Evolution Make-Up Name: _____

Biology 1102 Section: _____

This exercise replaces your quiz and homework grade for the Evolution lab (15 pts.). Read the two articles below and answer all of the questions found below (10 pts.). You will find the answers to most questions in the readings. All responses must be typed in YOUR OWN WORDS and in COMPLETE SENTENCES. The second part of this makeup assignment is an essay worth 5 points. See instructions on the last page.
If you have any questions, feel free to contact your TA.

1. (1 pt) Describe the Bighorn Basin. Include where it is located, how it was formed, and why it is important to paleontologists.

2. (1 pt) What is/are the name(s) of time period that these articles are concerned with? How long ago was that?

3. (2 pt)Explain how scientists can use the rocks themselves to infer information about conditions in the Bighorn Basin in the past.

4. (1 pt) Describe two ways leaf characteristics can be used to gather information about the past environment.

5. (2 pt) Give a brief overview of the theory proposed in one of the articles to explain the warming that occurred during the time periods under consideration.

6. (2 pt) Most animal fossils are found as fragments. What fragments are found most often? Why do you think that is?

7. (1 pt) The skeletons of which mammal have been found most often in the Bighorn Basin? Is it living now? If not, what existing mammal(s) is it most closely related to?

Hot Times in the Bighorn Basin

By Scott L. Wing

***Natural History*, April 2001**

A modern desert provides dues to an ancient period of global warming.

To most people who drive through, hurrying west to Yellowstone National Park, Wyoming's Bighorn Basin is nothing but a vast sagebrush plain crossed by two lanes of blacktop stretching away toward distant snowcapped peaks. Those with their eyes on the horizon may never notice badland hills striped with red and purple, and only those who leave the road will smell pungent, fresh-crushed sage, hear the total silence of the desert at midday, and feel dust as fine as powder between their fingers. Even those who experience the desert may not realize it is a country haunted by time travelers--paleontologists--who pull from the rocks not only fossils but an understanding of how the earth's climate has changed in the past and how plants and animals have responded to those changes. This part of Wyoming contains the world's best record of a period 55 million years ago, when the earth experienced an episode of global warming more rapid than any before, perhaps as rapid as the one we humans are about to cause and experience.

The Bighorn Basin is roughly 4,000 square miles (about 10,000 square kilometers) of badlands, sagebrush flats, and irrigated fields. Except for a narrow opening to the northwest, it is surrounded by mountains. Like other basins in the Rocky Mountains, the Bighorn Basin formed 60-50 million ?ears ago, during the late Paleocene and early Eocene, as mountains were pushed up on all sides. Fast-moving streams eroded mud and sand from the rising mountains and, slowing as they reached flatter land, spread sediment across the bottom of the basin. Year after year, flood after flood, layers of sediment accumulated until in some areas the pile was more than six miles deep, burying--and preserving--the remains of countless organisms. In the past few million years, this part of the North American continent experienced renewed uplift, the climate became colder and drier, and the vast deposits began to erode rapidly, dissecting the soft rocks into strange and intricate shapes and littering the slopes and flats with the fossils once contained inside.

Fossil riches first attracted paleontologists to the Bighorn Basin more than a century ago. Early scientists worked from horseback; photographs of their expeditions show U.S. Army cavalrymen, brought along to ensure safety. In photographs from the early twentieth century, field crews cluster around buckboard wagons or Model T Fords, replaced in more recent photos by weathered pickups and four-wheel-drive vehicles. Traveling in the badlands is still difficult and sometimes dangerous--anyone who has worked long in the basin has spent time digging a stuck vehicle out of a dry creek bed or walked miles to the nearest road to seek help. Stories of such experiences, retold around campfires, remind us of some constants in fieldwork--even if we now locate fossil sites with global positioning systems rather than with cairns and enter data into computers at night as well as into notebooks during the day.

The generations of effort have paid off handsomely. Hundreds of thousands of

fossils-- mammal bones, leaves, shells--fill the cabinets of museums around the country and even the world. There are fossil pollen grains by the millions. Each fossil reveals something about a once-living organism: a leaf may contain the fossilized trail of an insect larva that tunneled within it for food; the cusps and crests of a mammal tooth bear evidence of the food it was suited to chew; the bones of large land tortoises, soft-shelled aquatic turtles, and alligators show that the ancient climate was warm and that the rivers teemed with life.

Evidence of past conditions also comes from the Bighorn Basin rocks themselves. The varicolored bands running across the hills are fossilized soils. The bands' colors indicate such things as the wetness of the original soil, and their thickness provides evidence of the length of time over which they developed. The depth and sinuosity of sandstone deposits reveal the original dimensions and course of ancient river channels. Coal-dark deposits show where the floodplain was especially wet, inhibiting the decay of plant remains by the fungi, bacteria, and arthropods living in the soil. Veterans of fieldwork in the basin are familiar with the colors and shapes that indicate the likely presence of fossils. Bands of red, orange, purple, and light gray (evidence of well-drained soil) often contain fossil bones. Plant fossils occur in several types of rocks, including brown and dark gray layers--all that is left of ancient swamps--and also coarse silt and fine sand layers deposited millions of years ago by overflowing rivers. Sediments containing fossil plants also typically contain the mineral gypsum, which forms large crystals as it weathers out of the rocks. The flashing of gypsum crystals in the desert sunlight can beckon a fossil hunter from miles away.

Taken together, all the evidence yields a picture of the environment and life of the basin during the late Paleocene and early Eocene. The streams--mostly small, slow moving, and gently meandering--were lined with low, natural levees on which grew a variety of trees, including relatives of sycamore, poplar, walnut, and hazelnut. The most common streamside tree was a relative of the katsura tree (Cercidiphyllum), a genus restricted today to two species in eastern Asia but once common across the mid and high latitudes of the northern continents. In the understory of these streamside woodlands lived several types of ferns still found in temperate forests, but the areas of open grassland that are so common today were absent. (Grasses had evolved by this time but had not yet become important forms of vegetation.) A variety of turtles lived in the rivers, along with gar, freshwater clams and snails, crayfish, and alligators. More than a hundred species of mammals roamed the forested floodplains, including some of the earliest primates, dawn horses, the earliest even-toed ungulates (the group that includes deer, pigs, and antelope), early true carnivores, and other mammals that have no extant close relatives (see "Wyoming's Garden of Eden," page 55). Among the birds was Diatryma, a six-foot-tall relative of today's cranes.

Plants of the lower, wetter floodplains included dawn redwood (Metasequoia), a Chinese relative of bald cypress (Glyptostrobus), alder, a relative of witch hazel, and more than a hundred less-common species. Also flourishing in these swamp forests were relatives of a number of living, mostly tropical or subtropical plant families, including palms, cycads, tree ferns, gingers, magnolias, laurels, and hibiscus.

My work in the Bighorn Basin has focused on the plant fossils and the story of climatic change that can be learned from them. Even after nearly thirty years of fieldwork in the area, I still find it exciting to collect fossils of subtropical plants in a high desert

where winter temperatures sometimes drop to -40° F (-40° C). One indication that the global climate has cooled radically in the past 50 million years comes from the identification of fossil plants whose living descendants are restricted to relatively mild parts of the planet. But the shapes and sizes of leaves have their own story to tell. Today, for example, plants with smooth-margined leaves (such as magnolias) are more diverse in warmer climates; plants with toothed or jagged leaf margins (such as elms or birches) make up a larger proportion of the species in cooler areas. We don't fully understand the reasons for this difference, although we do know that the tissue in a leaf's marginal teeth matures more quickly and begins to photosynthesize earlier than its other parts--a developmental schedule that may be advantageous for plants in cool climates with short growing seasons. Water evaporates faster from the teeth, however, and in warmer, drier climates the cost of lost water may outweigh the benefit of a photosynthetic head start.

The size of a leaf, too, can inform us about past climatic conditions. The larger the leaf, the more quickly it heats up--and loses water. As a result, plants of drier climes tend to have smaller, more water-efficient leaves. Extrapolating from the relationships between leaf size and shape in living plants and contemporary levels of precipitation and temperature, scientists can use the sizes and shapes of fossil leaves to infer past levels of precipitation and temperature. The estimated mean annual temperature in the Bighorn Basin during the Paleocene and early Eocene varied from about 50 to 68° F (10- 20° C). Winter frosts, if they occurred at all, were short-lived and mild. The ground never froze.

Other clues to past temperatures exist in the ratio of two oxygen isotopes: ^{16}O and ^{18}O. These isotopes occur in rainwater and therefore also in the surface water that animals drink and that helps form soil minerals. The warmer the climate, the warmer the rain and the higher the ratio of ^{16}O to ^{18}O. Knowing this, scientists can estimate the temperature of ancient rain from the ratio of isotopes trapped in fossil mammal teeth and soil minerals.

The results of calculations using the isotopic method are generally in agreement with those based on studying leaves. Both show a complex pattern. Temperatures warmed fairly quickly during the last million or so years of the Paleocene (from about 56 to 55 million years ago). Then, about 55 million years ago--near the boundary of the Paleocene and the Eocene--they warmed even more, and very rapidly. Detailed analyses of cores taken from the ocean bottom suggest that this warming took place over about 10,000 to 20,000 years--very fast for such a large change. Over the course of the following 100,000 to 200,000 years, the moderate climate seen through much of the late Paleocene and early Eocene returned. Later in the early Eocene, temperatures cooled and then warmed once more (reaching the highest temperatures seen in the past 65 million years).

In the Bighorn Basin, evidence of the sharp warming near the time of the Paleocene- Eocene boundary can be found in several exceptionally thick, greatly weathered fossil soils. It is in these layers that fossils of odd-toed ungulates, even-toed ungulates, and primates first appear. These new mammals arrived simultaneously in Europe, and at the same time a number of hard-to-explain global events occurred: Single-celled seafloor organisms went extinct in record numbers. Warmth-loving plankton appeared in middle- and high-latitude oceans, such as the North Atlantic and the oceans surrounding Antarctica. Ocean surface waters at high latitudes warmed by as much as 14° F (about 8° C). The ratio of light to heavy carbon isotopes increased dramatically in

rocks and fossils. (Like oxygen, carbon has two common stable isotopes: light, or ^{12}C, and heavy, or ^{13}C. Many organisms use ^{12}C preferentially in their metabolism, because it's more chemically reactive, so an increase in the amount of ^{12}C in rocks and fossils could indicate that something had caused the release of large amounts of carbon previously used by living things.)

What was responsible for the rapid warming 55 million years ago, and did it perhaps have anything to do with these other events? We can pretty much rule out one known cause of rapid climate change--the melting and growth of ice sheets--because polar ice caps and continental ice sheets probably didn't exist during the Paleocene and Eocene. Recently, however, scientists proposed a new theory to explain the Paleocene-Eocene climate change: the melting of methane ice on the seafloor.

Microbes that feed on organic material raining down to the ocean bottom produce methane gas as a by-product of their decay. When this gas combines with water under the high pressures and low temperatures found on the seafloor, it can form ice-like compounds called clathrates. According to the new theory, rising ocean temperatures, an earthquake beneath the seabed, or some as yet unknown mechanism triggered the release of enormous quantities of methane that had been locked up in clathrates. This would have led to further warming of the atmosphere and the ocean (methane is a powerful greenhouse gas), encouraging the additional release of seafloor methane in a potentially self-reinforcing process. The released methane would have reacted rapidly with oxygen, producing carbon dioxide and water vapor (both powerful greenhouse gases), and both of these would have made their own contributions to the warming.

Eventually, however, much of this carbon dioxide would have reacted with rocks during the process of chemical weathering or been used by plants in photosynthesis. Much of the water vapor produced by the methane-oxygen reaction would have rained out of the atmosphere. The result of these processes would have been a gradual return to the earlier atmosphere and climate.

The methane theory illuminates more than just the increase in temperature that occurred 55 million years ago. A by-product of decaying organic matter, methane has a high ratio of light to heavy carbon, which could explain why geochemists have found more [sup.12]C in rocks from that period. In addition, carbon dioxide that formed when methane reacted with oxygen that was dissolved in seawater or contained in the atmosphere could have changed the chemistry of the deep-sea environment, making it more corrosive. This, plus the reduced amount of oxygen in the water, would help account for the extinction of bottom-dwelling microorganisms. Moreover, the temporarily increased rainfall and higher temperatures explain the highly weathered soils seen in the Bighorn Basin rocks of this time.

Warming probably also made high-latitude land bridges across what are now the Bering Strait and the North Atlantic Ocean more hospitable to mammals, enabling intercontinental migration and explaining the animals' sudden appearance in the basin. Unfortunately, we have found no fossil plants from the warmest period, but fossils from just after the Paleocene-Eocene boundary show that only a few new types of plants (including several ferns) appeared at this time. The modest change in vegetation is curious, because plants are famously sensitive to climate change. Perhaps warm-climate (probably evergreen) species found it difficult to adapt to the polar nights on the high-latitude land connections. Or perhaps plants were slow to disperse because their seeds did

not germinate and grow well in the shade of preexisting dense vegetation.

The warming that took place around the transition from the Paleocene to the Eocene demonstrates that greenhouse climates can come and go in a geological blink and that lasting rearrangements of animal life may accompany the changes. Although the temperature increase reversed within a geological moment, the effects on the mammalian community were permanent. The lineages that appeared during this period went on to dominate faunas for millions of years, largely replacing those that had been important on the northern continents for the previous 10 million years. Descendants of some of these immigrants, such as deer and pronghorns, are still dominant in this area today.

The lack of dramatic change in vegetation raises questions about how successfully plants can respond to warming climates, especially if they disperse slowly. Most of our knowledge about the issue has come from studying the recent geological past (the past 20,000 years), during which glaciers retreated from the northern continents. Plant populations altered their distributions very rapidly during this period, sometimes averaging more than half a mile (about one kilometer) a year. For those who hope this means plants will be able to cope with rapid climate change in the future, the message is not so simple. The difference between plant response to the Paelocene-Eocene warming and to the last deglaciation suggests that vegetation can't always respond quickly. (It may, for example, be easier for seeds to establish themselves on the new ground exposed by retreating glaciers.) Moreover, the past makes an imperfect predictor because of the complicated effects of human actions--including habitat fragmentation, introduction of nonnative species, and conservation efforts. These actions may skew the odds in favor of some plants and against others.

Much remains to be learned about climate change during the Paleocene and Eocene. Our current knowledge has come from the efforts of hundreds of scientists--paleontologists, geochemists, climate modelers, and oceanographers--working all over the globe. New methods of analyzing fossils and sediments allow us to ask new questions. For instance, we may soon have reliable estimates of the concentrations of carbon dioxide in the atmosphere during this time. As work continues in the Bighorn Basin and elsewhere, our static snapshots of individual reconstructed moments from the past are being transformed into a motion picture revealing the responses of ecosystems to long-term shifts in global climate and regional environments. In effect, scientists are discovering a movie about life during the last great warming.

This may be a movie worth watching. The past decade was by far the warmest since the beginning of good record keeping. Average global temperature is now higher than in any previous period for which written documentation exists. Present levels of atmospheric carbon dioxide are 30 percent higher than preindustrial levels and will continue to increase rapidly if current trends in the human generation of carbon dioxide continue.

Earth's future may well hold climates warmer than any experienced in the last several hundred thousand years. But we know from work in the Bighorn Basin and elsewhere that greenhouse climates are not without precedent in our planet's history. If our climatic future looks even a little like the greenhouse past, then the paleontological and geological work done in the Bighorn Basin is not just an exercise in intellectual curiosity. The horse- mounted paleontologists of the 1880s probably wouldn't have been surprised to learn that their successors 120 years later were still finding fossils in the

basin, but they would likely have been astonished that our minds are as much on the future as on the past.

A curator in the department of paleobiology at the Smithsonian National Museum of Natural History, Scott L. Wing ("Hot Times in the Bighorn Basin," page 48) first went to the Bighorn Basin in 1972, the summer after he finished high school. By the end of that first field season, he was a confirmed desert rat--captivated by the solitude and beauty of the badlands, intrigued by the information that could be extracted from their rocks, and addicted to the intermittent success that fossil hunting brings. His research interests and love of the country have taken him back to this part of Wyoming nearly every year since then. Wing, left, has also chased plant fossils in other parts of the western United States and in deserts in Egypt, Cameroon, China, Argentina, and Pakistan. For more on Wyoming geology and history, he recommends John McPhee's Rising From the Plains (Farrar, Straus and Giroux, 1986).

Wyoming's Garden of Eden

By Kenneth D. Rose
***Natural History*, April 2001**

The rich fossil record from the early Eocene Bighorn Basin includes the remains of the most ancient primates, hoofed animals, and carnivores.

Today Wyoming's Bighorn Basin, home to pronghorns and prairie dogs, coyotes and rattlesnakes, is nearly a desert. But close your eyes and imagine a scene in this same region 54 million years ago, after a time of rapid and dramatic warming. The ancient Bighorn is a subtropical lowland floodplain, lush with vegetation and teeming with animal life. Many of the mammals are new immigrants to the basin, and some look, if not modern, then strangely familiar. It is just after daybreak, and a group of primates forages peacefully among the trees bordering a pond. Resembling lemurs, they leap from branch to branch in search of fruit and nuts. Nearby, raccoon-like animals climb through the trees; occasionally one stops to groom itself, using its front teeth. On the forest floor, two rabbit-sized, hoofed animals hop through the low underbrush. Browsing on herbs and shoots, they are apparently oblivious to a herd of dawn horses, no bigger than beagles, running by. Suddenly the serenity is broken as a giant bird, recalling the mythological roc, barges through the brush, creating a momentary panic among the dawn horses. As they scatter, they are startled by a bear-sized Pachyaena with a monstrous head and threatening jaws. This time, however, the Pachyaena merely wants to scavenge a carcass. Some distance away, a pair of tapir-like animals ambles through a swamp while a hippo-like Coryphodon and its baby stand in the still waters and feed on aquatic plants.

For those of us who study Eocene mammals of the Bighorn Basin, such scenarios

are easy to envision, for the life and death of the region's ancient inhabitants are recorded in the fossils that abound in the badlands. Over the past 120 years, paleontologists working there have recovered remains of more than 200 species of mammals. These fossils not only tell us what early denizens of the basin looked like but also provide information about what they ate, how they moved, how they were related to one another, and what habitats they lived in. Tooth marks on bones reveal attacks or scavenging by ancient carnivores; some bones are even broken in ways that suggest an individual was killed by an owl. Bones that lay exposed long after the animals died often have characteristic gnaw marks left by rodents, or cracks due to drying.

Each summer for the past twenty years, often in collaboration with Tom Bown of the U.S. Geological Survey, I have led a group of students and associates to the Bighorn Basin to collect fossils of early Eocene vertebrates. Of particular importance to paleontologists, the early Eocene--from about 55 to 52 million years ago--is the interval when many of the modern orders of mammals, including our own, first appeared. The more than 50,000 specimens we have amassed from the 2,000- to 3,000-foot-thick sediments of the basin's Eocene outcrops now reside at the Smithsonian's National Museum of Natural History. Our collection, together with the others unearthed from the Bighorn Basin, constitutes the world's richest and most diverse record of the vertebrate life that existed during the warmest climatic interval since the demise of the dinosaurs. These specimens also provide evidence--some of the most detailed in the entire vertebrate fossil record--of how certain animals evolved, in many cases showing a continuous, gradual transformation from one species to another through time.

Like most Eocene fossils, those in the Bighorn Basin are almost always fragmentary, consisting mainly of isolated bones, jaw fragments, and teeth. While teeth can tell us a lot, other parts of the skeleton are essential if we are to understand many other aspects of these mammals' lifestyles and relationships. One of the main goals of our expeditions has been to find mammal fossils other than teeth and jaws. By concentrating on ancient soils whose color and other sedimentary features indicate that they are likely to preserve skeletal material, we have been rewarded with hundreds of partial skeletons of nearly fifty kinds of mammals. These include the most ancient primates, hoofed animals (ungulates), carnivores, and rodents, as well as many extinct groups. We can now re- create the mammalian life of the Eocene in considerable detail.

Impressive numbers of the lemur-like Cantius inhabited the newly formed basins and ranges of the Rocky Mountain region during the early Eocene. Thousands of its jaws and hundreds of isolated bones have been found in the Bighorn Basin. So far, however, only three partial skeletons have been unearthed. From these we know that Cantius was one of the earliest of the primates, the group that now includes monkeys, apes, and humans. It was an agile climber, with long hind limbs for leaping, nails on its digits, and a grasping big toe. Compared with other early Eocene mammals, Cantius also had a large brain and relatively large eyes. In all these characteristics, Cantius resembles modern primates and differs from the so-called archaic primates that were common in the Paleocene, the 10- million-year period after the dinosaur extinction and just before the Eocene.

Also adapted to life in the trees was Chriacus, a raccoon-like member of the arctocyonids, a now-extinct group that probably gave rise to the modern ungulates. In contrast to the feet of present-day hoofed mammals, which are specialized for ground

locomotion, the foot structure of Chriacus shows that it could climb up and down trees with facility. By turning its feet around and gripping the tree trunk with sharp claws, it could descend headfirst, in squirrel fashion. This creature was one of the first mammals we know to have had long, narrow lower incisor teeth arranged in the shape of a comb, similar to the tooth comb of modern lemurs. Microscopic grooves on these teeth confirm that Chriacus used them to groom its fur. Its molars indicate that it was an omnivore whose diet most likely included fruit, nuts, and even small animals, although it was probably no threat to the similar-sized Cantius. The primate and its young would have had more to fear from early tree-climbing carnivores known as miacids, from predators called creodonts, and from a variety of terrestrial meat-eaters.

While none of the true carnivores (those related to living dogs and cats, for example) got much larger than a coyote, some of the early Eocene creodonts were bigger than wolves. But even they were dwarfed by the formidable Pachyaena, a ground-dwelling cousin of the earliest whales, whose head reached the size of a Kodiak bear's. Diatryma, a six-foot-
tall flightless bird with a foot-and-a-half-long head, would have been equally intimidating. Both of these creatures, which are best known from the Bighorn Basin, appear to have been primarily carnivorous, although we cannot be certain if they were active predators or merely scavengers.

The bones of another Bighorn Basin mammal, Diacodexis, show it to be the oldest and most primitive of the even-toed ungulates. (We divide hoofed mammals into two main groups: the artiodactyls, having an even number of toes, and the perissodactyls, having an odd number of toes.) Diacodexis was thus the forerunner of all the living artiodactyls, a varied group that includes pigs, hippopotamuses, camels, giraffes, sheep, and deer. Diacodexis itself probably looked and moved something like the diminutive chevrotain, or mouse deer, of Asian forests. Its molars, which have low, rounded cusps, suggest a diverse herbivorous or omnivorous diet, but while its teeth are generalized, Diacodexis's skeleton is strikingly specialized for its time. Its small size and elongated, slender legs-- with the hind limbs markedly longer than the forelimbs--would have given the animal a somewhat rabbit-like appearance and way of moving, although it is not related to rabbits. Unlike the flexible joints of climbing mammals, Diacodexis's joints restricted movement to a hinge motion in a fore/aft plane. The feet had four functional toes, the two central ones being larger and of equal size. A delicate hoof tipped each digit. These features would have made Diacodexis one of the swiftest runners of its day. But given its probable forest habitat, diet, and ability to hop over branches, Diacodexis may have used its speed only occasionally, to escape predators.

Remains of odd-toed ungulates are among the most common Eocene fossils found in the Bighorn Basin. Jaws of Hyracotherium (or Eohippus, the dawn horse) have emerged by the thousands, and its skeletons are more numerous than those of any other mammal. Less common, and found only recently, are skeletons of Homogalax and other ancient relatives of the present-day tapirs of South America and Asia. The tapiroids were generally larger than dawn horses, the biggest being sheep-sized. Both Hyracotherium and Homogalax were well adapted for running, but the tapiroid was more primitive in this regard, suggesting that it more closely resembled the ancestor of all odd-toed ungulates than does Hyracotherium. The hind feet of both animals bore just three toes; the front feet had three plus a greatly reduced fourth digit. All the toes were equipped

with a small, broad hoof.

The molars of Hyracotherium and Homogalax were low-crowned, like those of Diacodexis, but had multiple shearing crests, a specialization for processing vegetation. Unlike many of their hoofed descendants, neither they nor any other early Eocene ungulate was a grazer. Grassland habitats were not to become widespread for millions of years. The teeth of early Eocene ungulates lacked the high crowns and elaborate chewing surfaces that allow grazers to grind grasses, which contain abrasive silica. These animals were probably browsers that fed on softer plant material, leaves, and shoots.

Not all the plant eaters in the Bighorn Basin Eocene mammal community were related to present-day ungulates. The most abundant large herbivore was Coryphodon, a ponderous, cow-sized member of an extinct group known as pantodonts. Like tapirs and pygmyhippopotamuses today, Coryphodon probably preferred wet forests or swamps, where it used its tusklike canines and broad, crested molars to feed on vegetation.

The newcomers that arrived in association with the warming at the end of the Paleocene-- especially primates and ungulates--significantly altered the composition of the Bighorn Basin's mammal communities. Paleocene faunas were dominated by what we refer to as archaic mammals: condylarths (archaic ungulates), archaic primates, small rodent-like multituberculates, pantodonts, and others. While all these groups survived into the Eocene, most were substantially reduced in numbers and diversity. The change in mammal life was not only abrupt, it was profound: fossil evidence shows that in the early Eocene, half the individuals in many mammal communities belonged to immigrant species. This faunal turnover at about 55 million years ago took place not just in the Bighorn Basin but across all the northern continents. The results have been long lasting. Even- and odd-toed ungulates are the predominant large mammalian herbivores in most of the world today, and primates populate rainforests from South America to Africa and Asia. One thing seems clear: the immigrations were tied to global warming. But had we been there 55 million years ago, we could hardly have predicted the eventual ecological impact of that warming event. Only through paleontology have we gained the hindsight to appreciate the potential consequences of widespread climate change.

Kenneth D. Rose ("Wyoming's Garden of Eden," page 55) established a fossil museum in his basement when he was in high school, and on occasion he exhibited his collection publicly. His love of paleontology was strengthened by visits to the American Museum of Natural History and particularly by a trip to the Smithsonian, where several curators helped him identify fossil bones he had found in Florida. Now a professor of anatomy at the Johns Hopkins University School of Medicine in Baltimore, Rose has collected mammal fossils in Wyoming's Bighorn Basin for the past twenty years. He is also a veteran of fieldwork in other parts of the western United States, as well as in Egypt, Pakistan, and, most recently, the Indian state of Rajasthan. Rose's avocation, collecting marine fossils, dates from his basement-museum days and has led him to comb the coasts of North America, Africa, Japan, and the Philippines. **Gale Document Number:**A73064224 © 2009 Gale, Cengage Learning

Make-up Assignment Essay: EVOLUTION

The following constitutes the essay portion of your lab make-up, with the topic provided below. Your essay will be worth up to 5 points, making the total value of the essay and make-up assignment 15 points (equaling the total point value of a single lab). Basic guidelines for this essay are listed at the bottom of this page.

TOPIC:

Name and describe at least **2 diseases** that occur only in the **later years of a person's lifespan**. Why is **natural selection unable to eliminate** such diseases from the human population?

Guidelines for Writing the Lab Essays

Please note: Your grade will be reduced if these guidelines are not followed.

1. Everything must be on one page only, single-sided, NO exceptions!

2. Must include your **Name**, **Lab Section Number** and the **Title** (the question or assigned topic) at the top.

3. 300-350 words, not including Name, Lab Section, Title or References.

4. Single-spaced

5. Typed

6. 12-point font size

7. Must use Times, Times New Roman, or Arial font style

8. Everything must be stated in your own words. Do not plagiarize!

9. Must include at least Two References Cited (only one of which can be Wikipedia).