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Evolution
11/5/17

Primate Speciation

Humans often try and find what sets us apart from the animal kingdom, what makes us so different from the organisms we share this world with. In reality, it's not much. We can boast about our bigger brains and advance intelligence, but when it comes down to looking at basic anatomy and genetic information, humans are just one more branch in the phylogenetic tree of life. To discuss humanity's differences from the world, first one must explore the similarities with our closest neighbors in the order Primates. The taxonomical order Primates includes Humans, great apes, lesser apes, old and new world monkeys, and prosimians.[6] For the sake of specificity, great apes include orangutans, gorillas, and chimpanzees, and lesser apes pertain to species of gibbons. In order to study the relatedness of of primates, it's helpful to look into what specifically changed, anatomically, leading to the modern extant species we are familiar with today.

Starting from the top, the head itself holds many recognizable differences even at a first glance. Much of the differences in head shape amongst primate species comes from the masticatory apparatus, or simply the jaw function. The condensing of the profile seen in hominids, I believe largely relates to the reduction of jaw size, as cranial size grew and the massive, protruding vices seen in the great apes gave way for smaller mouths. [2]

As jaw size reduced in hominids and cranial cavity size increased, the amount of space for the nose was reduced significantly. It's believed by many experts in the field, including Dr. Bernard Campbell, that this is where the more prominent noses in humans come from, moving outward in an attempt to maximize nostril space for our already limited olfactory receptors, and create a thick-walled cavity for the regulation of the humidity and temperature of air intake. This limited use of the olfactory bulbs in humans has left us with a sense of smell primarily used for cues related to feeding. Regarding feeding, it's important to note the change in dentition from apes to hominids. Most notably, the canines have changed the most across species. Great apes such as chimpanzees, baboons, and gorillas have prominent canines, protruding like fangs significantly longer than the rest of the teeth. For these species, the teeth are often used for defense in the absence of claws.[2]

A prominent aspect of primate skulls is the sagittal crest and keel, the skull and brow ridges that are often included in the parody of early man. The crest is related to the strength of a primate's jaws, supporting the temporalis muscle, which controls most of chewing function.

Humans have a minimal sagittal extension, barely protruding from the cranium, as opposed to those of other great apes. Hominid ancestor *Australopithecus* has a particularly defined brow in relation to other Hominids, and a crest that rises up from the skull in a similar manner to other great apes, particularly that of the Gorilla. This related keel gives a heavy, defined casing around the eyes and front of the brain, and the crest creates a domed shaped to the head, giving room for a thick bundle of masticatory muscles.[2] This trait links *Australopithecus* closely to the great apes, evidence of the shift from ape to hominid. The shift of the sagittal keel to a slimmer, flatter profile also affected the the eyes. More distant primates such as prosimians display more nocturnal habits, with a higher concentration of photoreceptors. The large eye sockets of larger primates allowed for more complexity in the eye, as the visual cortex in the brain advanced and the great apes focused on daytime habits.[5]

The limbs of primates have varying proportions, often related to habitats and locomotive behaviors in certain species. Tree-dwelling species of lower primates and hylobates have dramatic differences in front and hind limb proportion, arms generally much longer than hind limbs. This gives an advantage of reach and muscle concentration for traveling through trees, as well as hanging for periods of time while feeding. Shorter legs allows the primates to more easily tuck away their legs while brachiating, making less of an effort to hold them up. Primates that primarily spend their time on the ground have shown a shift toward shorter forelimbs. The shift is evident in Gorilla populations, where the arms stretch slightly longer than the hind limbs, with a much smaller ratio of the difference in limb length. [2] This shift is especially apparent in hominids, in the transition from knuckle-walking to upright bipedalism. Humans and late hominids are unique in their ability for bipedal, upright locomotion, as opposed to others in the order who rely on quadrupedalism and brachiated movement. In conjunction with limb changes, primate hands also vary across species. Gibbons are defined not only by their elongated arms, but also in their extreme digits. This taxon defining trait is an exaggerated example of the varying hand ratios amongst primates. Humans and other hominids have relatively short fingers in comparison to close relatives such as chimpanzees, most likely due to a reduced use of fingers for grabbing onto tree branches. Interestingly, gorillas and hominids are similar in their lack of significant change, while chimpanzees and orangutans exhibit convergent evolution in terms of digital elongation. [1] Changes in the feet on primates also vary amongst species. For instance, hominids have very little gripping ability, with a greatly reduced toe size. Even our closest ancestor amongst the great apes, the chimpanzee, uses feet and toes in hand-like ways. This is a function retained by most primates, as much of the order inhabits trees. Gorillas have longer, more functional toes than humans, but also have exhibit a flatter walking foot convergently evolved to our own.

As well as feet adjusted for walking, hominids also changed in terms of pelvis structure. One of the reasons childbirth is so painful for humans in particular is that the evolution of bipedalism didn't leave much room for the pelvis to adjust, leading a starkly recognizable pelvic shape. One might think that females would have evolved a much wider pelvis to account for the more painful birth, and they did, to an extent. Individuals with pelvises too small to safely deliver offspring were less likely to pass on those genes, however even for those with larger pelvises who experienced painful labor, the offspring often survived. Evolution does not choose a beneficial direction to go in, once a middle ground was reached where females could safely birth their children, there was much less evolutionary pressure on the trait, because it wasn't impeding the reproductive success of the species. When examining the pelvises of quadrupedal and tree-dwelling primates, the general butterfly shape is recognizable, yet much more flattened out. The pelvis of chimpanzees arcs along the backside parallel to the spine, with the femur connecting at a nearly perpendicular angle.[2] The bowl shape the of hominid pelvis is an autapomorphic, or taxon-defining, trait that shows how a change in behavior can affect selection for anatomy in a species, as well as changes in anatomy can affect the selection for behaviors.

One last aspect of the differences between primate species, hominids are very particular in the order due to the lack of hair. Most primates have a blanket of hair covering their bodies, while looking across hominid species, that hair is lost in the march towards modern humanity. Humans actually have the same amount of follicles as the great apes, but produce less hair for a peachfuzz coat rather than fur. It's believed that this hair loss is for the reduction of the amount of heat the body retains, which then explains why hair exists on the scalp. The scalp doesn't retain as much heat as the rest of the body, making it a much cooler area that benefits from the insulating quality of hair. In the underarms and pubic area, hair is presumed to be present due to the quantity of scent glands in these spots, but researchers are unsure of specific reasoning for the presence of this hair. [2]

Drawing on this research I can determine some ideas to expand on with my upcoming project. The most basic is that the primate anatomy adapts because of changes in their environment behavior. Delving into the etiology of the specific traits discussed is just as important as acknowledging them in the first place. For instance, elongated limbs and digits of lesser primates came about because of a need for reaching and gripping in a wooded environment. Another example would be that a the shift to living on the ground influenced the change of hominid structure in the pelvis or feet to adjust for walking. For my project, I hope to use the many differences that I've researched to illustrate the splits between species of hominids. Anatomical features such as skull shape, dentition, hand and feet structure, and other skeletal factors all give clues to the changes that gave rise to specific species within the primate order. I hope to examine the traits that are specific to each species, for instance the extended digits and small face of gibbons, or the knuckle walking and elongated vertebrae of gorillas. I’m imagining a set of trading cards, describing mostly extant species and their characteristics, as well as what sets them apart from the rest of the order. In order to tie it into the ideas about the etiology of these traits I would create cards, like in a Magic: The Gathering style, describing environments or behaviors that are associated with development of traits. It would be both an educational tool as well as a collectable-style toy, similar to the animal trading cards found in the kid’s science magazines from my childhood.

Annotated Bibliography

1. Almécija, Sergio, et al. "The Evolution of Human and Ape Hand Proportions." *Nature News*, Nature Publishing Group, 14 July 2015, www.nature.com/articles/ncomms8717.

This source shows the physical differences in the hands and fingers of multiple primate groups in relation to humans. Digit elongation and thumb ratios between species are inspected, revealing physical changes and adaptations between different species. Gibbons are shown to have the largest distances between thumb and finger, while humans have a relative small distance. Chimpanzees, like Gibbons also have extended digits and a wider proportion, while Gorillas have smaller hands that are more similar to human proportions.

2. Campbell, Bernard G. Human Evolution; an Introduction to Man's Adaptations. Chicago: Aldine, 1967. Print. *(Library Source)*

Although this book is an older source, it's very comprehensive. The book delves into anatomy and taxonomy of humanity's closely related primates, and how evolution speciated primates and brought about the rise of humans. The anatomy discussed is very specific, from the neural correlates of binocular vision, to the differences in dentition of hominidae and pongidae (a now-obsolete paraphyletic taxon representing chimpanzees, gorillas, and orangutans). The information in the source speaks to a higher level of understanding than other informational books I've examined in my research.

3. Cartmill, Matt. *Human Lineage*. John Wiley & Sons, 2017. Web. https://goo.gl/sAfh5H

This source contains comprehensive information of evolution and adaptation of primate species. I used this source specifically for information about order *strepsirrhine*, which include Madagascar lemurs and other small tree-dwelling primates like galagos, bushbabies, lorises, and so forth. *Strepsirrhine* covers a large amount of specialized island-dwelling creatures that evolved in isolation, giving them interesting and unique adaptations that are unlike other small primates like tooth combs, grooming claws, wet noses, and improved night vision.

4. Dunbar, R. I. M., and Susanne Shultz. “Understanding Primate Brain Evolution.” Philosophical Transactions: Biological Sciences, vol. 362, no. 1480, 2007, pp. 649–658. JSTOR, www.jstor.org/stable/20209875.

This source delves into the progression of brain size in primate species. Through extensive data collection and comparison, intersections are assessed between neocortex size and lifespan, and how these traits also interact with group and home size, predations, and other variables. These intersections are presented with a large amount of numerical data and charts making the information easier to absorb.

5. Fleagle, John G. *Primate Adaptation and Evolution*. Academic Press, 2013. Web. https://goo.gl/LcQ6h7

Fleagle’s textbook on the evolution of primates gives a comprehensive look into the physical attributes of multiple primate species. Primate anatomy is well expressed in the book, allowing for comparisons to be made across species. Specific traits are discussed, such as the tongue, teeth, sensory systems, and many more specialized aspects of the body.

6. Raven, Peter H. *Biology*. McGraw-Hill, Higher Education, 2005. https://goo.gl/yGbXrB

This source discusses a comprehensive overview of human’s relationship to primates. A phylogenetic tree is presented, showing the similar species of primates Humans, chimpanzees, gorillas, orangutans, and gibbons, as well as “old world monkeys”, “new world monkeys”, and certain species of lemurs. Comparisons between skeletons and skulls are made, showing the homologous physical similarities.

7. Young, Nathan M., et al. "Development and the Evolvability of Human Limbs." Proceedings of the National Academy of Sciences of the United States of America, vol. 107, no. 8, 2010, pp. 3400–3405. JSTOR, JSTOR, www.jstor.org/stable/40537298.

This source discusses the evolution of front and hind limbs in humans and other hominids and primates. By reviewing the illustrations and timelines, comparisons can be made from extant human anatomy, to skeletons of ancient hominids such as Homo Ergaster and Australopithecus Afarensis, as well as drawing comparisons to non-hominid primates that are closely related to humans such as gibbons, gorillas, and orangutans. These comparisons and timelines reveal the path of skeletal evolution amongst primates.