolobus badius), though they also eat blue duikers, bushbucks, red-tailed monkeys (Cercopithecus ascanius), yellow baboons (Papio cynocephalus cynocephalus), and warthogs (Boesch et al. 2002).
(http://pin.primate.wisc.edu/factsheets/entry/chimpanzee)

“...meat comprises a very small proportion of the chimpanzee diet. At Gombe National Park, Tanzania, chimps spend less than 5% of their feeding time consuming meat.” (Tennie, Claudio et. al. p. 422).

“At Ngogo, we have established for the first time a positive relationship between hunting frequency and fruit availability...hunting is an energetically expensive activity...Hunting here occurs most often when the chimpanzees can easily meet their daily energy needs because they have large fruit crops available. Thus, hunting and patrols are to some extent luxury activities that occur when no risk of energy shortfall exists.” (Mitani, John C. & David P. Watts).

"Requirements for juvenile to adult primates, expressed as grams of protein per kilogram of body weight (BW) per day, range from 0.59 g/Kg of body weight for adult humans to 4.3 grams per Kg of body weight for juvenile squirrel monkeys; most adult primates (when there were sufficient data) required less than 3 g per Kg of body weight per day. When the daily energy intakes of the species were considered, protein concentrations needed to support requirements were 4.6 − 7.5% of metabolic energy calories or 6.4-8% of dietary dry matter. There were insufficient data on adult rhesus macaques and chimpanzees to fix requirements exactly."

This research supports the notion that chimps can't get enough protein through plant foods, combined perhaps with some bugs--but this does not seem terribly conclusive, especially given that some plant proteins are not that well digested.

Insects 4 percent of fresh weight ingested

Some minerals, protein, and fat may be acquired in the small amounts of meat consumed by such primates as the chimpanzee. Chimpanzees are capable of digesting small amounts of meat consumed over relatively length spans of time averaging as long as 3.5-9 hours (Goodall 1986). While their consumption of meat does contribute to their overall protein intake, the relative protein contribution is considered to be of little importance in supplying any significant amounts of protein to their overall diet. Despite this, meat is often prized among chimpanzees, and is the only food that has been observed being shared (Harding 1974, Boesch 2002, Goodall 1990 pp.210-211, Stanford).

Diet information-by species of chimpanzee

Fongoli chimpanzees spend more time obtaining termites than any other chimpanzee population studied, and this extensive insectivory contributes to the list of distinctive behaviors they display relative to chimpanzees living in more forested habitats. We suggest that savanna chimpanzees at Fongoli differ significantly from chimpanzees elsewhere as a result of the selective pressures characterizing their harsh environment, and this contrast provides an example of a viable referential model for better understanding human evolution. Specifically, our results support the hypotheses that invertebrate prey may have figured more prominently into the diet of early hominins in similar habitats, especially given that invertebrates are an important source of protein and other essential nutrients in a highly seasonal environment. (Bogart 2011)

Source for digging for food: McGrew, W. C. “Savanna Chimpanzees Dig for Food.” *PNAS*, National Academy of Sciences, 4 Dec. 2007, www.pnas.org/content/104/49/19167.full.

This is the first systematic study of chimpanzee diet composition at Toro-Semliki Wildlife Reserve, Uganda. The Mugiri community is the only habituated savanna chimpanzee community experiencing a bimodal rainfall pattern. Over one year (2009-2010), diet composition of this community was assessed through fecal samples (n=311) and observations.
Semliki chimpanzees relied on 1-2 food species in their monthly diet, and most food items were harvested in the gallery forest, rarely from the bush- and grassland. After the unusually short first dry season in 2010, normally preferred species failed to produce an abundant crop. Chimpanzees consumed figs, Phoenixpalm fruits and fruits from shrubs (Securinega virosa, Dovyalis macrocalyx). When these were depleted, chimpanzees fed heavily on the cambium/bark of trees and Aframomum fruits. This study supports the notion that savanna chimpanzees must cope with great spatio-temporal variability in food resources. (Deimel 2013-poster abstract)

Do not consume c4--not grasses or animals that feed on these (Sponheimer 2006).

While chimpanzees at Fongoli are species-typical in certain regards, such as including ripe fruit in the diet during all months of the year, they also adjust their behavior to the particular stresses of this dry, hot and open environment. For example, their large home range (>63 km2) is sometimes used cyclically, with the community traveling as one large party, in contrast to the typical chimpanzee fission-fusion pattern. Here, we report on Fongoli chimpanzee activity budgets and ranging behavior during dry versus wet seasons based on over 2500 hours of observational data collected from March 2005-August 2006. Combined with data on temperature in the various habitats within the savanna mosaic, results show that Fongoli chimpanzees minimize energy expenditure during the hottest months and at the hottest time of day by resting more and traveling less in addition to selectively using small patches of closed-canopy habitats, such as gallery forest. Details of how chimpanzees alter their ranging behavior on a larger scale at these times will also be examined (Pruetz and Bogart 2009).

animal prey eight percent of their diet, so not that much more (I think this is from Goodall 1986, not certain though)

Further on diet: 60 different plants, fewer species than other chimps, but still same basic distrubution of lots of fuits, and leaves but consume more unripe fruit, more seasonal availability so more fallback foods, less in the wet season so more fallback foods then, like bark
so adaptation seems to be chimps cover more terrain, stay together more, but still eat the same diet..... (Pruetz 2006, pp.161-182)

SENSING

HEARING

Hearing red colobus monkeys calling may incite a hunt (Wrangham, McGrew, de Waal, & Heltne p. 84).

Males sometimes make sound-producing, non-vocal displays (e.g. throwing rocks in water) (Jane Goodall Institute of Canada)

Clear anatomical differences in the middle and outer ears of chimpanzees and humans (Nummela 2005; Masali, Maffei, and Borgognini 1991)
Source: Masali, M., Maffei, M. & Borgognini Tarli, S. M. (1991) in The Circeo 1 Neandertal Skull: Studies and Documentatio

Hearing most acute at 1 kHz, the frequency of pant-hoots, and at 8 kHz; loss of sensitivity at middle range frequencies (2-4 kHz) making it difficult to differentiate between human vowel sounds and to understand spoken human language (Martinez 2004)

Note:These differences in human and chimpanzee hearing is related to several genes that likely underwent adaptive evolutionary changes in humans due to the need to understand spoken language. One of these genes is related to the development of the outer and middle ear, which makes sense, as the anatomy of the human and chimpanzee outer and middle ear differ (Martinez 2004). Another important gene, which some say has the “most significant pattern of human-specific positive selection is alpha tectorin”-this gene makes a protein that is vital in the tectorial membrane of the inner ear, which affects our ability to hear different frequencies of sound (Clark et al. 2003)

SMELL

Based on genetic data, chimpanzees and humans appear to be able to detect a somewhat different set of odors. Anatomically, chimps’ olfactory bulb is more than twice as large as it is in humans (Go & Niimura 2008), which may indicate that chimpanzees have a greater sense of smell, but this has not been proven yet. There have been no behavioral studies that have directly compared chimpanzee’s and human’s sense of smell.

As in other higher primates, chimpanzees are overall less reliant on their sense of smell. Genetic studies have revealed that both humans and chimpanzees have been acquiring dysfunctional olfactory genes at a relatively similar rate since they diverged from a common ancestor. Humans and chimpanzees living today possess about the same number of intact, functional olfactory genes as well dysfunctional pseudogenes. In spite of this similarity, 25% of the intact OR (olfactory) genes in humans and chimpanzees are specific to the species (Zufall & Munger p.55 & Menini p.185), suggesting that there are likely to be some differences in the repertoire of odors that can be detected by chimpanzees versus humans (Hirohisa, Imai & Go p.51)

Distinct lifestyles and of course dietary differences giving rise to varying selective pressures on odor detection are thought to underlie the genetic variation in OR (olfactory) genes between humans and chimpanzees. Of course, the integration of cooked food that offers its own unique array of odors may have given rise to new olfactory needs in humans (Gilad 2003). Chimpanzees also use sense of smell within social and sexual contexts that humans do not. Male chimpanzees engage in territorial “patrol-type sniffing” to detect foreign chimpanzee invaders (Matsumoto-Oda et al. 2007). Female chimpanzees in particular often sniff their food before ingesting-this is to increase their feeding efficiency, which helps them achieve reproductive success (Matsumoto-Oda et al. 2007).

Male chimpanzees also engage in more sexually-oriented sniffing behavior-like sniffing female genitalia or their finger after touching genitalia. While male chimpanzees do engage in patrol-like sniffing behaviors, they more often sniff in the central part of their territories, not on the edges. In the Matsumoto-Oda article, they only sniffed on patrol 1 out of 31 times, the other 30 times they sniffed in the central part of their range. Matsumoto-Oda say that males likely sniff in a social context to collect information on their group of chimps and to manipulate relationships between members, including their relationships with other members of the group (Matsumoto-Oda et al. 2007).

Females also sniff themselves or their hands after checking themselves (particularly their genitalia)-Matsumoto-Oda calls this ‘self-checking’ (Matsumoto-Oda et al. 2007).

VISION

Trichromatic, Excellent Visual Acuity up close and far away, Good Depth Perception, Color vision deficiencies (e.g. red-green color blindness) more rare than in humans, Vision is important for social interactions as in humans

Trichromatic vision, same color range as humans (blues, greens and reds) (Rumbaugh 1977-need pg.#, Surridge 2005 p.64)

Allows for the detection of ripe, red/orange fruits and young leaves dappled in red that are lower in plant toxins and digestive inhibitors, and higher in more readily absorbable protein (Surridge 2005 p.64) (They hypothesis is that trichromacy actually evolved specifically for the purpose of identifying ripe fruits against a background of forest leaves and for identifying high protein leaves-particularly since trichromacy allows for great discrimination between red and green (Surridge p.64 & Dominy & Lucas 2004).

A gene duplication event occurring 35 million years ago gave all Old World primates the genes to code for 3 different kinds of opsin protein pigments sensitive to short, medium, and long wavelengths of light. (Jacobs 2008)

Color vision defects among wild chimpanzees are rare, estimated up to this point to occur at a frequency of only 1.6% (Saito et al. 2003). In humans, defects are more common with the prevalence of red-green color blindness estimated to be 8% (Surridge 2003).

Also share with humans: Forward facing eyes set side by side that allow for binocular and stereoscopic depth perception for seeing relative distance of objects in a 3D space; Excellent visual acuity — can fine focus on objects up close (within a few centimeters) and far away (Matthews p.19)

Like humans, vision plays an important role in the chimpanzee's social life. Vision is used to interpret facial expressions, gestures, to follow another's gaze, and to identify who is kin or has an alliance (Surridge p.64). (The ability to recognize other individuals via visual discrimination is considered crucial to the development and evolution of mammalian social systems- interestingly, chimpanzees are highly skilled at identifying mother-son relationships in unknown individuals simply using visual cues!)

TASTE

Chimp taste (taste all five flavors)

Question: *Even though Chimp ostensibly have all five tastes, same as us, their food reportedly is disgusting to the human palette...So clearly we taste different? Or interpret tastes differently?*

The basic answer to these two questions are yes and no, go figure. Essentially, we have different taste sensitivities to particular tastes and to astringent/tannic foods. So, things taste different due to our sensitivity, which means we interpret the taste differently for a given food. However, this doesn't necessarily mean that bitter, overall, tastes different for humans versus chimps; rather, we experience 'bitter the same, only at different concentrations. (see below for detailed information)

SWEET

Humans and chimps have same taste threshold for fructose (Remis 2006 & Hladik 1996)
Chimps also express the same facial reflex as humans with regard to sweet foods. Specifically, they show a slight smile and a relaxed facial expression. This is the same reflex human babies show in response to sugary foods. The fact that this reflex is consistent between species shows some similarities in taste preferences (Hladik 1996).

Similar patterns in humans:
Interestingly, humans who live in different environments (i.e. the rainforest vs. the savanna) show somewhat different taste thresholds for sweet flavors. For example, people in forest populations show lesser taste sensitivity to glucose and fructose than people in savannah populations. This is likely because fruits in the rainforest are extremely sweet, so they have correspondingly lower sweet sensitivity. Foods in the savannah environment are less sweet, so

greater sweet sensitivity in human populations in the savannah promotes foraging efficiency (Hladik 1996).

Question: *As for sweet, sucrose, in particular, I believe we are about the same as Chimps in our sensitivity?*
Correct, our thresholds are similar to chimps' (Hladik 1996) We do not really cook our fruit or honey and it does not change the sweetness much anyway. In short, I do not see any reason why we would vary our sensitivity to sweetness from chimps. Since sweet foods almost always provide calories, our sweet sensitivity is modulated to make us enjoy foods with sufficient sweetness linked to sufficient calorie intake. That way, we are positively reinforced to eat the sweet foods and get enough calories to survive. If the sweet foods didn't have calories, we probably wouldn't like them as much, since we wouldn't be positively reinforced from an energetic perspective to eat the sweet foods.

ACIDITY
Humans, chimps and other primates similar taste thresholds for citric acid (Hladik 1996)

We have similar taste thresholds and innate responses to acidic foods (i.e. sourpuss face when we eat sour/acidic foods as babies) (Hladik 1996).

BITTER

Chimps, also similar to humans, have a negative facial response to bitter foods and the typical pursed mouth response to acidic/sour foods (Hladik 1996, Simmen & Charlot 2003). Chimps definitely taste bitter foods, though their bitter taste sensitivity is lower than that of humans. chimps taste bitter less than we do: foods that are overwhelmingly bitter to us are tolerated by chimps--chips can tolerate bitter four times more than we can--due to their ability to detoxify the bitter (Hladik & Simmen 1996)

Question: *We already know that we are way more sensitive to bitter. We taste bitter better, which is negative, which then makes us eat less bitter. Why is this?*

Tasting bitter is not actually a negative, it's a survival mechanism that's held over to the present day, so I wouldn't consider it a negative. Importantly, we can be conditioned to like bitter foods over time, thus overcoming the natural bitter taste aversion. Common examples of this include coffee, beer, dark chocolate, and dark green veggies. One interesting piece of information about aversion to bitter taste remaining is that there is a tuber (cassava) that has a compound that inhibits the growth of the malaria parasite. It was a little unclear to me how this worked overall, but the implication was that humans who have the gene that increases bitter taste sensitivity will eat more cassava and be protected- a little confusing, but the main point is that the researchers (Hladik et al.) suggest this bitter taste sensitivity is still a good thing. They also say that some populations prefer bitter cassava to sweet varieties. They also write about our ability to adapt and eat more bitter substances over time, despite original disgust at the flavor. Of course, some data suggest that bitter taste, while somewhat protective against toxic foods, isn't completely protective, as there are several toxic foods that we don't taste as bitter, and thus are not protected from eating them. This is why, according to the researchers, humans experience food neophobia (fear of new food) during the preschool years (3-4 years old) to protect against eating potentially toxic foods. They specifically state that the evolution of bitter taste thresholds in humans may have happened "exclusively in response to naturally occurring toxic chemicals of potential foods" and that bitter tasting foods correspond to peripheral stimulation in the human body and to genes.

Hladik et al. suggest that chimps are less sensitive to bitter (and humans more sensitive) because there are more potentially toxic foods in their environment, and the proportion of bitter foods in their diets aligns with the proportion of bitter foods in their environment. They say that there was likely coevolution between primates and their environments/feeding niches. However, they do note the point about toxins not always being detectable by bitter taste. Overall, it does seem like there's still missing information on this

Other notes on bitter: Chimpanzees can learn the positive effects of consuming bitter foods to help 'cure' themselves from parasitic infections, which likely helps explain their higher threshold for bitter (Hladik & Simmen 1996)

*We cannot detoxify and tolerate bitter/toxins as well as primates and chimps,
*We tend to specialize on fewer plants—so we are at risk of overconsumption one toxin in particular—so we are more sensitive as a warning. Yes, in contrast, chimpanzees have so many bitter foods in their environment, so high sensitivity to bitter would limit their ability to survive to a certain degree, if it resulted in them rejecting so many foods that they didn't consume sufficient calories. Also, as noted above, their sensitivity to bitter aligns with the presence of toxic bitter foods in their environment.

*Accordingly we evolved to have less bitter in our diet through several channels:
+more animal foods
+more refined foods, with less toxins, such as fruits, tubers, grains
+and cooking, perhaps most of all, which destroys many toxins and reduced taste of bitter

Other note on bitter: Chimps have more T2R genes than humans. These are the genes that affect bitter taste perception. The evolution of these genes likely reflects species' specific diets. Having more functionally T2R genes than humans suggests that chimpanzees might be able to distinguish more kinds of tastes than humans can (Sugawara et al. 2011). Additionally, the ability to taste bitter foods actually differs between subspecies of chimpanzees, which implies that each subspecies evolved bitter taste receptors that are specific to their environment and the associated bitter (sometimes toxic) chemicals they could potentially consume (Nakamura, Hosaka, Itoh & Zamma p.254). This supports your arguments above regarding how humans refining and cooking foods destroys many toxins, thus reducing the taste of bitter. Due to the fact that we successfully remove many toxins from our foods, it makes sense that we would need to be highly sensitive to bitter and associated toxins when they do exist in our food. Overall, our food environments evolutionarily promoted greater bitter sensitivity, while chimps' environments promoted lesser bitter sensitivity, as well as sensitivity to particular bitter foods in their subspecies' environments.

Astringent: causes mouth to dry out and feel fuzzy

Chimps have much greater tolerance for astringency (makes mouth feel dry and fuzzy) for example, chimps eat unripe figs that to humans are disgusting because of their astringency. (Reynolds pp.62-64)

Tannins: most foods are either high in sugar and low in tannins or the reverse. but in some cases, they are high in tannins and sugars and chimps can eat their fill of these foods (Hladik 1996).

In humans, the median threshold for tannins is around 1mM/L, but it ranges widely, from 0.3-10mM/L. (Hladik 1996)

Question: *Astringency is obviously different between human and chimp. This may affect the cooking hypothesis. It does seem that undercooked fibers feel somewhat astringent on the tongue—but cooking appears to change fibers making them less astringent (ex. Cooked vs raw plantains) In any case, fiber in raw food does affect mouthfeel—and I do believe we have evolved to tolerate less raw fiber as the UM experiment recently revealed?*

Important note: Astringent foods are high specifically in tannins. Tannins are not necessarily in high fiber foods. Tannins are a type of polyphenol, which commonly exist in fruits in particular (Clemson 2012). In other words, there isn't a correlation between the astringency of food and the amount of tannins. Though some high fiber foods are high in tannins. The foods high in tannins include grapes, pomegranates, barley, nuts, beans, chocolate, tea, and red wine. With regard to cooking, steeping tea longer increases the tannin content and aging red win in oak barrels also increases tannin content. Tannins also tend to concentrate in fruit peels, so peeling fruits reduces tannin content. Hulling beans (like soybeans and cowpeas), decreases tannins, similar to peeling fruit, because the tannins are mainly located in the seed coat. Also, soaking beans and pulses overnight can decrease tannin content from 25-50%. Finally cooking beans and pulses can decrease tannins by up to 70%. So, your theory that cooking foods helps with tannins is correct, it's just that this is specific to tannins, not to fiber. (Tannin content of pulses: Varietal differences and effects of germination and cooking. P. Udayasekhara Rao; Yeshwant G. Deosthale; and "Effect of soaking, dehulling, cooking, and fermentation with Rhizopus oligosporus on oligosaccharides, trypsin inhibitor, phytic acid, and tannins of soybean, cowpea, and groundbean"; Egounlety and Aworh- 2003).

With regard to tolerating less raw fiber, this seems likely to me as well. Particularly in considering the Hadza-they have the high fiber tubers and they chew and spit out the fibrous matter. This makes sense because too much fiber interferes with nutrient absorption and fills us up without providing calories, which could be dangerous if we have so much fiber that we don't eat enough calories for survival.

With regard to cooking effects on fiber- that depends on the characteristics of the plant's cell wall structure. Plant cell walls are degradable depending on the cooking conditions. For example, cooking apples sloughs off some of the plant cells from the cell wall, making the fiber easier to digest. Another example is carrots, cooking the carrots ruptures the cell walls, thus decreasing the fiber content. Grinding foods before cooking them also disrupts cell walls and reduces the particle size of the fibers. Cooking fibrous foods can also make them more viscous, changing mouthfeel, as you note. So, yes, cooking affects both fiber and tannin content of foods, making them more appealing to humans. I haven't actually found data on how this specifically relates to evolution of taste, but it seems like we've been cooking long enough in human history to suppose that the effects of cooking on fibers and tannins resulted in coevolution of taste. This makes sense when examining chimps- whose sensitivity to tannins is much lower than ours, allowing them to tolerate much more astringent foods. This tolerance allows them to consume more foods in their natural environments to meet their nutrition needs. Without this tolerance, they might not have survived, because the foods in their environment would have been unpalatable. Humans, in contrast, are less tolerant, possibly because cooking foods lowers tannin content, so we're more sensitive. Overall, I'm thinking your hypothesis about cooking effects is likely correct, there just isn't enough data I've found to confirm it.

SALT

Chimps can taste salt; however, none of their foods has enough salt to actually exceed their taste thresholds, meaning that, while chimps can and do taste salt, the foods they eat actually do not taste salty to them.

The Pygmies are more insensitive to salt than any other humans--due to not much salt in their environment. Indeed, pygmies have poor taste acuity for sugar too-the fruits they eat have 10-50x greater sugar content than that of the weakest sugar solution perceived in other humans (Hladik 1996)

Inuit, way salt sensitive, to keep them from overconsuming (Hladik 1996).

Question: *Where are we on the salt threshold of sensitivity? Assumably, we have lower sensitivity, because we evolved later to consume more which is ok, because we also evolved to excrete more of it through urine?*

The salt story is a little less clear. Even Hladik et al. (2002) state that 'salt perception appears even more puzzling in the context of coevolution'. They disagree with the idea that salty taste evolution emerged due to the relative rarity of salt in the environment, stating that, in natural diets, thresholds for salty taste perception are too low to taste the salt that naturally occurs in foods. So, we couldn't taste salt sufficiently to help us achieve adequate salt intake in the past simply by detecting the flavor. They do state that adding salt to food is a recent phenomenon in human evolution, stating that we can't really talk about salty taste perception evolving with response to diet, since we've had such recent changes in our diet with regard to salt. This makes me think that perhaps we are currently evolving to have a different salt taste threshold because we have so much salt in our diets now. Overall, we're not very salt sensitive, as mentioned above- our sensitivity to salt is too low to detect the salt naturally occurring in vegetables, etc. – and Hladik et al. say that, if salt taste evolved for optimal adaptation, then the best adaptation "would have resulted in lower thresholds, allowing for detection of sodium in available foods" (2002). Since this isn't the case, they state that adaptive responses that are independent of salt taste perception are likely what drove humans to eat sufficient salt, despite lack of ability to taste it in naturally occurring foods. So, basically, the beneficial effect of salt in our bodies promoted us eating foods with salt, even though we couldn't actually taste the salt. We learned a preference for these foods that correspond with adequate amounts of salt in the diet. This is a great example of learned conditioning with regard to food intake.

As far as removing the extra salt through urine- yes, we do that, so in the short term, that's protective against high salt levels in our diets. I do wonder, as mentioned above, whether we might currently be evolving our salt taste perception in response to added salt in the diet. An adaptive evolution would likely promote increasing our salt sensitivity so that foods taste even more salty, and possibly so salty we will no longer enjoy large amounts of salt. This would help protect against too much salt intake. However, thousands of years will need to pass to answer that question! In the meantime, thirst mechanisms and the kidney's ability to filter and excrete excess salt can protect us against some of the negative effects of too much salt. Side note: Only about 7% of the human population have hypertension that is responsive to salt intake, so while salt can increase the risk for or extent of hypertension, this only happens in a small part of the population-predominantly people with African heritage.

My overall interpretation based predominantly on Hladik's writings is that we can't view salt taste perception from an evolutionary standpoint because salt was so recently added to the human diet as a flavor enhancer of food. I think the one exception to this is Inuit, because they are the only group who had sufficient salt in their natural food environment to cause them to have differing salt sensitivity. As noted, they're more salt sensitive and that's a protective mechanism-this supports my hypothesis that we could be evolving to be more salt sensitive now that we have more salt in our food environment, but that remains to be tested.

UNAMI (AMINO ACIDS)

Chimps taste umami as have reaction to it but few of their foods have that as dominant taste (Nishida et al. 2000). Chimps do eat meat, providing them with amino acids (Nishida and Uehara 1983). However, scientists suggest that they are not driven by umami but rather respond to these foods--are conditioned to eat these foods, post-ingestive responses

Nakamura et al. also state that psychological and electrophysiological studies show taste responses to salt and umami in chimps (Nakamura et al. p.250).

Question: *Theoretically, we should be way less sensitive to umami than Chimps because cooking meat makes it taste way more umami—presumably because that one amino acid is being freed? If this is the case, this makes a strong case for evolution to cooking flavors.*

Cooking does degrade some of the glutathione (aka glutamic acid, MSG, etc.), which is responsible for umami flavor. Umami flavor is also related to the presence of 5'-ribonucleotides, which are present in large amounts in meats. For example, the combination of MSG with inosine 5-monophosphate (IMP) (a ribonucleotide) acts synergistically to increase the umami flavor of foods. The right combination of these two compounds increases the umami taste intensity of foods. When cooking food, some of the glutathione is changed to its disulfide version, some to pyroglutamic acid, and some to cyclocysteinylglycine. The glutathione that remains in the cooked meat contributes to umami flavor. One study investigated wet-heat cooking effects on umami-flavor compounds and found that cooking in water decreased the amount of glutamic acid, total free amino acids, and IMP in the meat, but it increased in the cooking liquid- so, it was released into the liquid. They also found that the total amount of glutamic acid and free amino acids remained the same, but IMP increased significantly after cooking for at least 10 minutes. So, cooking increased IMP, which increases umami flavor. Increasing IMP also would have changed the ratio of glutamic acid to IMP, which likely increased the taste intensity (based on the other research cited above).

Cooking does increase umami flavor substantially in some foods. For example, the taste of a baked potato is due to the natural mixture of glutamic acids and other amino acids, plus GMP and other 5'-ribonucleotides that are produced during the cooking process. So, cooking the baked potato enhances umami flavor by producing other amino acids that, combined with the umami flavors, make the potato palatable. Importantly, research shows the MSG alone does not make food more palatable; rather, a combination of MSG, salt, and other amino acids makes the food palatable. Indeed, flavoring with MSG (or glutamic acid alone) often makes food less palatable. It has to be combined with salt and/or other amino acids to make the food palatable. Also, increasing MSG or other-umami substances in food decreases the desire for salty foods.

Ripened vegetables also have more umami flavor because the amount of glutamate increases during the ripening process. With regard to tomatoes, apparently the ratio of glutamate to aspartate in a ripe tomato contributes to flavor, and the ratio and coexistence of both amino acids is important to producing the best flavor. Ripening cheese also results in the breakdown of proteins into smaller polypeptides and individual amino acids, including glutamate, among others. These increases in individual amino acids contributes to the flavor. Another example is curing ham- Curing ham increases the free amino acid content, with glutamate being the most abundant amino acid in the final product, thus contributing to overall flavor. Interestingly, glutamate is the most abundant free amino acid in human breast milk, accounting for >50% of the amino acid content. Researchers have found that infants consuming an MSG flavored broth have similar, positive reactions to those caused by sweet-tasting foods. They suggest that this implies glutamate is a powerful taste stimulus for human infants and makes breastmilk more palatable. Chimpanzee and other non-human primate milk also has free amino acids and, similar to humans, the most abundant free amino acid is glutamic acid. In human milk, there is anywhere from 1412-2157 umol/L of glutamic acid (depending on the baby's age); whereas, in chimps, it's around 2528 umol/L. Overall, researchers include humans, chimps, gorillas, and other non-human primates in the same 'cluster' with regard to the free amino acid content of their breast milk, suggesting that we are quite similar to chimps in this regard.

When considering cooking meats, I think it's also important to consider the effects of the Maillard reaction. Cooking meats causes the Maillard reaction, in which the chemical reaction between amino acids (not glutathione, however) and sugars in foods makes them taste fantastic- sort of like the flavor from caramelization, though it is a different process than caramelization. The amino acids involved in the reaction differ by the type of food. In meat, for example, the breakdown of the tetrapyrrole rings of muscle protein myoglobin contributes to the Maillard reaction and subsequent yummy flavor. This is referred to as non-enzymatic browning. It happens with both meat-based foods and in breads, toasted marshmallows, etc. When we have sear marks on steaks, that browning is due to the Maillard reaction. So, I actually think that the Maillard reaction is what is making meats taste so good when they're cooked, with umami flavor being secondary. Though, I did read that the browning of fried onions, caused by the Maillard reaction, gives an umami flavor. The umami flavor is important, but it's not as predominant as the flavor from the Maillard reaction. So, cooking does effect food flavor and does produce a yummy flavor in meats in particular, but, in the case of meat, this may be due more to the Maillard reaction than effects on the availability of glutathione contributing to umami flavor.

Side note: The origins of 'umami' taste perception were discovered in Japan in the early 1900s, specifically with regard to soups prepared from boiling dried kelp in water. Ikeda investigated the flavor and discovered that it came from the glutamate in the food. There's interesting info about this in an article in Dropbox by Yamaguchi.

THE TONGUE

Sugawara hypothesizes that taste receptor genes likely evolved under different selective pressures experienced by humans and chimpanzees, which explains our differences in, for example, taste thresholds. Hladik and Simmen note that one difference between humans and chimpanzees is the tongue. Chimpanzees have different tongue morphology than do humans and some parts of their tongues many specialize in specific tastes corresponding to taste nerve fibers. These specialized locations on the chimp tongue likely respond to bitter, sweet, or salty tastes. In contrast, humans' tongues do not have much taste specificity in particular areas, rather, the taste buds typically respond to several substances, having higher affinity for some tastes as opposed to others. Humans and chimps do express the same facial reflexes in response to bitter, sour, and sweet foods.

An important overall note on human taste: “Among humans, psychological and sociocultural factors appear to be extremely important in modulating sensory pleasure and deciding what is the desirable body image” (Hladik and Simmen). In other words, while humans do have particular taste sensitivities to specific flavors, we often overcome or modulate these sensitivities in response to social and cultural cues. Common examples of this include humans consuming coffee and dark chocolate, both bitter substances, despite innate aversion to bitterness. The fact that the taste for such bitter flavors develops with age relates to these social/cultural influences. This also explains why young children typically do not eat these bitter foods, because insufficient time has elapsed for social/cultural pressures to overwhelm innate responses to bitter foods. Food neophobia in children occurs at the same time their exploration of their environment rapidly increases, around 3-4 years old, and this food neophobia is supposed to be a protective mechanism against ingesting toxic foods. This is overcome by increased cognition and social learning as children age. Of course, innate preferences still exist in humans and are not always possible to overcome with social/cultural force or with learning. There is still wide inter-individual differences in taste preferences in humans that exist due to innate and learned mechanisms. Such conditioning also occurs in non-human primates, for example with regard to consuming the Veronia leaves to treat parasitic infections or consuming clay to prevent GI problems, though this conditioning likely occurs to a lesser degree in non-human primates. However, in contrast to the olfactory receptor gene repertoire, where humans have a higher proportion of pseudogenes than apes, there is no evidence that the rate of loss of bitter taste receptor genes varies among humans and apes.

Source: Anne Fischer, Yoav Gilad, Orna Man, Svante Pääbo, Evolution of Bitter Taste Receptors in Humans and Apes, Molecular Biology and Evolution, Volume 22, Issue 3, March 2005, Pages 432–436, https://doi.org/10.1093/molbev/msi027

Question: *Do they have smell sensitivity to cooked food?*

There’s not a lot on this, though I did find an interesting article on humans’ sense of smell. The article, overall, suggests that we have a much better sense of smell than we give ourselves credit for and that we evolved to have shorter noses because, with becoming bipedal, we were further away from the ground and didn’t need noses with as much filtering capability since we were further from smells. This also allowed our eyes to move closer together for stereoscopic sight. The study says that retronasal smelling is actually what is related to the hedonic value of foods with regard to scent. Retronasal smelling is when olfactory molecules go from the back of the oral cavity through the nasopharynx into the back of the nasal cavity. So, essentially, through our moves and up to the back of the nasal cavity. The research says that this retronasal sense of smell is particularly important in humans. Stating that: “First, with the adoption of bipedalism, humans became increasingly wide ranging, with concomitant diversification of diet and retronasal smells. Second, the advent of fire, perhaps as early as 2 million years ago (Wrangham and Conklin-Brittain 2003), made the human diet more odorous and tasty. From this time also one can begin to speak of human cuisines of prepared foods, with all their diversity of smells. Wrangham and Conklin-Brittain (2003) support the view that prepared cuisines based on cooked foods are one of the defining characteristics of humans.Third, added to the cooked cuisines were fermented foods and liquids, with their own strong flavors. These developments occurred among the early hunter-gatherer human cultures and continued through the last ice age. With the transition to agricultural and urban cultures 10,000 years ago, human cuisines changed by the advent of animal domestication, plant cultivation, use of spices, and of complex procedures, such as those for producing cheeses and wines, all of which produced foodstuffs that especially stimulate the smell receptors in the nose through the retronasal route and contribute to complex flavors." So, it seems as though human smell is adapted to increase the hedonic value of food and that the way we smell enhances food flavor, particularly through the retronasal route. This evolved with bipedalism, cooking, and other cultural changes with regard to gastronomy.

Side note: I found a study conducted by Richard Wrangham where they were testing to see whether non-human primates had a taste preference for cooked versus uncooked foods. They conducted the study to test the hypothesis that preference for cooked foods would have driven early humans to adopt cooking and to attempt to control fire for the purposes of cooking. They did find that several populations of captive apes tended to prefer their food cooked, though with important exceptions. They say: "These results suggest that Paleolithic hominids would likewise have spontaneously preferred cooked food to raw, accepting a pre-existing preference for high-quality, easily chewed foods onto these cooked items. The results, therefore, challenge the hypothesis that the control of fire preceded cooking by a significant period." In other words, control of fire and cooking likely occurred, somewhat, in tandem with each other in human evolution.

Source: Wobber, Victoria, et al. "Great Apes Prefer Cooked Food." Journal of Human Evolution, vol. 55, no. 2, Elsevier BV, Aug. 2008, pp. 340–348. Crossref, doi:10.1016/j.jhevol.2008.03.003.

Other note on taste: There are sex-based differences in gustatory anatomy and taste sensitivity in chimps and humans (and in capuchins). These sex-based differences potentially reflect reproductive adaptations in females, with female primates feeding on more sugar- and protein-rich foods than males. This is likely because reproductive females need sufficient nutrients while also avoiding toxins, so they are very selective when ingesting high protein foods (like insects and leaves) because they could have toxins. "They must strike a balance between ingesting too many high-protein foods and very few." Overall, females benefit from greater taste sensitivity to avoid toxins and other compounds that could inhibit reproductive ability. (Muchlinski et al. 2011).

Touch: Chimpanzees also use their tactile abilities (haptic sensitivity) to detect when certain foods are ripe. For example, figs stay green throughout development, so chimps deliberately palpate individual figs to determine ripeness, as it provides better information regarding the fructose concentrations of the fig than do visual cues. This task requires advanced visuomotor control, and Dominy et al. state that such behavior "could explain the adaptive origins of advanced manual prehension", obviously an important contribution to evolution! (Dominy et al. 2016).

LOCOMOTION

TERRITORY

Chimpanzees live along the equator in Africa. While their overall geography is fairly small, they live within many different ecosystems within that region, including these forests: evergreen, mountain, swamp, and rain forests; one group of chimps has even started the process of wondering away from the forests onto the savannah where they sometimes live in caves and wonder from tree to tree over the ground.

Source: (Goodall 1986; Fruth et al. 1999; Poulsen & Clark 2004). (Their range spans 22 countries, representing almost 1 million square miles. So, their north south range isn't large, since they're close to the equator, but they spread very far east-to-west (wisc.edu)

So that they show greater flexibility and adaptability in adjusting to their environment than some other primates--which is certainly in part due to their ability to adjust their culture to their environment (wisc.edu). However, at the same time, chimps, through the various eco-systems, do show some meaningful genetic differences which also may account for that adaptability.

Successfully inhabit many different habitats along equatorial Africa including dry savannas, evergreen rainforests, montane forests, semi-deciduous forests, swamp forests, and dry woodland-savanna mosaics; chimpanzee culture aids in adaptation to varying habitats (Cawthon Lang-http://pin.primate.wisc.edu/factsheets/entry/chimpanzee)

Savanna chimps do not stray far from trees, and will interestingly, sometimes—especially during the hottest season—escape the heat by hanging out in caves where they groom and eat; latin species name "troglodytes" actually means "cave-dwelling," although chimpanzees do not typically spend time in caves; also soak in pools of water during hot, early rainy season to cool off; may travel and forage at night when phase of moon provides enough light; larger home range (ten times that of Goodall's Gombe chimps), travel farther to food resources but travel less during hottest months and time of day, stay closer together and travel as one large party in contrast to other chimps (Pruetz 2007)

Chimpanzees' movement throughout their territories/habitats are affected by fruit ripening at different times and different places. In other words, they follow the food (Tweheyo et al. 2004)

TYPE OF LOCOMOTION

They spend most of their time in the trees but also move along the ground, usually on all fours (using 'quadrupedal knuckle walking') but they are capable of walking upright for shorter distances (Cawthon Lang).

Source: “Primate Info Net.” *WNPRC*, pin.primate.wisc.edu/factsheets/entry/chimpanzee.

Split time between ground and trees; move on all fours on the ground and in the trees; knuckle-walkers; longer arms than legs, arms longer relative to bodies than human arms (Matthews, John p.19)

Capable of standing and walking upright (i.e. bipedal locomotion), which they primarily do to travel with objects in hand (Matthews John p.19)

Move skillfully through trees, climbing, swinging from branch to branch, maintaining a precision grip about branches with long palms and sole and their opposable thumbs and toes; hand’s pincer grip not quite as precise as humans’ (Matthews, John p.19)

Their palms and soles are so long that they can grip a branch with just the palm or the sole, leaving their fingers (and toes) free for finer manipulation, like when investigating items or playing. (Matthews p19)

Use both hands and feet to grip, carry and manipulate objects, but use hands for finer manipulations — captive chimps use hands to draw and paint (Matthews, John p.19)

Spend significant time traveling between food sources and on average, half the day is spent feeding; not much napping; use cognitive maps of home range to direct movement towards previously exploited food resources

The amount of time spent on the ground varies both between sites and sexes

Source: “Primate Info Net.” *WNPRC*, pin.primate.wisc.edu/factsheets/entry/chimpanzee.

<u>SIZE AND SEXUAL DIMORPHISM</u>

Chimps are close to the size of humans; when males stand upright, they are about five feet and six inches and weigh about one hundred and fifty pounds with arms much longer than our own, which obviously aids in their movement through the trees. (FYI- wisc.edu primate factsheet says that, for the common chimpanzee (Pan troglodytes) males are 88-132 lbs. and females are 70-104 lbs.) The females are only slighter smaller so that chimps, like humans, have little sexual dimorphism which strongly influences the nature of their society.

Source: “Primate Info Net.” *WNPRC*, pin.primate.wisc.edu/factsheets/entry/chimpanzee.

<u>CAPTURE</u>

PLANTS

As we have noted, chimps consume one of our own favorite foods--honey—which, like any food, has its own defenses--that is, the stingers of bees. Chimpanzees regularly strip leaves from branches and then dip the twigs into the honey--and then lick the honey from the twigs. When the bees are more aggressive, they use longer sticks, showing some further use of cognition (Sanz 2009). When water is scarce, chimpanzees will select certain types of leaves, crumble them in their mouth, then use the leaves like sponges to soak up water from small pools that they cannot access with their mouth. They then will repeatedly squeeze the sponges to gather the water. (Sugiyama 1995). As we shall see, chimps also use tools to acquire animal foods.

NOTES: “Chimps crave variety, eating a large number of different plant foods - 184 vegetable foods from 141 species of trees and plants (1/2 fruit, 1/4 leaves), with around 13 different food types in a given day.” (Bellisari, A.).

Figs are a staple food for chimps. They eat them most or all months of the year (Newton-Fisher 1999). Figs are present in 29% of fecal samples and fig trees are one of the most abundant trees in chimps’ habitats (Stanford & Nkurunungi 2003).

Note: Chimps use several different techniques to gather honey. The most common is dipping twigs into the honeycomb. They also detach the entire nest or the stick/branch to which the nest is connected, and then dip into the nest with a twig. Finally, they will sometimes pound the hive with a branch to open it up (Sanz 2009). Chimps often eat the entire nest, not just the honey, which means they get the honeycomb, which also includes bee larvae and pupae, thus providing significant protein. According to McGrew (1983), bees are the third-most common species of insect that chimps eat and are found in 23% of all fecal specimens. Despite this, Jane Goodall only reported seeing chimps eat honey once, whereas, Wrangham observed it on several occasions.

Chimps also use hammers and anvils to crack nuts. Even more impressively, they select the type of stone hammer to use based on the properties of the different types of nuts- for example, they’ll use granite hammers for harder nuts and wood hammers (aka clubs) for softer nuts. Some hammers weigh up to 9 kg (~20 lbs). Finally, they will carry their hammers and nuts to specific anvil sites, will collect hammers even when they aren’t near anvil sites, and they’ll use the same anvil sites repeatedly (Boesch and Boesch-Achermann 1983 and 2000- The Chimpanzees of the Tai Forest).

ANIMAL FOODS/HUNTING

While chimps eat mostly vegetarian diets, they supplement their diet with small amounts of animal foods in the form of insects, termites, birds and bird eggs, and honey (McGrew 1983). (Female chimps eat termites consistently, spending up to 15% of their waking hours capturing termites. Males, in contrast, do not eat termites during the dry season in particular (McGrew 1983).) They also eat small to medium sized mammals, mostly other primates, such as Bushbabies, Duikers, Red-tailed monkeys and even yellow baboons--as well as their favorite, the Red Colobus Monkey, which you may remember as being the only primate to have a fermenting forestomach. While these animal foods seem essential to their diet, they nonetheless do not devote that much time to acquiring them--maybe as much as five percent of their total, foraging time (Note: Less than 5% of their feeding time is spent consuming meat and only around 3% of their foraging time is spent hunting-this varies by source though...)(Stanford, Craig); but at the same time, relative to the amount of actual calories they receive from these foods, they will devote considerable more time to acquiring them--which, in the end, suggests these foods are quite important for them for reasons that we will explore shortly in the section on physiology.

But for now we should understand that chimps generally are less habitual and more opportunistic hunters. (They will grab animals or insects that cross their path-based on convenience. They will also steal meat from baboons.)(Stanford, Craig) It has been proven that hunting for chimps is risky--that is, they can devote lots of time to hunting but, if the conditions are not good, they can return with only scraps or with nothing at all; on the other hands, it’s possible that luck is on their side and be rewarded by that ubiquitous, human investment strategy of high risk, high reward; or in other words, they could hit the bounty. But, even if that is the case, it is nonetheless obvious that chimps are not good enough and reliable enough hunters to depend on animal foods to provide them sustenance. The result is that chimps hunt generally under certain conditions: when they are otherwise sated with fruit or when conditions are otherwise particularly good. Numerous studies now have shown that chimps only actively hunt when they have plentiful fruit--and as such are not likely to starve (Mitani & Watts 1999); they also tend to increase their "military" actions at these times as well. And as is the case with other primates like the Baboon, chimps are most prone to hunt when conditions are particularly good--therefore hedging their risks. Or, in many cases, chimps merely start hunting when in the course of their other activities, an opportunity becomes available. For example, the chimps and the Red Colobus occupy the same habitat and in some cases will compete for the same foods; during this time, it is more likely that chimps will opportunistically hunt and kill them, killing the proverbial two birds with one stone: getting a meal for themselves and eliminating their competitions for food.

They acquire animal foods through several strategies, using several different tools. To get termites chimps will regularly strip away the leaves from stems, then poke the stem into a nest of termites to collect and eat them--similar to how they collect honey. Chimpanzees have also been observed sharpening sticks to impale bushbabies (ScienceDaily, 11/13/07, www.sciencedaily.com/releases/2007/11/071112172155.htm).

Note: Chimps primarily use their arms and upper body strength to capture prey, rarely using their teeth. For example, with colobus monkeys, they kill the monkey by using their arms and upper-body strength to beat the colobus monkey against the ground or a tree limb, essentially beating it to death. They will, however, use their teeth when they kill young colobus, by biting them on the back of the neck (Harding 1974).

Jane Goodall once observed their hunting behavior in the wild: working together in a calculated, human-like way, one group of chimps isolated one colobus monkey in one tree, blocked off all of his means of escape until one adolescent chimp climbed the tree, captured and killed the Colobus when all of the other chimps rushed forward to get their share (I think this comes from Hardin 1974-Not sure the Jane Goodall reference is correct); naturally, the more alphas will feed first, then the others later; in some cases the other males have to beg. Based on observations, meat-sharing amongst the males increases alliances and bonding; as the males seem to share with each other, not randomly, but based on certain alliances that help them in their bid for power amongst other males (Boesch 2002).

Note: Hunting strategies differ between chimpanzee populations (Boesch 2002). Also, there is typically a driver chimp, who follows the colobus monkeys in the branches without trying to capture them, simply guiding them into the blocked escape route- This reminds me of Native Americans' hunting strategies, where they drive buffalo over a ravine or into an enclosure, and the kill them. Also, overall, hunting behavior seems to be cooperative in chimpanzees, with hunts being social, similar to humans. This cooperation was important to human evolution and, in chimps, there is a positive relationship between the number of chimps who are involved in a hunt and the odds of success, reinforcing the need for cooperation. Meat-sharing after a hunt also reinforces this social/cooperative hunting behavior (Stanford, Craig B.). Chimps rarely hunt solo, and the success rate of lone hunters is low- only 30%, while it's almost 100% when there are 10 or more hunters in a group (Stanford, Craig). Forest chimpanzees almost always hunt in groups (Boesch 2002).

Although chimps, like all other animals, eat all their other food on the spot in the field, they sometimes bring meat back to their groups--which is interesting because this foreshadows what happened in our own evolution--the communal, sharing of food in one particular place. In any case, once the male chimps bring back food, the females frequently have to beg to get some share or, otherwise, exchange sex for meat.

Note: Also with regard to sharing, sharing behaviors vary between chimpanzee populations. In some populations, the largest share goes to the best hunters, and it can take up to 20 years of practice before chimpanzees can perform reliably on a hunt- a lengthy learning period that is similar to some hunter-gatherer societies. However, in other populations, like the Gombe chimpanzees, bystanders get as much meat as the hunters, so it doesn't really pay-off for chimps to join in the hunt in that population (Boesch 2002).

Like other predators in the wild, chimps seem to show preference for organs and connective tissues, as they will eat intestines and liver first and otherwise eat the entirety of the animal, including the brains and the bones. (Jane Goodall-1986-Reported that chimps typically eat the brain first.)

Source: Craig Britton Stanford, Chimpanzee and Red Colobus: The Ecology of Predator and Prey, Palm Fruits, Marrow p.192

My work on carcass consumption indicated that Gombe Chimpanzees seek fat from the brain and from bone limb marrow over other body parts after the kill.

My theory on chimps hunting:
When other food is abundant and when it's easier; or translated, hunting is higher risk (though higher reward). Instead of depending upon it, they use it when they are already full of fruit or when opportunity presents itself.
The reason: if depended upon, may come back empty-handed and starve--but when full, can hazard the risk: sort of like richer people making riskier investments.
So why hunt?
--nutritional considerations: obvious answers, great digestible source of amino and fatty acids (other: phosphorous, potassium (do not need), iron, zinc, b 12 and 6, calcium--other possible effects: long chain efa's for brain etc....also mono and saturates
--social theories

My theory (the synthesis): evolutionary advantage: when fruit is high, need to counterbalance with greater amounts of protein; at that point, hit nutritional high, maximize growth and energy and food. Naturally, mate and possibly even invade.....

MEDICINES/DETOXIFICATION

Goodall 1986--chimps eat clay from termite mounds high in K, Mg and CA

Chimps also use plants and other substances, such as clay, medicinally, to help themselves heal from various ailments. In an article published in the Journal of Chemical Ecology in 2005 for example, scientists observed that chimps, whom they believed were suffering from parasite infections, eat the young pith of a tree which was known to contain chemicals effective in controlling parasites. In the Mahale National Park in Tanzania, chimps are known to use leaves effective in eliminating worms from their colons: they find leaves which are covered with fine hairs and then carefully swallow that leaf whole, without chewing; evidently the leaf is not digested and stays intact and when reaching the colons, the worms then become trapped in the hairs of the leaves and then is eliminated through the stool. Chimps also use plants with various compounds to keep their infection by nematodes under control. Interestingly local populations of humans generally use the same plants for the same purposes. Chimps also practice something called geography common throughout the animal kingdom, which is the process of eating clay or dirt. It was found amongst chimps that they ate specific types of clay, abundant in something called kaolinite, which when combined with various plant-foods actually made certain compounds in the plants become anti-malarial. Interestingly again, the local healer used the same clay to heal his patients from diarrhea and even attained clay from the same source as the chimps.

Source: Springer. "Down To Earth Remedies For Chimps: Eat Mud." ScienceDaily 11 January 2008. 27 February 2008 <http://www.sciencedaily.com /releases/2008/01/080109094344.htm>.

Other examples of this sort of behavior abound.

Medicinal plants-chimps have been seen chewing the plant Aspilia, a medicinal plant believed to relieve stomach pains or reduce internal parasites.

GEOPHAGY

When clay mixed with certain plant, the combination became very antimalarial
also, particular clay, Kaolinite, used by humans and chimps and used by humans to treat diarrhea.

Meta Study on humans: Overall, the protection hypothesis fits the data best, the Cornell researchers found. The database shows that geophagy is documented most commonly in women in the early stages of pregnancy and in pre-adolescent children. Both categories of people are especially sensitive to parasites and pathogens, according to Young and her colleagues. In addition, geophagy is most common in tropical climates where foodborne microbes are abundant. Finally, the database shows that people often eat earth during episodes of gastrointestinal stress. It's unlikely the intestinal problems are caused by the dirt itself because the type of clay people usually eat comes from deep in the ground, where pathogens and parasites are unlikely to contaminate it. Plus, people usually boil the clay before eating it.

Source: University of Chicago Press Journals. "Eating dirt can be good for the belly, researchers find." ScienceDaily. ScienceDaily, 4 June 2011.
<www.sciencedaily.com/releases/2011/06/110602162820.htm>.

Chimps are Dirt Eaters --
Up to 2x/day, animals ate pieces of earth of about 10 to 20 grams...While minerals are obtained from the earth, the most likely function of eating clay [according to this particular scientist] is that it acts to absorb certain components of the stomach such as tannins...[and is not a believed adaptation to dietetic balancing].

DIGESTION

As we already know, the guts of nearly all primates have the same basic design and function, including ourselves: that is, the acidic and sterile stomach, the small intestine and the colon. Similarly, while our guts are quite similar to the Chimps, too, they are also different. For example, the chimps have much larger, overall guts relative to their mass, as compared to ourselves and, as you might expect, relatively humongous colons to ferment all the fiber they get in their diet, and there are other relative differences as well. In fact--in that fashion as before--if you compared the guts of the Chimpanzee to that of the human, and noted the differences. You would then see that those differences in part tell the story of our dietary evolution over the course of seven million years.

With both mammals and primates in particular, we have already seen some patterns in the design of digestive systems depending upon the nature of the diet. When the diet is rough, animals like cows tend to have fermenting forestomach to break down fibrous foods. However, as the diet becomes slightly more refined, we see more acidic forestomachs. But since these diets, such as the horses, can continue to be somewhat rough and contain lots of fiber, they typically have shorter long-intestines because they just do not have all that many nutrients to digest and absorb--and then they have their fermenting colon at the end to process the fiber into the "ferments." But as the diet becomes even more refined--that is, containing more fruit, seeds and animal foods--we continue to see the same configuration of the digestive system--but the small intestines become longer to absorb more sugars, fatty acids and the colons become smaller because there is less fiber to ferment. We also have evidence to support the claim that the more refined the diet, the smaller the overall digestive system relative to the overall size of the animal. (Note from Luke- May need to reconfirm this)

With the chimpanzee, we see that same pattern; he has the same digestive configuration of nearly every other primate, with the exception of the Red Colobus (explore this relationship), the monkey which interestingly enough the chimp likes to eat the most. However, as compared to the Gorillas, whose diet is more rough and dependent upon the "ferments" for ATP, its long-intestine is longer, its colon smaller. As compared to the Capuchin, the monkey who most resembles our own digestion and accordingly eats refined foods, the chimps have shorter long-intestines and larger colons and likewise, the same can be said about their digestion in relation to us--that is, as we shall see when we cover the human digestive system in detail, we have the same, basic design except that we have relatively longer small intestines and much smaller colons and our overall digestive system is much smaller relative to our whole body. Or said in another, more revealing way--given that we consider the chimpanzee as the model for our common ancestor, we can assume that over the course of millions of year of our evolution, our digestive system became, compared to theirs, smaller overall with more small intestines and smaller colons--which strongly reflect what indeed happen--that is, that our diet became more refined like the Capuchins, with more animal protein and fats and even richer sources of sugars--all of which were increasingly processed through various techniques, such as grinding, soaking and cooking.

Liver is the same size as ours. As is explained in the last section, the size of the liver is strongly correlated with the size of the brain since the brain is so dependent upon the liver for glucose during periods of fasting or low CHO diets. Thus, the larger human brain still needs a relatively large liver. That being said, the splanchnic organs (liver & GI tract) are as metabolically expensive as brains.

“Humans have a rather small digestive tract for an animal of their size. They also differ from apes in that the small intestine accounts for the greatest fraction of the volume of the human digestive tract; in apes, the colon accounts for the greatest volume.” (Milton, K. “Diet & Primate Evolution” p. 93). Greater than 45% of the total gut is colon in apes, with only about 14 to 29% of the total gut volume in the small intestine. For humans, the small intestine accounts for greater than 56%, with only about 17-23% of the total gut volume in the colon.

*My Note: Seemingly due to a change in the amount of fiber that would need to be held in the colon... "The difference in gut proportions between modern humans and great apes, for example, seems to reflect the fact that most foods humans consume are 'predigested' by technology in one way or another before they ever reach the gut. This 'predigestion' minimizes dietary bulk relative to the diets of wild apes & generally enhances dietary quality." (Milton, K. "Back to Basics..." p. 480-1).

This is reiterated in the following quote that compares the hind-gut volume in apes is about 52%, and about 17-20% in humans...
"...chimpanzees digest relatively more fiber than humans or pigs. Larger chimps had higher fiber digestion and longer retention times...Although the digestive systems of chimpanzees and humans have similarities, the proportion of the gut devoted to fermentation is smaller relative to body size in humans than in other hominoids. The hind-gut volume in apes is about 52%, in humans, about 17-20%.

In the evolution towards modern day man, the digestive tract keeps shrinking, particularly the length and width of the colon. However, the small intestine keeps increasing, eventually accounting for the greatest fraction of the volume of the digestive tract. A longer small intestine was a critical adaptation to a higher quality diet composed of more protein and fat of which would be largely digested in the small intestine.

Apes today, on the other hand, still have colons of a size that account for the greatest volume in their GI tract. This volume is needed to accommodate the fermentative capacity necessary for great apes to derive a size-able portion of their energetic needs (ranging 21-60%) from the short-chain fatty acids obtained through fermentation of fibers. Compared to humans who can derive no more than 10% of their energy demands from hind-gut fermentation, the great apes have a significantly greater ability to produce short-chain fatty acids that may be used as an immediate source of fuel.

METABOLISM

Most importantly, we analyze every facet of the chimp diet. As we already know, the chimps eat a refined diet, as compared to many other animals, that is especially rich in sugars from fruits to feed their larger brains. But it's also important to note, that chimps do not necessarily eat the most refined diets of all primates; several smaller primates, like the Capuchin monkey, eat a diet that is even more refined especially in fats; and if you remember, smaller primates must typically eat more refined diets to power their speedier metabolisms. Or in other words, since there is this pattern between refined diets and intelligence, you may conclude that we evolved from primates, like the Capuchins, who eat the most refined diets but we did not, showing yet again that while evolution has patterns, it does not seem to have absolutes in its design. In the end we eventually started eating diets that were even more refined than the mighty Capuchin.

In any case, we will break down the diet of chimps into the overall percentage of fruit, tender leaves, other plant foods, as well as animal foods. From there we can analyze their underlying nutrition, considering first of all, what nutrients they use as fuel for ATP. As already mentioned, they get most of their fuel from the sugars in fruit, which allows them to fuel their larger brains; but it’s important to note that, while chimps principally eat fruit, they do not get more fructose in their diet than glucose; in fact they get more glucose due to their fruits being lower in fructose as compared to our own, which have been carefully cultivated to be more sweet. Also, their fruit, in addition to all the other plants they eat, is rich in fiber so, as compared to even whole-foods vegetarians, they get way more fiber in their diet--which means, of course, that that fiber dumps into their colon and is then fermented into organic acids--which then serves next to sugars as the principal source of fuel for ATP.

Chimps also get some fat in their diets, from plants, such as nuts and, amongst particular troops, palm nuts in particular, as well as some animals: it has been observed, for example, that when chimps hunt other monkeys, such as the Colobus, they preferentially eat the fatty parts of the animal such as the marrow and brains. And, although it’s not fully proven, it does appear likely that Chimps, from troop to troop, keep the overall amount of fat in their diet low--even when greater amounts of fat are available. Furthermore, there is some evidence to suggest that chimps can only digest so much fat at any given time; when they overconsume, it seems to dump into their stool. We should also consider that their particular ecosystem, tropical jungles, just typically do not contain much fat--certainly not any fatty animals, or many fatty plants--for reasons that we will discuss later.

But, nonetheless, it is obvious that, even as far back in our evolution as chimps, our line of evolution has shown a preference for animal fat, including the parts that contain considerable saturated fat; chimps love the brains and marrow and other fatty tissues or the Colobus monkey. Furthermore, some troops of chimps eat the various parts of the palm fruit, which includes the nuts--and both of which contain various amounts of fatty acids that are similar to those found in animal fat--that is, lots of saturated and monounsaturated fatty acids in various relationships with each other. But once considering all the various factors, we will see that Chimps get plenty of short-chain polyunsaturated fatty acids in their diets from all the plants and animals they consume, as well as longer-chain polyunsaturated from the animals they eat: and they consistently keep their Omega 6 to Omega 3 ratios balanced naturally. At the same time, they get decent amounts of the saturates and polyunsaturates in their diet.

But ultimately, we can draw these conclusions about chimps and fats: as we have already seen, one class of animals, including mammals, typically consume their fatty acids in fairly consistent sorts of ways; and they certainly store them in consistent ways--and those ways vary from one animal to another, for reasons that are not particularly understood--though I will attempt to offer an explanation at some later time. Likewise with chimps: from troop to troop, individual to individual, chimps appear to eat their fatty acids in about the same ratios; and they certainly store them in the same way. And these ratios include basically not just the "good fats" but more or less all of the dietary fats, including the "bad ones" like Saturated Fat and Arachidonic Acid and, overall, resemble the fat of some other animals, like wild boars and even chickens--while having important distinctions.

Furthermore, humans and chimps store their fat in ratios that are precisely the same as ours--even though we differ from nearly every other mammal. Or said more specifically, we humans are unique in that, although we are one species, we eat our fatty acids in all sorts of ratios; one person eats olive oil, high in monounsaturates, another one eats butter, much higher in the saturated. Even though we humans tend to eat our fatty acids in different ways, and even though, in the end, we nonetheless store them in the same ways, we cannot conclude that all ways of eating dietary fatty acids are equally as good. Since chimps represent the evolutionary blueprint for dietary fats, we will learn lots from them about the best way for us humans to consume our fats. In fact, we will even see that from Australopithecus all the way to modern humans, our line of evolution has shown evidence to eat their fatty acids in more or less the same ratios as chimps--while eating increasing amounts of it.

Believe it or not, we actually appear to need about the same amount of protein as chimps; by one estimate based on metabolic studies, we actually need less per mass--though I have reasons to doubt this claim. The popular media associates our evolution with the greater consumption of meat--but this claim, while bearing some elements of truth, is not really accurate for reasons that we will explore later. And certainly whatever its validity, this remains constant: from the scientific perspective, there is not much, if any reason, to believe that we need much more protein than chimps, per mass, although there is reason to believe that we need either slightly more or less. In general, chimps get their protein principally from tender leaves and research has even suggested that those leaves actually provide ample protein for the chimps. But, for some reason not clearly understood, all chimps, from one region to another, and from one troop to another, persistently eat small amounts of animal foods--for reasons not clearly understood. However, it does seem most likely that, while the additional protein may provide some benefits, the chimps may be eating other animals more for other nutrients, like the fatty acids and even the minerals, such as the calcium and phosphorus found in bones that otherwise would be scarce in their usual diet.

But what happens once chimps swallow their foods? How do they derive their ATP and their building blocks from their foods? Before answering this question, I have to confess that research in this field is lacking and inconclusive--but nonetheless highly suggestive. As I proceed forward, I will present what is indeed conclusive and at the same time, inconclusive. But when all factors are considered, a pattern emerges and from that, I think we can make some reasonably certain claim about how their physiology actually operates.

GLUCOSE

In consideration of their sources of energy, we have noted that chimpanzees are predominantly frugivores, getting about eighty percent of their calories from fruit. As we have already noted, too, fruit consists mostly of glucose and fructose in about equal parts--but is generally low in amino acids and fatty acids. Additionally, fruit, especially wild fruit, is abundant in that other but indigestible form of glucose--fiber. Before considering the other nutrients, let's first concentrate on the available, non-fibrous glucose in the pulp of the fruit. As we have already noted, glucose provides more ATP than the ferments. While it does not provide nearly the same amount of ATP as fatty acids, it nonetheless burns more quickly. For this reason, certain tissues have come to prefer glucose as its primary source of fuel, namely the nervous tissues including the brain, as well as the testes, and the fast-twitch muscles activated around the skeletal muscles during times of intense exercise--that is, during fight or flight--or in other words, not all that often.

Or, said in another way, when chimps eat fruit, they are supplying themselves with an excellent source of glucose to feed their rather large brains and testicles--which may in part describe why they have one of the largest, most encephalized, brains of all species and also one of the most active and exciting sex lives. Generally the process is wonderfully efficient: enzymes digest the fruit, the blood uptakes glucose which generally flows through the liver then onto the cells where it is used as fuel to make ATP, creating only water and carbon dioxide as wastes products.

When considering this point, we should consider, too, that the plant world--and nature in general--does not include many excellent, dense sources of sugars and, accordingly, it's no surprise that we as humans are acquainted with all of them: grains, tubers like potatoes, and fruit, as well as honey and syrups and the like. If you look around in your own, local ecosystem, you will find that most of these foods are not available--and even if they are, they are available only at certain times of year when fruits or seeds ripen and, even in that case, most of these sources are too small to provide many nutrients. Around my home here in Colorado are many grasses that produce seeds but thus far I have not found one seed that seems large enough to bother with eating, even if I was starving. Furthermore, when any of these foods are available, they are frequently well-protected: tubers reside under the ground, beyond the reach of nearly every animal; grains are frequently protected by tough, fibrous husks and contain various anti-nutrient. Or in other words, as compared to nearly all of the rest of the animal kingdom, chimpanzees are able to exploit one of the greatest, but most difficult to utilize, sources of fuel found in nature, specifically for powering the brain--glucose. (NOTE: need to place this paragraph elsewhere--that is, on primates in general: as a particular niche containing vital fuel for the brain.)

FRUCTOSE

The other half of the sugars in fruits is fructose which, though quite similar to glucose, nonetheless performs radically differently in mammalian bodies--that is, since cells cannot actually burn fructose, it must first go to the liver where it is converted into glucose.
At that point, the liver can use glucose as fuel or store it as glycogen. But that same fructose, once converted into glucose, can also be converted into the fatty acid, Palmitate and from there into other Saturated and Monounsaturated Fatty Acids. But why would chimps do that? Why would they convert one form of fuel into another form of fuel, especially if that conversion requires energy and space, as it does (Note from Luke- Want to reconfirm and investigate this)

For starters, chimps would do this to more effectively store energy for the long-term; or more specifically, all mammals can only store small amounts of glucose in the form of liver and muscle glycogen because it must be bound to water and therefore becomes too heavy for extensive storage.

So for that reason, the fructose/glucose is then converted into fatty acids which are much lighter and efficient to store; the fatty acids provide other advantages as well, such as the ability to create more ATP per mass, as well as insulation and cushioning. So, in other words, they would make this conversion, from fructose, to glucose, to fatty acids, to store greater amounts of energy for later use.

But chimps would convert fructose into fatty acids for another, more interesting reason--because some of their tissues prefer fatty acids as fuel. As we shall see as we continue with their diet, chimps do not actually consume much fat in their diet; nonetheless, it does appear that their heart and slow-twitch fibers in their skeletal muscle--the fibers used during normal exercise--prefer to burn fatty acids likely because they provide greater, more stable energy. Furthermore, since chimps spend hours every day climbing, swinging and walking, they need considerable amounts of this sort of energy. So, it follows somewhat logically that they therefore need to make those fatty acids, in the liver, starting with fructose. Unfortunately, we do not have the studies to confirm or deny this claim. But the claim seems bolster by another line of evidence--that is, that chimps, while receiving little saturated and monounsaturated fat in their diet, stored considerable amounts of it in their adipose fat--that is, their storage fat--which leads me to believe that most of those fatty acids are indeed synthesize primarily in their bodies from fructose. For now we have to leave ourselves hanging on this critical point in our evolutionary story; however, once we arrive at human physiology, we will renew this line of reasoning with greater research and relevancy. In any case, from this one, glorious source, chimps in other words provide most of their needs for fuel in the form of glucose and fatty acids--and as such explain why they so greatly prefer this as their primary food.

NOTES: While fructose has been found to raise blood sugar and insulin levels less than other sugars, such as glucose, fructose has been found to increase obesity in both nonhuman primates and humans due to its inability to decrease leptin, a hormone that signals your brain to stop eating when you are full. In addition, fructose has an increased ability in both humans and nonhuman primates to increase the body's fat stores in the liver, blood, and adipose tissue compared to glucose.

Fructose's ability to increase fat stores was potentiated by a genetic mutation that occurred in the ancestors of the Greater & Lesser Apes from the middle Miocene Era approximately 15 and 9 million years ago. This mutation lead to the loss of the activity of the enzyme that normally degrades uric acid, a product released in the breakdown of protein. The subsequent rise in uric acid due to the loss of this enzyme may have provided a survival advantage to apes experiencing food shortage during the global cooling of the Miocene epoch. The higher levels of uric acid would have potentiated fructose's fat making abilities and encouraged food intake, ultimately leading to overall weight gain. Thus, fructose-rich fruit would have been a very helpful food for an animal that was experiencing intermittent bouts of food shortage.

While this mutation proved to be important for the survival of our ancestral line, it has proven to be a non-functional mutation in our today's modern world of fructose-filled snacks, sodas, breads, fruit juices and more. The modern diet, composed of an overabundance of fructose-rich processed foods, often leads to an excessive increase in uric acid levels that result in major physiological imbalances that can eventually progress into disease states. Conditions linked with increases in uric acid include obesity, high blood pressure, unhealthy blood lipid levels, heart disease, kidney disease, diabetes, and cells that are unresponsive to insulin, all of which are closely associated with the metabolic syndrome, also known as "syndrome X."

High Fructose Diet Leads to Metabolic Syndrome in Humans & in Monkeys...
"After fructose-containing meals, increased plasma triglyceride concentrations are typically observed in human subjects." (Adams, Sean H.; Peter Havel et. al.).

"Non-diabetic, chow fed monkeys consuming a high fructose diet may have a higher triglyceride, cholesterol and HDL-Cholesterol." (Wagner, Janice D. et. al.).

"within a 6-12 month period, consumption of a high fructose diet in monkeys produces many of the features of metabolic syndrome in humans, including central obesity, insulin resistance, inflammation, and dyslipidemia. In a subset of animals, the high fructose diet also results in overt Type II diabetes." (Bremer, Andrew A. et. al.).

"the ingestion of a high fructose diet [in monkeys] consistently and quickly resulted in the development of metabolic syndrome components." (Bremer, Andrew A. et. al.)

Excess carbohydrates may also be handled by the liver where the carbohydrates may be converted to fat. In lab experiments that fed very high amounts of carbohydrates to nonhuman primates, the excess was converted to fat which over time lead to the accumulation of fat in the arteries resulting in the disease atherosclerosis. Overall, this physiological response to a high carbohydrate diet resembles the response seen in humans, coupled with the same increase in fat production, fat stored in the liver and in the blood, and a decrease in the responsiveness of the body's cells to insulin.

It has been shown that increased fructose consumption leads to increased de-novo lipogenesis and a subsequent increase in plasma triglycerides and general dyslipidemia. Although I found no research that specifically states that fructose is converted in nonhuman primates directly to mono and sat fatty acids, I did find evidence that indicated that saturated and monounsaturated fatty acids were synthesized de novo in squirrel monkeys fed glucose. Thus, we might ascertain that the increase in de-novo lipogenesis that occurs with the ingestion of fructose leads to the synthesis of sat and mono fatty acids as with glucose consumption.

“Fructose is distinct from glucose in its superior ability to increase fat stores, including the liver, visceral fat, and plasma triglycerides.” (Richard J. Johnson et. al.).

Fructose increases pyruvate from which fatty acids are made and increases the enzymes that creates fatty acids in the liver....

“...a dietary carbohydrate content of 66% may be excessive [in the primate species Macaca mulatta], and that much of it, regardless of type, is disposed of in the body by being converted to fat.” (Lang, C. Max, Curt H. Barthel. “Effects of simple & complex carbohydrates on serum lipids & atherosclerosis in nonhuman primates.”).

“Of interest is the fact that, as a rule, sugar in the pulp of wild fruits (the kind most primates include in their diet) is dominated by hexose (considerable glucose and/or some fructose, and very little sucrose), whereas, that of cultivated fruits is high in sucrose, a dissacharide. Cultivated fruits are therefore very tasty to humans because sucrose tastes sweeter than glucose.” (Milton, K. “Back to Basics...” p. 481).

Humans have an increased ability (3 fold) to metabolize high-starch root vegetables compared to chimpanzees, indicating the increasing importance of high-starch vegetables in the evolution of humans.

FIBER

“Even though the fruits chimpanzees eat tend to be rich in sugar, they contain far less pulp and considerably more fiber and seeds than do the domesticated fruits sold in our supermarkets. Hence, I calculated that wild chimpanzees take in hundreds of grams of fiber each day, much more than the 10 grams or less than the average American is estimated to consume.” (Milton, K. “Diet & Primate Evolution”).

But we also know that fruit contains another form of glucose--the form that is bound in fiber, impossible to digest and that soon arrives in the colon to be fermented by trillions of microorganisms. Once this glucose is consumed and used as fuel, the micro-organisms then emit a class of nutrients called the short-chain fatty acids--fatty acids that are way shorter than the ones we get in our diet. It is putatively believed that there are three of them used by primates and humans--all of which perform slightly differently in the body. While how primates use these "ferments" has not been studied, we do know how mammals and other animals use these fuels, as well as humans; and it appears to remain somewhat consistent. For that reason, some scientists and I myself feel reasonably comfortable making the claim that primates use them in the same way--which is as follows.

The first of these, Butyrate, is actually used by epithelial cells--the cells that typically line the walls of our digestive system and these cells seem healthier when burning Butyrate. Accordingly the colon itself uses much of the Butyrate while it does appear that some Butyrate enters the blood to access other epithelial cells throughout the body. Propionate is also used by the colon but most of it entered into the blood in the portal vein where it then flows to the liver to be converted into glucose--and then used as needed. Or in other words, while primates eat glucose in the form of fiber, they then work symbiotically with microorganisms to convert glucose into Propionate which then reports to our liver to be converted back into glucose--which seems horribly inefficient but is nonetheless the way it works. Acetate, otherwise known as acetic acid which is found in vinegar, which is the most abundant of the "ferments" can actually be used in many tissues, mostly muscle tissues, directly as fuel to create ATP. Acetate is also converted into fatty acids as well.

As happens with other animals, including humans, it is likely that primates uptake other nutrients from the colon, including water, certain vitamins, as well as vital minerals.

It appears that primates, just like humans as we shall see, are dependent upon this fiber and its "ferments." For example, when primates are fed certain foods, where sugars are readily available but stripped of their fiber, primates react the same way as humans--that is, they start to develop certain diseases like obesity, diabetes and heart disease. Though the reason for this is not known--as it applies to other primates--scientists are now starting to understand the reasons for it in humans. For example, we are starting to learn that these ferments, especially Acetate, may play important roles in the regulation of glucose in the body. And more and more studies are now starting to show that the type of microorganisms in our colon can determine, in relation to diet, our propensity to obesity--all issues which we will explore later on in more detail.

Those scientists that have, have written that SCFA’s are used as readily available energy in the bloodstream or, ultimately, are converted to glucose and stored in the liver. They further explain that short chain fatty acids are readily absorbed through the walls of the cecum and large intestine and transported via the blood to other cells in the body that may use SCFAs instead of glucose in the TCA cycle for energy.

Because of the consistency in the metabolism of SCFA’s in these other animals, some scientists have ventured to assume that SCFA’s have the same effects in great apes.

“Apes are not physiologically adept at handling the large quantities of readily available sugars they are receiving from fruits, vegetables, and primates biscuits; instead they were designed to obtain their energy through VFA’s from fiber fermentation...can predispose them to diabetes and incur problems such as obesity.” (Schmidt, D.A.; J.L. Dempsey et. al.).

NUTRIENT SYNTHESIS

We also have similar, if not almost identical, abilities to convert certain nutrients into other nutrients. While there are many similarities here amongst mammals in general, we have much greater similarity with the Chimpanzee. We can both convert beta-carotene into Vitamin A; and glucose into the fatty acid, palmitate, which can then be converted into other fatty acids. We can also both convert short-chain polyunsaturated fatty acids into their longer chain versions, like the famous fatty acids found in fish oils, DHA and EPA, to build the cell walls of our brains.

We both use organic acids, both from plants as well as from the fermentation of fiber in our colons, in the same way, although we use much fewer of them.

As we shall see, we have many other reasons to believe that the Chimpanzee serves as a meaningful, original blueprint for understanding our own foodways. At the end of this section, we can see that the chimp is, indeed, our younger brother, so like us in ways that most of us have not previously imagined, especially in all aspects of our foodways. They are our Evolutionary Genesis who, just like Adam and Eve, inhabited the lush and warm jungle ripe with succulent fruits. Additionally, they swing joyfully through the branches, far removed from the reach of the devilish predators that lurk below. And just like Adam and Eve, our common ancestor was pushed from their ancestral paradise, not by some sly snake, however, but by the working of what some might call God or at least larger, cosmological sources--that is, climate change--and then cast into another world that was way more dry, harsh, unstable, dangerous and even cruel.

ENCEPHALIZATION

Their brains are about one third the size of our own, at about 300 cc or, said another way, they are only about one third as encephalized as ourselves, although this does rank them as one of the most encephalized of all animals, not too distant from the Porpoise.

CULTURE

Chimp troops typically consist of just over one hundred individuals; however, instead of troops being defined by the number of individuals, they are rather defined by territory--that is, though all of one troop will never or rarely congregate together, the males of that troop will aggressively defend that territory--which amounts to about one square kilometer per 2.2 individuals. This, I suppose, is not too dissimilar to modern-day states or countries--in which most of us never congregate together for anything but our armies will nonetheless defend our territories. In any case, each member of this troop must have some knowledge of the other one hundred individuals to be able to identify them as friend or foe--and in that sense, chimps must possess considerable social knowledge and skills. At night, smaller groups nest together, like so many other primates, the mothers with their babies, sleeping about ten hours per day and in the morning they split into even smaller lose and fluid groups that range in number from one to over twenty or so--all of which can consist of either all males or all females, or some mixture of both; mothers and their children tend to be more isolated in their feeding, perhaps to keep the adults from stealing the babies' food, and sometimes groups of mothers and children will feed together. In the organization of their labor, chimps, in other words, are quite similar to humans--in that you may sleep with one group, perhaps your family, but work with others in many different configurations. However, as we shall see, in Paleolithic Times, humans had much stricter divisions of labor between males and females than chimps.

They spend about half of their day feeding--that is, actually gathering, chewing and digesting food and most of the remainder of that time moving from one place to another. They do not nap as much as other primates, perhaps due to the superior energetics of their diet, which we can discuss later.

As usual, the mother to child bond forms the basis of society for chimps but with the chimps it seems even more developed and eerily similar to humans. Mother chimps have babies about once every three to five years and then nurse them for two years, and do not completely wean them until they are three or four years old; but after this, they continue the relationship all the way into adulthood. Along the way aunts and grandmothers (BE SKEPTICAL, as females migrate) can be active in helping raising the infants as well; in fact even the presence of grandmothers amongst troops can boost reproduction. And Mothers maintain their relationships with their children so long that their older children will help them raise the younger ones; or in other words, brothers and sisters become more relational with each other and therefore more bonded. And when the mother dies, the older child will then help raise the baby.

As for the role of the mother, she spends the first couple of years close to the baby, breastfeeding and nesting with it at night and, as the baby becomes older, it gradually becomes more and more separate. Observers have reported that some mothers seem more possessive and protective of their children, rarely letting them stray far from them, while other mothers seem more relaxed and lenient or perhaps this depends on the temperament of the infant. During this time of closeness, the mothers allows the baby to ride mostly on its back as it moves through its terrain--and when the baby starts eating more than just mother's milk, the mother starts teaching the child about foodways: which foods can be eaten, which ones are toxic. Though we do not have any evidence supporting this claim, it is likely, too, that the mother teaches the baby about how to eat foods in certain ratios to satisfy nutritional needs: for example the baby chimps probably learns to eat so much fruit for sugars, then enough tender leaves for protein and other nutrients--all the while, helping the infant become acculturated to food, as well as likely learning to trust its own feedback system located in the second brain, the enteric part of the brain as well as the liver. Chimp mothers also teach their babies how to use plants medicinally--an issue we will address later.

In later sections we will see that chimps use tools much more extensively than other primates and animals to extract food from the environment; so, chimp mothers will teach these skills to their babies--tasks that to us seem quite simple but that take considerable effort to teach to chimps and that some chimps are never able to learn. The mothers, too, constantly groom their babies, keep them close to protect them from predators and other, aggressive chimps and when the time comes, helps them socialize with other chimps in the troop. I have seen many pictures of mothers and babies and it seems evident, from their expressions, from the way they interact and hold each other, that it is the feeling of love that holds them together: both seem equally enamored in their role with each other.

When the children reach puberty, the females migrate to other groups--even after they have settled into one group, they can move onto yet another, while the males on the other hand stay in their group of origin--that is, with their fathers, mothers, and brothers.

For that reason, the males form stronger bonds of kin than the females--and work together more cooperatively, while the females stay focused on their relationship with their children, the males in the group and other females of direct kin, if any still exist in her troop. Accordingly, the males tend to hold at least some of the power--or certain types of power--within their troop: they form strong alliances with each other and while those alliances are cooperative, they are also competitive--that is, the males operate within hierarchies headed by one alpha-male while the other males have various degrees of submissiveness. However, chimps elect their alphas; they do not just necessarily cease power. While some male chimps will tend to seek the alpha position based on their strength and size, they can easily be defrocked if the other chimps do not like him and, as such, it appears to be that popularity, politics and other skills determine alphas rather than strength or age and, accordingly, the alphas tend to form alliances mostly with other males and even the females to earn their role and, accordingly, if they do not perform as expected, they can be overthrown--which appears to happen somewhat regularly. The alphas tend to fluff their coats and stretch themselves to make themselves look larger and use different tactics to intimidate others in the group, such as loud, shrieking vocalizations, not too dissimilar from the lead singer of ACDC, breaking branches and throwing rocks, to keep the other chimps submissive while the betas will show outward signs of submissiveness. While holding his position, the alpha works to resolve disputes between various parties, to help find food, to secure their territory and, as his reward, he usually has greater access to the females and perhaps more access to food. While the males may be jockeying for power occasionally, aggression within groups is rare, though it does happen.

Though maintaining most of the power, the males, however, do not just dominate the females either physically or sexually, as we have seen in other primates. In many primate societies, there are more females than males, as we have seen with the Gorillas--which paradoxically can give the males more power because there is more competition for them amongst the females. But with chimps the ratios between males and females stays more equal--therefore balancing their numbers. At the same time there is little sexual dimorphism, so the females are about the same size as the males and, as we have noted, less sexual dimorphism tends to result in more equality between the sexes, as well as, perhaps, less dominance and more cooperation amongst the males. At the same time, the female chimps also have their alpha females—roles, which are sometimes just inherited from mother to daughter but also frequently earned. However, they exercise power differently from males; while males can control females by ultimately resorting to force and using their superior size and strength, females tend to exercise power through other means, though the way that happens appears to differ--that is, they seem to use their more nurturing characteristics by resolving conflicts and creating peace and harmony in the group, using grooming as one of their tools. (Note: will also kill the babies of other females.) In exchange for the responsibility of their role, it appears that the female alphas tend to have greater access to food.

Furthermore, the females counter-balance over the males by deciding in part who serves as the alpha male: without their continued approval, the alpha male can be ousted, especially if he does not provide food; and they will refuse to mate with him. Or, in other words, the alpha male needs to seek the approval of the females. And, perhaps most of all, the females are not at the beck and call of the males sexually. Female chimps come into estrus similar to females--that is, about the middle of their cycle but some reports suggest that they are even more inclined to mate during this time if food is abundant; perhaps they are more primed for reproduction with greater nutrition like the Orangutans.

During this time, the females will tend to mate with multiple males, as many as ten in one day. It has been suggested that females breed--and therefore bond--with so many males to actually disguise the father of her child, as this will protect him from the tendency of male chimps to kill the babies that are not theirs. As a result of this mating strategy, male chimps have unusually large testicles, about three times as large as our own and considerably larger still than the mighty Silverback Gorilla; since so many males are inseminating females with their sperm, they have to create considerably more of it to win the possibility of actually fertilizing the egg. Although this distinction may seem, well, if not perverse, then perhaps too raucous, it is important to note for this reason: that as humans evolved, our testicles actually shrunk as a result of pair bonding--an issue which we will address later in the book.

The females, too, will show their preferences for the alphas who will mate more than the others. Chimps, too, have been observed tending towards temporary monogamy, as the males may try to prevent the female, with whom they have mated, from copulating with other males. In one particular example observed by Jane Goodall, one male chimp separated his girlfriend from the rest of the troop, so he alone could mate with her while she was in estrus, jealously guarding her from the other males to optimize his chances at reproduction. Whether the female felt kidnapped or complicit, who knows? In any case, since chimpanzees are competing so hard against each other to fertilize the female with their sperm, chimps have developed inordinately large balls, or testicles, about three times as large as our own and even larger still than the mighty Silverback Gorilla.

It is curious to note that male chimps tend to prefer foreign females--or females not from their group—finding them more attractive, which may happen to avoid inbreeding.

DIVISION OF LABOR

Naturally, male and female chimps show some division of labor. We have already seen that female chimps, at maturity, devote most of their time to caring for their babies--not an easy task. Compared to the males, they have in some senses twice as much work to perform in transporting another body around and feeding it. As we have seen, too, there is some additional division of labor between the alphas males and females and the betas: while the alphas have additional chores for their status, they appear to get some counterbalancing advantages, such as greater access to food, and the males at least seem to have greater access to sex as long as continues to provide and play role well. But the males also play their part, as they are entrusted with two, additional roles themselves--that is, of protection and hunting. Although it does not appear that protection of territory is necessarily assigned to the males in other primates, that is, indeed, the case with Gorillas as we have seen, as the silverback usually carries that role alone. But with chimps, both all the adolescent and adult males are responsible for protection and will generally fight to the death to defend their territory from other groups of chimpanzees. Additionally, groups of male chimpanzees will patrol the border of their territories, actually looking for other males to harass and even kill. And chimp warfare can indeed match or even exceed the excessive violence of our own warfare--on occasions when they do succumb to outright war, male chimps can attack other, neighboring troops and even eat their babies.

A raid upon neighboring chimpanzees was recently captured on video. In this particular case, the chimps were not defending their territory but actually moving into the territory of the neighbors. As the males moved single-file though the jungle, they emitted lower-tones, while each of them stopped every now and then, silent while listening for the cries of any chimpanzee not part of their troop. Momentarily, too, they would sniff at something, evidently identifying the smell of the other troop. When arriving at their neighbors, they rushed forward using the element of surprise, shrieking and pounding on trees like drums, to scare the others, but instead of targeting the males, they sadly targeted a female who narrowly escaped, and then they at last captured a youngster--which they then cannibalized, passing around the flesh from one chimp to another.

Warfare: Witnessed 18 fatal attacks over ten years by group 150 chimps--where two-thirds of these attacks took place, chimps started using that territory--attacked females and tried to kill the babies, prolonged attack on female, held her captive and tried to wrestle the infant from her arm but she resisted…

Source: University of Michigan. "Chimpanzee gangs kill for land, new study shows." ScienceDaily. ScienceDaily, 22 June 2010. <www.sciencedaily.com/releases/2010/06/100621121348.htm>.

Also have police, in conflicts high ranking males and females intervene

Source: University of Zurich. "Chimpanzees have police officers, too." ScienceDaily. ScienceDaily, 7 March 2012. <www.sciencedaily.com/releases/2012/03/120307185016.htm>.

OTHER CULTURE

Chimpanzees, too, generally contain all the most benevolent and darkest forces of our own nature. They usually greet each other with hugs and kisses and spend hours grooming and comforting each other, and they even form special friendships with other chimpanzees. Jane Goodall has observed chimpanzees break into spontaneous dance while watching a waterfall, perhaps an indication of the spiritual awe that humans feel themselves.

On the other hand, Jane Goodall has witnessed all sorts of more deviant and diabolical behavior over the decades: For example, one male chimp kidnapped the baby of a mother who he then coerced into following him as the alpha male--essentially resorting to force and coercion to attain power: an ancient and prevalent human practice. Another male used empty kerosene bottles as weapons to get other males to follow him. She also observed a faction of males splintering from one of the troops, resulting in warfare that lasted for four years until the dissident group was all but annihilated. At the same time, Goodall has witnessed alpha females killing the babies of other females, and males, as we have seen, will use all of the same violence as ourselves in the name of defending their territory, including cannibalizing their enemies.

Goodall has even observed examples of what you might call neurotic or pathological behaviors in Chimpanzees. One female, named Flo, was nursing her baby, but because she was becoming older and weaker, could not wean the baby at the proper time, probably because she needed to physically prevent the baby from suckling (and wasn't strong enough to do so?). So, the baby stayed dependent upon its mother for longer periods of time--so when the mother died, so did its baby, because it was of the age where it should be able to find its own food but could not.

Notes: "Both have the capacity for endless romping and play, are highly curious, learn by observation and imitation, and above all, need constant reassurance and attention. For both, affectionate physical contact is essential for healthy development. Various mental traits once regarded as unique to humans have been convincingly demonstrated in chimpanzees; reasoned thought, abstraction, generalization, symbolic representation, and concept of self. Non-verbal communications include hugs, kisses, pats on the back, and tickling. Many of their emotions, such as joy and sadness, fear and despair, are similar to or the same as our own" - from Goodall

In captivity, they have been taught to count, use symbols for communication and have even out-performed college students on tests for memory.

Other: predation by felines: throw branches and sticks at them

LIFE EXPECTANCY

Chimps live longer than gorillas 40 to 60 in the wild, 70 in captivity, gorillas to 40 in the wild, longer in captivity

COMMUNICATION

As they move along in the forest, they are extremely vocal, using their calls as other primates to signify predators, their own whereabouts, the presence of food:

As the Jane Goodall website states: "Chimpanzees communicate with a wide range of calls, postures and gestures. The food calls -- a mixture of food grunts, barks, and pant hoots -- alert other chimpanzees to the whereabouts of food sources. A special intensity of excited calls of this type indicates that there has been a successful kill after a hunt. Each individual has his or her own distinctive pant-hoot, so that the caller can be identified with precision. A loud, long, savage-sounding wraaaa call is made when a chimpanzee comes across something unusual or dangerous."

<u>TOOLS</u>

As we have already noted, chimps inhabit many different ecosystems, ranging from lush forests and dry savannahs--which raises the question: What provides them with the ability to adapt to these environments?

Genetics may play some part, as chimps show some meaningful genetic variation from one group to another. But another explanation is that their intelligence and culture allow them to adapt, including the use of tools--which is considerably more pronounced in chimps than other primates. For example, like the Capuchins, Chimps can gather rocks, which they can use as hammers and anvils in one area, transport them to another area--and then use those tools to crack nuts open (Boesch and Boesch-Achermann 1983, 2000). Evidently, based on evidence from excavation, chimps have been using this technology for thousands and probably millions of years. While this behavior may seem intuitive, it is not: as older chimps teach the younger ones, just as humans teach their own children to use forks. In fact, some chimpanzees can never even learn how to use tools in this way, showing some discrepancy in chimpanzees in their intelligence regarding the use of tools.

Sources: National Science Foundation. "Nut-Cracking Chimps: First Primate Archaeological Dig Uncovers New Tool Development Links."

ScienceDaily 24 May 2002. 27 February 2008
<http://www.sciencedaily.com/releases/2002/05/020524073245.htm>.

Sex-differences in tool use: Tool use in chimps differs between the sexes, with females using probing and stone tools more often than males. With regard to termite fishing, females at Gombe do this three times more often than males and start doing it at a younger age (31 vs 50 months), thus achieving higher proficiency. As previously noted, females also eat more termites overall, which is attributed to the need to support reproductive health. Females are also better than males at cracking nuts. This suggests, to me (and other researchers), that the differences in tool use are more related to physiological needs of females of reproductive age, which require them to develop strategies to obtain reliable food sources, and do not reflect inherent differences in intelligence or skill between male and female chimpanzees. Males, in contrast, are not as dependent upon reliable food sources and can spend more time in social activities, other forms of foraging, and hunting (Boesch and Boesch 1984).

SAVANNAH CHIMPS

Tool-use, however, is not only used for attaining animals. A team of anthropologist only recently have observing the behavior of chimps living in harsher, savannah/woodland environments; in these environments, where softer, richer foods are more rare, the chimps would be facing

greater difficulties in attaining foods—adapting to an environment which, as we shall see, our human ancestors encountered millions of years ago. In this environment, chimps are evidently using sticks and pieces of barks with sharp edges to break through hard, crusty layers of dirt to unearth tubers which, according to researchers, have the appearance of potatoes. Then chimps then chew on the tubers, sucking the moisture and many of the nutrients from the roots, then spit out the fibre. Some of these tubers are used by many of the local Africans, as medicinal plants, suggesting that the chimps might be using them for the same purpose.
Source: University of Wisconsin-Madison. "Tool-wielding Chimps Provide A Glimpse Of Early Human Behavior." ScienceDaily 13 November 2007. 27 February 2008
<http://www.sciencedaily.com /releases/2007/11/071112172155.htm>.

Interestingly, these same chimps use caves to escape the heat of the savannah, using such dwellings for sleeping, grooming, playing and eating. And as one anthropologists jokes, he expected them at any moment to start painting on the walls.

Among savannah chimps increased predation on eggs and vertebrates—in marginal environments.

In Savannah, rarely venture very far from trees, just from one forest to another

Notes: sav chimps crave roots and tubers even when food above ground is plentiful and use digging sticks to penetrate the earth--so do not eat as fallback food but as preferred
Source: University of Wisconsin-Madison. "Tool-wielding Chimps Provide A Glimpse Of Early Human Behavior." ScienceDaily. ScienceDaily, 13 November 2007.
<www.sciencedaily.com/releases/2007/11/071112172155.htm>.

Chimps break limbs, strip them sharpened with teeth and impale bushbabies in the hollows of trees then eat them like "popsicles: hunt during rainy season: assume more abundance…
Source: “Spear-Wielding Chimps Studied.” *Video*,
video.nationalgeographic.com/video/news/wild-chronicles/00000144-0a35-d3cb-a96c-7b3d66bd0000.

First evidence of plant sharing between chimps, probably for sex
Source: Iowa State University. "Savanna chimps exhibit human-like sharing behavior, anthropologists say." ScienceDaily. ScienceDaily, 11 December 2011.
<www.sciencedaily.com/releases/2011/12/111201094819.htm>.

Home ranges ten time larger than Goodall’s chimps, so work harder to stay together
Source: Iowa State University. "Wild chimps have near human understanding of fire." ScienceDaily. ScienceDaily, 23 December 2009.
<www.sciencedaily.com/releases/2009/12/091222105312.htm>.