7-2 Final Project Submission

Museum Exhibit Recommendations

Impact of Primate Evolution

Prominent Examples

All modern primates share a set of distinctive traits that set them apart from other mammals. One key feature is their highly dexterous hands and feet. Primates have opposable thumbs, enabling them to grasp and manipulate objects with precision. Some species even have opposable big toes on their feet, further enhancing their ability to grip. Additionally, tactile fingerprints on their fingers and toes enhance sensitivity and improve their ability to handle objects effectively.

Modern primates generally have shorter snouts, which reduces their reliance on smell. Unlike many other mammals, their sense of smell is less developed. To compensate, primates rely more heavily on other senses, especially vision.

Modern primates have forward-facing eyes, enclosed eye orbits, and stereoscopic vision. This type of vision allows both eyes to send information to both brain hemispheres, providing them with excellent depth perception, crucial for navigating complex environments.

The dental structure of modern primates is generalized, allowing them to consume a wide variety of foods, including meat, vegetation, fruits, and nuts. This flexibility in diet reflects an adaptation to diverse habitats.

Modern primates also have extended life histories compared to other mammals. They experience longer gestation periods, prolonged childhood development stages that foster social learning and environmental awareness, and extended maturation periods, which contribute to longer lifespans (Boyd, R., et al. 2023. p. 197).

Finally, modern primates have relatively large brains in proportion to their body size, which allows for greater behavioral flexibility, problem-solving skills, and social complexity (Boyd, R., et al. 2023. p. 190).

Table 1.1: Geologic Time Scale (Boyd, R., et al. 2023. p. 207)

Era	**Period**	**Epoch**	Period Begins – million years ago (mya)	Notable Events
Cenozoic	Quaternary	Holocene	0.012	

		Pleistocene	2.6	*Homo sapiens* appear in the fossil record
	Tertiary	Pliocene	5	
		Miocene	23	Hominidae (apes) flourish in the fossil record
		Oligocene	34	First primates resembling modern monkeys appear (*Aegyptopithecus zeuxis*); early Hominidae appear in the fossil record
		Eocene	54	
		Paleocene	66	First primates appear in the fossil record (*Plesiadapiforms*)

Plesiadapiforms first appeared in the fossil record during the Paleocene, around 66 million years ago (mya), marking them as the earliest known primates. Unlike modern primates, they lacked several key traits we associate with today’s primates. Their eye orbits were not fully enclosed in bone, their teeth were more specialized, their eyes were positioned on the sides of their heads, they had tails, and an elongated snout. However, they did possess opposable thumbs, enabling them to grasp objects. Lemurs are among the closest living relatives of Plesiadapiforms, preserving some of their early primate characteristics (Boyd, R., et al. 2023, p. 190).

Another significant primate ancestor, Aegyptopithecus, emerged in the fossil record during the Oligocene, approximately 34 mya. Often considered an early example of a true anthropoid, Aegyptopithecus exhibited a mix of primitive and advanced traits that provide insight into primate evolution. This small arboreal primate had forward-facing eyes, a relatively enclosed eye orbit, and a dental structure similar to that of modern monkeys, indicating dietary versatility. With its combination of ancestral and derived characteristics, Aegyptopithecus serves as a bridge in our understanding between earlier primates like Plesiadapiforms and the later catarrhine primates, from which modern monkeys, apes, and humans descended (Boyd, R., et al. 2023, p. 218).

During the Oligocene, around 34 mya, early Hominidae began to appear in the fossil record, marking a significant shift toward modern ape lineages. By the Miocene, approximately 23 mya, Hominidae, or hominoids, were flourishing. Hominidae is the superfamily of apes that encompasses both lesser apes (such as gibbons and siamangs) and great apes (including gorillas, chimpanzees, and orangutans). Early hominoids, such as Proconsul, exhibited a mix of monkey-like and ape-like features: they had a more flexible spine, a larger brain relative to body size, and more advanced upper body adaptations suited for climbing and brachiation. Unlike monkeys, they had no tails, a trait that is characteristic of all modern apes (Boyd, R., et al. 2023, p. 223).

Modern Primate Behavior

One of the primary traits of primates is their large brain size relative to body size compared to other mammals, which supports complex cognitive abilities. According to the social brain hypothesis, the demands of living in social groups favor the evolution of larger brains with enhanced cognitive capacities (Boyd, R., et al. 2023, p. 190). For example, chimpanzees, with their relatively large brains, form complex social groups, use tools, and engage in sophisticated communication.

The ecological brain hypothesis, on the other hand, emphasizes the role of environmental challenges in driving brain evolution (Boyd, R., et al. 2023, p. 190). Chimpanzees often inhabit regions where food and water are scattered, requiring them to forage in resource-scarce environments. The social brain hypothesis explains the cognitive abilities chimpanzees use to navigate social relationships, while the ecological brain hypothesis accounts for the problem-solving skills they apply to locate and access resources in challenging environments. Together, these hypotheses illustrate how both social and ecological pressures have shaped the cognitive and behavioral complexity of chimpanzees.

Evolutionary Split

During the Paleocene, around 66 million years ago, the supercontinents Gondwanaland and Laurasia had already begun to break apart due to continental drift. However, the modern configuration of continents had not yet fully formed. North America remained connected to Eurasia, while South America and India were isolated. It was during this epoch that the earliest primates, the Plesiadapiforms, emerged. As the continents continued to drift apart, forming the geography we recognize today, oceans acted as natural barriers, isolating primate populations and leading to evolutionary divergence (Boyd, R., et al. 2023, p. 210).

Climate change also played a crucial role in the evolutionary split of primates. Throughout much of the Cenozoic era, temperatures were warmer and more stable than today. However, toward the end of the Cenozoic, global temperatures dropped, cooling approximately 16 degrees Celsius from their peak. This shift in climate pressured primates to adapt to their changing environments, spurring evolutionary changes in response to new ecological challenges (Boyd, R., et al. 2023, p. 210).

Ethical Considerations

There are several ethical considerations to keep in mind when designing the exhibit. One important decision is whether to display live animals or show videos of primates in their natural environment. Primates have complex social, environmental, and psychological needs that are challenging to meet in captivity, which can lead to stress or abnormal behaviors. Captive primates may also display behaviors that don’t reflect their natural state, potentially giving visitors a misleading impression.

Another key consideration is whether to use real specimens or replicas. High-quality replicas, when possible, as they provide a realistic representation of primate anatomy while respecting the dignity of animal life. If anatomical specimens are displayed, they should be sourced ethically, ideally from existing collections at other natural history museums or institutions. This approach ensures the display is informative and respectful of primate species.

Hominin Evolution

Sahelanthropus tchadensis

Sahelanthropus *tchadensis* derives its genus name, Sahelanthropus, from the Sahel region—a dry expanse south of the Sahara Desert—and its species name, *tchadensis*, from Chad, the African country where its skull was discovered in 2002. This species, which lived between 7.2 and 6.8 million years ago (mya), is considered the earliest known hominin. It exhibits a blend of derived and primitive traits, providing critical insights into the early stages of hominin evolution (Boyd et al., 2023, p. 233).

One notable feature of S. *tchadensis* is the positioning of its foramen magnum. This opening, through which the spinal cord connects to the skull, is located at the back of the skull in quadrupedal primates. However, in Sahelanthropus tchadensis, the foramen magnum is positioned underneath the skull, indicating that this species was likely bipedal. (Boyd et al., 2023, p. 235).

Ardipithecus ramidus

Discovered in 1992 in the Middle Awash region of Ethiopia, Ardipithecus *ramidus* has been dated to approximately 4.4 million years ago. In subsequent years, additional *Ar. ramidus* fossils were found in the Gona region of Ethiopia. The name *Ardi* means "ground" or "floor," and *rami* translates to "root" in the local Afar language, reflecting its connection to early terrestrial habitats. Fossil evidence for *Ar. ramidus* includes a partial skeleton, as well as skull fragments, teeth, hand bones, and a pelvis. This extensive fossil collection provides significant insights into the evolutionary shift toward a more human-like anatomy. For example, its reduced canines lack the honing complex typically seen in chimpanzees, marking an evolutionary step toward modern human dentition. Additionally, its pelvis exhibits clear adaptations for bipedal locomotion (Boyd et al., 2023, pp. 237–240).

The pelvis, a structure composed of three bones— the iliac crest (upper portion), the pubis (central portion), and the ischium (lower portion)—forms a protective ring for internal organs and supports the lower vertebral column. It connects to the leg bones and forms the hip joint with the femoral head of the femur. In modern humans, the iliac crest is shorter and broader than in chimpanzees, enabling the attachment of large muscle groups essential for maintaining upright posture. This broadened and robust iliac crest is absent in chimpanzees and other quadrupedal hominins. Ardipithecus *ramidus* is the earliest known hominin to exhibit a broadened iliac crest, suggesting it had the anatomical components required for upright locomotion (Boyd et al., 2023, pp. 237–240).

The hands of African apes, such as gorillas and chimpanzees, are characterized by long metacarpals (the bones in the palm), long phalanges (finger bones), and relatively short thumbs. This hand anatomy allows them to bear weight on their knuckles for quadrupedal locomotion and to hang below branches while feeding or moving through trees. In contrast, Ardipithecus *ramidus* had shorter metacarpals and phalanges, along with more robust thumbs. This hand structure was better suited for walking along the tops of branches and bearing weight on the palms, reflecting a unique adaptation to arboreal locomotion (Boyd et al., 2023, pp. 241).

Australopithecus afarensis

Fossils of Australopithecus *afarensis* have been discovered at several sites since the 1970s, including Dikika, Hadar, and the Middle Awash Basin in Ethiopia, Laetoli in Tanzania, and Bahr el Ghazal in Chad. These fossils have been dated to between 3.6 and 3 million years ago. The skull of *A. afarensis* retained several apelike features, such as a small brain, a shallow jaw joint, and a pneumatized cranial base. Its teeth and jaws were intermediate between those of apes and modern humans. The dental arcade was less parabolic than in modern humans and featured larger, more dimorphic canines. While the front teeth were smaller than those of extant apes, the premolars and molars were large and had thick enamel, reflecting adaptations to their diet. The brain cavity is larger than chimpanzees, but much smaller than humans. A. *afarensis* cranial cavity has a volume of approximately 466 cc, compared to humans of about 1300 cc (Boyd et al., 2023, pp. 247–248).

Australopithecus *afarensis* was fully committed to bipedalism. Its spine closely resembles that of modern humans, featuring an S-shaped curve known as lordosis, which helps maintain balance and upright posture. Additionally, its pelvis was adapted to facilitate bipedal locomotion, further supporting its ability to walk upright. Chimpanzees on the other hand have a bow shaped spine that facilitates quadrupedal locomotion (Boyd et al., 2023, pp. 251-252).

Homo erectus

Since 1976, Homo *erectus* fossils have been unearthed at various locations across Africa, including Lake Turkana, Olorgesailie, and Ileret in Kenya; Konso-Gardula and Daka in Ethiopia; Olduvai Gorge in Tanzania; and Drimolen and Swartkrans in South Africa. These fossils date back to approximately 1.8 to 1.7 million years ago (Boyd et al., 2023, pp. 265).

The skulls of Homo *erectus* exhibit several traits characteristic of earlier hominins, such as a receding forehead and the lack of a pronounced jaw. However, they also begin to display features more similar to modern humans, including smaller teeth and taller cranial structures.

Notably, the cranial volume of H. *erectus* increased compared to earlier hominins, reaching approximately 1000 cubic centimeters. Evidence suggests that the brains of H. *erectus* became less ape-like and more human-like over time (Boyd et al., 2023, p. 266).

The inferior frontal cortex, which is larger in humans than in apes, plays a critical role in cognition, tool use, and language. Paleontologists have developed methods to trace these evolutionary changes in H. *erectus* brains by examining faint impressions left in the skull by deep ridges in the brain, called sulci. In later H. *erectus* skulls, the traces of sulci appear more human-like than ape-like, indicating a significant development in cognitive abilities compared to older hominins (Boyd et al., 2023, p. 266).

Early hominins had ribcages that were narrower at the top and flared out at the bottom. In contrast, *Homo erectus* exhibited a ribcage more like that of modern humans, with a barrel-shaped structure. This shift in ribcage morphology suggests changes in their internal organs. Modern humans, for example, have shorter intestines compared to apes, largely due to a diet that includes cooked foods. Cooking reduces the energy required for digestion, as it breaks down food more effectively than raw consumption. This adaptation would have allowed *H. erectus* to allocate less energy to digestion and more energy to power and evolve their brains (Boyd et al., 2023, p. 268).

Homo erectus likely utilized its evolved bipedalism to become an efficient long-distance runner. As hominins transitioned from quadrupedal to bipedal locomotion, H. erectus further refined this ability, enabling effective travel over extended distances on foot. Its pelvis shape and leg structure facilitated a twisting motion of the torso during running, optimizing energy use. While H. erectus was not adapted for high-speed running like many other mammals, its movement was highly efficient for endurance, making it well-suited for covering long distances (Boyd et al., 2023, p. 268).

In addition, H. *erectus's* full commitment to bipedalism likely aided in body temperature regulation during long-distance travel. Its upright posture allowed greater air circulation over the length of its body, enhancing its ability to stay cool while moving over long distances (Boyd et al., 2023, p. 242).

Homo neanderthalensis

Approximately 1 million years ago, hominins with advanced cognitive abilities began migrating out of Africa as an adaptation to climate change. As climates grew colder, these hominins sought regions with more favorable living conditions (Boyd et al., 2023, p. 292). Homo neanderthalensis is among the earliest hominins known to have evolved outside of Africa. Much of its evolutionary development resulted from adaptations to diverse environments and genetic drift caused by geographic isolation from earlier hominin populations.

The first fossils of Homo *neanderthalensis* were discovered in 1856 by quarry workers in the Neander Valley, Germany. Although H. neanderthalensis is not a direct ancestor of modern humans, it is one of the most extensively studied hominins. This is due to its wide distribution across Eurasia and the extensive research conducted in the regions where it lived. Scientists have successfully extracted DNA from H. *neanderthalensis* fossils, enabling them to map its genome and trace migration patterns over time by comparing genetic differences among fossil groups (Boyd et al., 2023, p. 305). Research has also revealed that H. *neanderthalensis* and Homo sapiens (modern humans) interbred, meaning that modern humans share genetic links with H. *neanderthalensis*.

Homo *neanderthalensis* shares many features with modern humans while retaining distinct characteristics. They had large brains, with an average cranial volume of approximately 1520 cubic centimeters—slightly larger than that of modern humans. Their skulls were long and low, with a rounded bulge at the back, and they had prominent brow ridges. Their bodies were robust and heavily muscled, a distinctive build that may have evolved to conserve heat in cold environments (Boyd et al., 2023, pp. 305-306).

In addition to their physical traits, H. *neanderthalensis* exhibited highly developed cognitive abilities. They created and used tools to hunt large game, likely buried their dead, and produced art (Boyd et al., 2023, p. 306).

Homo sapien

In 1960, the oldest known fossils of anatomically modern humans were discovered during a mining operation at Jebel Irhoud in Morocco. These fossils have been dated to approximately 315,000–286,000 years ago. Modern humans, scientifically known as *Homo sapiens,* represent our species, which has existed for roughly 300,000 years. Over that time, *Homo sapiens* have evolved into the complex beings we are today, successfully migrating and settling in nearly every corner of the globe (Boyd et al., 2023, p. 327).

Map

Image 2-1: The map highlights significant sites in Africa where early hominins and humans were first discovered. *Created in QGIS.*

Ethical Sourcing and Cost

In many cases, the scarcity of excavated fossils of early hominin species makes obtaining original specimens extremely challenging. Even when fossils are available, their acquisition raises significant ethical questions, including whether they were ethically sourced, how they were originally obtained, and if they have ties to questionable origins. Additionally, repatriation concerns often arise, as countries and communities increasingly advocate for the return of artifacts and remains taken without consent. These factors are compounded by practical issues, such as ensuring that the fossils are properly cared for to avoid accidental damage or loss, and addressing cultural sensitivities related to the public display of ancestral remains.

Given these challenges, I propose that the museum acquire accurate replicas for display. Replicas offer a scientifically precise and visually compelling alternative to original fossils, mitigating the ethical and logistical concerns tied to their acquisition and use. They eliminate risks to fragile and irreplaceable fossils, ensuring their preservation for future research while respecting repatriation rights. Replicas also address cultural sensitivities by providing a respectful alternative to displaying actual ancestral remains, which might conflict with the spiritual or cultural beliefs of certain communities.

By utilizing replicas, the museum can achieve its educational and scientific goals without compromising ethical integrity or preservation standards. These replicas allow the public to engage with the story of human evolution in a way that honors the rights and heritage of source communities, protects irreplaceable scientific resources, and fosters a responsible approach to museum curation. Through this strategy, the museum can inspire and educate visitors while maintaining the highest ethical standards.

Companies like *Bone Clones* provide fossil replicas of hominins that the museum may wish to display. Below is a sample cost breakdown of the replicas currently available from Bone Clones.

Table 2-2: Table breakdown of fossil replica costs.

Hominin	Fossil Description	**Cost**
Australopithecus afarensis, Kenyanthropus platyops, Australopithecus africanus, Australopithecus boisei, Homo ergaster, Neanderthal, Australopithecus africanus, Homo erectus, Homo habilis	Set of 9 Fossil Hominid Skulls	$2,490
Homo neanderthalensis, Homo erectus, Australopithecus boisei, Australopithecus afarensis, Chimpanzee, Human, Gorilla	Set of 7 Primate Skulls	$2,090
Australopithecus afarensis	"Lucy" Skeleton, Articulated Walking	$7,850

Further exploration of the fossil and tool replica options can be found on the *Bone Clones* website. https://boneclones.com/category/all-fossil-hominids/fossil-hominids

Impact of Culture and Environment

Many diseases are caused by recessive genes. Sickle-cell anemia, for instance, occurs when an individual inherits two copies of the hemoglobin S (HbS) allele, making them homozygous for this gene. Hemoglobin S is an abnormal form of hemoglobin, the protein in red blood cells responsible for carrying oxygen throughout the body. This condition arises from a mutation in the HBB gene, which replaces the amino acid glutamic acid with valine in the hemoglobin molecule. This mutation exemplifies human genetic diversity shaped by environmental pressures. An allele is a specific version of a gene and being homozygous means inheriting two identical alleles for a particular gene. Genes are segments of DNA that code for traits, while alleles are variations of these genes that lead to different expressions of those traits (Boyd R. et al., pp. 370-378).

In regions where malaria is endemic, individuals who are heterozygous for the HbS allele (HbA/HbS) are more likely to survive malaria because the sickle-cell trait provides partial protection against the disease. The high frequency of the HbS allele in these areas is partially attributed to environmental conditions shaped by early agricultural societies. For instance, clearing land for farming created standing pools of water that became breeding grounds for mosquitoes carrying the malaria parasite. This environmental factor, combined with natural selection, drove the adaptation of the HbS allele in populations from sub-Saharan Africa, the Mediterranean, and parts of India. However, individuals who are homozygous for HbS (HbS/HbS) develop sickle-cell anemia, in which red blood cells become misshapen under low oxygen conditions, leading to anemia and other severe health complications (Boyd R. et al., pp. 373, 377-378).

The prevalence of malaria in specific geographic regions has significantly shaped the genetic diversity associated with sickle-cell anemia. Malaria, a mosquito-borne infectious disease, exerted intense selective pressure on human populations in tropical and subtropical climates, leading to an increased frequency of the HbS allele. This genetic adaptation is closely linked to environmental factors such as local climate, temperature, rainfall, and the presence of infectious diseases.

A primary ethical concern in featuring sickle-cell anemia in a museum exhibit is the risk of reinforcing stereotypes about populations most affected by the disease, particularly individuals of sub-Saharan African, Mediterranean, and Indian descent. Without sufficient context, highlighting the disease could perpetuate biases and misunderstandings, reducing a complex interplay of evolutionary and environmental factors to a simplistic association with specific populations.

To mitigate these risks, the exhibit should frame sickle-cell anemia within a broader narrative of human adaptation and genetic diversity rather than isolating it as a condition tied to ethnic or racial groups. Emphasizing the evolution of the HbS allele as a response to environmental pressures like malaria can present a shared human story of resilience and survival, shifting the focus from racial or ethnic divisions to the universality of adaptation. Moreover, incorporating perspectives from communities affected by sickle-cell anemia can ensure their voices are represented respectfully and authentically. A balanced presentation that examines the disease's evolutionary background alongside its medical and social implications can foster greater understanding and compassion among visitors.

Deconstructing Race

In Renaissance Italy, the term *razza* was originally used to describe breeds of animals. Over time, this concept was extended to classify differences among people, eventually evolving into the modern notion of race. Today, however, it is widely understood that all humans belong to the same species, Homo sapiens, and share far more genetic similarities than differences. In fact, genetic studies show that variation within so-called racial groups often exceeds variation between them. The physical traits historically used to define races, such as skin color or facial features, are superficial and do not correspond to deeper genetic divisions (Boyd R. et al., pp. 389).

Although genetic variation can be used to analyze a person's geographic ancestry with a degree of accuracy, these distinctions are not absolute or sharply defined. Advances in genomics reveal that certain genetic markers are more prevalent in specific populations, reflecting historical patterns of migration, isolation, and adaptation to environmental conditions. These markers help group individuals into broad categories aligned with geographic regions but do not constitute discrete racial boundaries (Boyd R. et al., pp. 389).

In the United States, racial identity is frequently used to categorize individuals. Official documents such as the U.S. Census, employment applications, and higher education applications often use race and ethnicity interchangeably to classify people into categories such as White or Caucasian, Black or African American, Asian, Hispanic or Latino, and Native American. These classifications serve as identifiers, but they often blur the distinction between race, a social construct based on perceived physical traits, and ethnicity, which reflects shared cultural or historical heritage (U.S. Census Bureau, n.d.).

The socially constructed nature of race is evident in the inconsistent and fluid application of these categories. For example, the U.S. Census has revised its racial and ethnic categories multiple times throughout its history, reflecting changes in political priorities, social attitudes, and demographic trends. Additionally, self-identification varies depending on personal experience, societal expectations, and context, further demonstrating the flexibility of these labels. While such classifications can be useful for identifying disparities in health, education, and employment, they can also perpetuate stereotypes and reinforce systemic inequalities by oversimplifying complex identities. Moreover, conflating race and ethnicity often obscures the cultural diversity within groups, such as the numerous national and linguistic identities included under the Hispanic or Asian categories. This highlights the importance of developing a more nuanced understanding of human diversity that transcends rigid or binary classifications.

As a concept, race refers to a socially constructed system of classification historically used to group individuals based on perceived physical traits like skin color, facial features, or hair texture. These classifications are typically imposed externally and tied to systems of power, serving to categorize and stratify populations. However, such racial categories lack biological validity, as human genetic diversity does not align with them. Instead, race reflects social, political, and historical contexts rather than inherent biological differences.

Ethnicity, in contrast, is defined by shared cultural elements such as language, traditions, religion, ancestry, and historical experience. Unlike race, ethnicity is often self-determined and emphasizes collective cultural identity rather than perceived physical characteristics.

Biological anthropology underscores that race is not a biologically meaningful way to categorize human variation. Instead, it approaches human diversity through the lenses of genetics, adaptation, and culture. Cultural relativism is a critical framework for understanding race as a social construct, as it highlights how racial categories, and their meanings vary significantly across societies and historical periods. By adopting a cultural relativist perspective, biological anthropologists can better comprehend how societies construct and use racial categories without imposing external biases or assuming universality (Boyd R. et al., pp. 391).

Citations

Boyd, R., Silk, J. B., & Langergraber, K. (2023). How Humans Evolved (10th ed.). W. W. Norton. https://mbsdirect.vitalsource.com/books/9781324061762

U.S. Census Bureau. (n.d.). *United States: Race and ethnicity*. Retrieved November 28, 2024, from https://data.census.gov/profile/United_States?g=010XX00US#race-and-ethnicity