DOWNLOAD PDF THE AGE OF MAMMALS

Chapter 1 : GUTHRIE LONERGAN

Age of Mammals features a total of specimens, including 38 articulated mammal skeletons, illustrating to visitors the wondrous diversity of mammal life as it's evolved over the past 65 million years. Taxidermy specimens of extant species include a sprinting cheetah alongside a similarly posed cheetah skeleton, an alpaca, a zebra and more!

It is divided into 7 epochs, the most recent and familiar sounding , being the holocene which began , years ago, and also extends to the present. The supercontinents continued to spread apart, to drift into the continents we have today. Vulcanism and Uplift created massive mountain ranges. Early on about 56 million years ago temperatures rose quickly, then the planet began to cool, with a serious of ice ages interspersed with warming periods. Changes in ecology, such as climate, elevation, topography, latitude, changes in vegetation, access to water, competition between species, and predation all led to new life forms adapting to and radiating out to newly formed ecological niches. Plant life changed over 65 million years. Before, world-wide temperatures were more similar, and there was less variation in plant-life. During the cenozoic, angiosperms became dominant, and as there began to be more variation between latitudes, there began to be more variation in forests and grasslands. Plant evolution fine-tuned their survival to temperature and water availability, predation and competition. Everything from kiwis and ostriches, chickens, condors, parrots and ravens. Early cenozoic mammals were small and nocturnal. They adapted to changing environments and newly opened niches, splitting into many new and novel branches on the evolutionary tree. Placental mammals had evolved shortly before the extinction of the dinosaurs. Although some marsupials and monotremes egg laying mammals survive to this day, most of the mammals that immediately pop into your head unless you live in Australia are placental mammals. Early small rodent-like mammals diverged into the many groups we recognize today: Early cenozoic proto-primates diverged into lemurs, old and new world monkeys and great apes. A small branch from the apes to hominids, to hominins, eventually leading to us - Homo sapiens and many now-extinct Homo species. We invented agriculture, allowing us to abandon a hunter-gatherer lifestyle, and live in larger densities. We developed language, domesticated animals, and crops. We learned to extract resources from the earth to build tools, and machines, and crossed oceans and land bridges, until we had spread everywhere but antarctica. Eventually, large villages and cities, and city states became empires, and countries. Tools changed from stone, to bronze, to steel as we harnessed fire, then charcoal, then coal, then oil. We learned about sanitation, and germ theory, and invented vaccines. We invented machines that replaced human and animal labor. We learned how to transform raw materials pulled from the earth, and turn them into fertilizers, plastics, and fuels. Human populations began to skyrocket, after having stayed under ,, for all of human history, up until the middle ages. Our expansion into previously thriving ecosystems, the pollution we pour into the air, water, and land, our agricultural practices, our extraction techniques of natural resources, our deforestation, and disruption of waterways, everything we do to make modern society possible is driving what is considered the Sixth Mass Extinction. There is a push for changing the name of the epoch we are currently in:

Chapter 2 : Dentition - Age of Mammals - Fossil Hunters

The Cenozoic is also known as the Age of Mammals, because the extinction of many groups allowed mammals to greatly diversify so that large mammals dominated it. The continents also moved into their current positions during this era.

At the end of the Cretaceous, 65 million years ago, not only did the dinosaurs disappear completely, but so did flying reptiles pterosaurs , and marine reptiles ichthyosaurs and plesiosaurs. Most turtles, crocodiles and primitive birds also disappeared but some survived to give rise to modern forms. There have been numerous theories to account for the extinction of dinosaurs. Enormous amounts of debris would have been thrown into the atmosphere, making the Earth so cold and dark that cold-blooded animals like dinosaurs were unable to survive. Supporting the impact theory, about Impact Craters have now been discovered on the earth. One of the most spectacular is the Barringer Crater in the Arizona desert. The Barringer crater was formed about 30, years ago much too young to have anything to do with dinosaur extinction. But it is tiny compared to some older craters. The impact responsible for the extinction of the dinosaurs would have produced a crater at least miles across. The entire planet shows a 3 mm-thick layer of rock at the appropriate level i. This layer contains many glass-like beads, mm to cm in diameter, that were probably formed by melting of rocks during the impact. The molten rock would have been ejected, and then would have fallen back to earth. The composition of these layers suggests an ocean impact. Over the past few years geologists have discovered a mile-diameter submarine crater the Chicxulub crater , of exactly the right age but buried under 2 km of sediment, off the coast of the Yucatan peninsula in Central America. It has been estimated that after the collision there was so much dust in the atmosphere that the entire planet was completely dark for months. The lack of sunlight would have caused the extinction of many plants and animals. Among the animals, cold-blooded forms like dinosaurs would have been affected more than the warm-blooded mammals. Geologists have found that the rock in the Chicxulub crater is unusually rich in sulfur. They conclude that the impact could have produced a global sulfur dioxide fog that could have caused darkness and acid rain for over a decade. For a long time people found it hard to believe in such spectacular collisions. But impact craters are very common on many planets and the moon. And in a comet that had already broken into 13 pieces crashed into the planet Jupiter. Although the crash was not visible from earth, we were able to see the effects of the impact soon after it happened. This made it much easier to believe that comets can crash into planets. However, not everybody believes that this kind of catastrophe finished off the dinosaurs. A meteorite impact was observed in Greenland in December A flash of light seen from fishing trawlers turned night into day, seismic signals were detected in Norway, and satellite images showed a cloud that suddenly formed and then blew away. If you are interested in whether the Earth may be hit again by an asteroid or comet, NASA has a web site on impact hazards for you, including a list of the close predicted close approaches! The period between the extinction of the dinosaurs and the present day is called the Age of Mammals or Cenozoic. Mammals appeared on the earth long before the extinction of the dinosaurs; in fact, dinosaurs and mammals originated within 10 million years of each other, in the late Triassic about million years ago. By late Cretaceous small primitive marsupials mammals that brood their young in a pouch, like opossums , and insectivores, similar to shrews and hedgehogs, were quite abundant and widespread. But only after the dinosaurs were gone did the mammals begin their great diversification and become the dominant land animals. Then, within 10 million years, there were mammals of all kinds living in many different habitats on land, in the sea and in the air. There were herbivores, carnivores, whales, bats. During the Cenozoic there was also tremendous radiation in other groups including birds, reptiles, amphibians and fish, leading gradually up to the peak of biological diversity that occurred in the recent past. The major continental land masses were initially fused together into one giant continent named Pangaea during the Paleozoic era. In the Mesozoic, Pangaea gradually broke up into the present-day continents, which have been moving apart from each other, by continental drift, ever since. This idea of continental drift was first based on the remarkably close fit between the coastlines of major continents, most notably the west coast of Africa with the east coast of South America. It is now supported by measurements, which show that the continents on either side of the Atlantic Ocean are still moving apart from one another, at the rate of several centimeters per year. Continental drift was actually a little more complicated, with the North American plate drifting around in the Pacific Ocean for quite a long time. A large chunk of the North American plate was recently found in Argentina, left there after the two continents bumped into each other then moved apart. Learn more about This Dynamic Earth. The separation of the great land mass into different continents allowed biological evolution to take quite different paths in different parts of the world. And the formation of oceanic islands, often by volcanic activity, produced many more isolated areas where evolution could experiment with different forms. Breakdown of this isolation, either by geological changes or by transport of organisms between the isolated areas, has often led to extinction of the endemic forms, and so loss of diversity. During the Cenozoic era the last 66 million years , there was a gradual lowering of temperatures as well as the gradual establishment of different climatic zones of the earth -the tropics, the temperate zones and the cool climates of the higher latitudes. The culmination of the cooling trend was the Pleistocene epoch, or Great Ice Age, of the last 1. During this time vast expanses of North America and Eurasia were periodically covered with enormous continental glaciers. These glaciers advanced during the four ice ages glacial periods and retreated during the three interglacials. We are probably now living in the fourth interglacial stage. During the glacial periods the sea level became much lower because so much water was converted to ice. Consequently land bridges, especially the Bering land bridge across the Bering Sea joining Asia with North America, became available for animal migrations. During the Cenozoic the mammals reached their peak of evolution, producing a tremendous variety of species, many of them very large. The segment of the fauna containing these large creatures those weighing more than about pounds is called the Megafauna. Most of these animals are extinct. We know about the Pleistocene mammals not only from fossils but also from carcasses, especially of the woolly rhinoceros, which have been found in petroleum deposits in Romania. Mammoths, complete with flesh, hair and stomach contents, have been found frozen in the ice in Siberia. Some members of the Pleistocene megafauna were restricted to certain areas. For example, the woolly rhinoceros, giant deer, the moose-like giraffe shown in the slide, and the cave bear were found only in Eurasia and Africa. But the Bering land bridge has been present intermittently through the entire Cenozoic period. It allowed the entry of many of the large mammals that were to subsequently dominate the North American fauna, including the woolly mammoth, imperial mammoth, mastodon, bison, deer, sheep, cattle and many large carnivores. Slide shows a reconstruction of a Pleistocene scene in North America. Notice the saber-toothed cat with its enormous canine teeth. The Bering land bridge also allowed animals that evolved in North America to colonize Asia. They subsequently 8, years ago for horses became extinct in North America. See slide of the evolutionary history of the horse - one of the most complete fossil series available, often used as a classical example of evolution. Mammalian Evolution in South America. At the beginning of the Cenozoic era, there was a land bridge between North and South America, as there is today. This land bridge allowed primitive mammals to colonize South America from the North. This land link was later during the Eocene broken, and those animals which had settled in South America then evolved in complete isolation from the rest of the world. Over about 40 million years these primitive groups diversified in many unique ways. The placental mammals those that carry their young in a uterus, using a placenta to provide nutriment of South America evolved as herbivores, many of them large and slow moving, like the ground sloth Megatherium which reached up to 29 feet tall when standing upright on its hind legs. The ground sloth was the largest and heaviest of all land mammals there may have been a sighting in ! These are examples of convergent evolution. The marsupials mammals that carry their young in a pouch, like kangaroos evolved in the other direction, becoming carnivores. One of them bore an amazingly close resemblance to the independently evolved saber-toothed cat of North America, which was a placental mammal. This is another example of convergent evolution. New forms of wildlife continued to arrive in South America even after the continent was cut off from North America. They included primates which gave rise to the New World monkeys, including howler monkey, marmosets, capuchins, woolly monkeys and spider monkeys; and rodents which evolved into a number of families, several of which are found nowhere else in the world. These include the capybara, the agouti, the coypu, the cavy Guinea pig and the chinchilla. In South America there is a greater variety of rodents than anywhere else in the world. The

Invasion of South America. This was a disaster for many of the animals that had evolved in isolation in South America. South America was invaded by deer, camels, raccoons, tapirs, horses, mastodons, bears, peccaries, rabbits, shrews, cats, dogs, weasels and rodents. For some reason these animals were able to displace many of the South American species, driving many of them to extinction. Some of the new arrivals e. Others were very successful, for example the camel family which has given rise to the vicunas, guanacos, alpacas and llamas. The camels as well as the horses subsequently became extinct in North America where they originated. Another group of uniquely South American mammals, the edentates sloths, armadillos and anteaters , survived the competition with the invaders and are still abundant in South America. The armadillos, like their primitive ancestors, are armor-plated mammals in which the armor plating is composed of separate shields and hinged bands. But the related species of one extinct group, the glyptodonts, had a single-piece carapace similar to that of tortoises. These glyptodonts, some of which were as big as a Volkswagen and armored like a tank, survived up until quite recent times and may have been hunted by primitive Indian tribes; piles of glyptodont bones have been found alongside various human artifacts. A few of the animals that had evolved in South America migrated in the reverse direction, becoming established in North as well as South America: South America provides a spectacular example of how evolution can take off in novel directions when a region is isolated for a long enough period of time. It also provides a dramatic lesson in how apparently well adapted species can often be driven to extinction when exotic species those coming from outside are introduced. Mammalian Evolution in Australia. The mammalian fauna of Australia also evolved in isolation since the early Cenozoic Eocene , but in this case the isolation remained complete. For unknown reasons, Australia was apparently originally populated entirely by marsupials rather than placental mammals. Today the native mammalian fauna of Australia is made up of marsupials of many different kinds, that occupy ecological niches similar to those occupied by placental mammals in other parts of the world.

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The period between the extinction of the dinosaurs and the present day is called the Age of Mammals or Cenozoic. Mammals appeared on the earth long before the extinction of the dinosaurs; in fact, dinosaurs and mammals originated within 10 million years of each other, in the late Triassic about million years ago.

Review What allowed mammals to outlast the dinosaurs? With dinosaurs around, mammals could not thrive. It took a catastrophic event to rid the planet of dinosaurs. Luckily for mammals, the extinction of the dinosaurs left many opportunities for mammals to take over and flourish. Mammals took advantage of the extinction of the dinosaurs. They flourished and soon became the dominant animals on Earth. You can learn more about the evolution of mammals during the Cenozoic at the link below. The Cenozoic began 65 million years ago and continues to the present. During the Tertiary Period 65â€”1. This allowed mammals to evolve further and fill virtually all niches vacated by the dinosaurs. Many mammals increased in size. During the Quaternary Period 1. This created land bridges between continents, allowing land animals to move to new areas. Some mammals, like the woolly mammoths adapted to the cold by evolving very large size and thick fur. Other animals moved closer to the equator or went extinct, along with many plants. The last ice age ended about 12, years ago. The Last Ice Age Imagine a vast grassy ecosystem covered with herds of elephants, bison, and camels stretching as far as the eye can see. But this also describes Northern California at the end of the last Ice Age. What happened to all this wildlife? Were they over-hunted and killed off? Scientists are not sure, but this relatively recent loss of life does raise many interesting questions. Summary The Cenozoic Era is the age of mammals. They evolved to fill virtually all the niches vacated by dinosaurs. The ice ages of the Quaternary Period of the Cenozoic led to many extinctions. The last ice age ended 12, years ago. When did the Cenozoic Era begin? What animals are no longer present at the start of this era? What is the closest fossil to a human-chimp ancestor? How old is that fossil? When were stone tools first used? When did human migration begin? Where did it begin from? Review What explains why mammals were able to flourish during Cenozoic Era? Create a timeline of major evolutionary events during the Cenozoic Era. Discuss climate changes during the Tertiary and Quaternary Periods, and the effects of these changes on geology and vegetation.

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Age of Mammals Small, shrew-like mammals scurry around the skeleton of a Triceratops at the end of the Age of Dinosaurs. Mammals scurry among a dinosaur's bones.

Geologic time scale The Cenozoic Era The Cenozoic Era is the most recent of the three major subdivisions of animal history. The other two are the Mesozoic and Paleozoic Eras. The Cenozoic spans only about 65 million years, from the end of the Cretaceous Period and the extinction of non-avian dinosaurs to the present. The Cenozoic is sometimes called the Age of Mammals, because the largest land animals have been mammals during that time. This is a misnomer for several reasons. First, the history of mammals began long before the Cenozoic began. Second, the diversity of life during the Cenozoic is far wider than mammals. Paleogene and Neogene are relatively new terms that now replace the deprecated term, Tertiary. The Paleogene is subdivided into three epochs: The Neogene is subdivided into two epochs: In the s and s a geologist named Giovanni Arduino was studying the rocks and minerals in Tuscany. He classified mountains according to the type of rocks that he found in them. Unfossiliferous schists, granites, and basalts all volcanic rocks that formed the cores of large mountains he called Primitive. Fossil-rich rocks of limestone and clay that were found on the flanks of mountains over the Primitive rocks were called Secondary. Finally, there were another group of fossiliferous rocks of limestones and sandstones lying over the Secondary rocks and forming the foothills of the mountains that Anduino called Tertiary. So at first, Tertiary referred to a certain type of rock found in the area of Tuscany. But later, geologists used the fossils found in the Tertiary rocks there to recognize rocks of the same age elsewhere. Rocks with the same species of fossils were the same age. Extensive Tertiary age rocks were recognized in the Paris Basin, which is the area around Paris, France. In the s and s Charles Lyell, a noted English geologist who had a great influence on Charles Darwin, subdivided the Tertiary rocks of the Paris Basin on their fossils. Lyell came up with an ingenious idea. He noticed that the rocks at the top of the section had a very high percentage of fossils of living mollusc species. Those at the bottom of the section had very few living forms. He deduced that this difference was because of the extinction of older forms and the evolution of living forms during the time that the rocks were being deposited. He divided the Tertiary rocks into three sub-ages: These subdivisions of the Tertiary have been correlated around the world using the fossil species in them. The same goes for the other subdivisions. This was because during those periods there had been no deposition in what would later be the Paris Basin. These two periods, later designated Oligocene and Paleocene, were inserted into the Tertiary in their proper places. Cenozoic fossil localities Bodjong Formation, Indonesia: Numerous deep-water molluscs from this Pliocene locality have given us a picture of past tropical marine life in what is today a very species rich area. A rich plant community from this Oligocene locality in southwestern Colorado includes pine, fir, barberry, and a variety of other species, all very well preserved. This Eocene locality lies in the Rocky Mountains of Colorado. Rich in fossils of plants, insects, and fish, this Eocene locality extends across Utah, Colorado, and Wyoming in the western U. Rancho La Brea Tar Pits: One of the most famous fossil localities of all, La Brea is an asphalt seep containing Pleistocene fossils located in Los Angeles, California. Vast area of exposed Miocene outcrops along the coastal ranges of California. Fossils include macroalgae, microfossils, shells, crabs, and porpoises. Until recently, our only good source of information about Tertiary animals in the South American tropics was this site in Colombia. Many of the pre-Pliocene animal groups represented have been found nowhere else outside of the continent. Resources For information about other Cenozoic localities, see our pages on the Eocene , Oligocene , and Miocene. Find out more about the Cenozoic paleontology and geology of North America at the Paleontology Portal.

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Chapter 5 : After the Dinosaurs

Rudolph F. Zallinger's great mural The Age of Mammals is the centerpiece for the Hall of Mammalian Evolution at the Yale Peabody Museum. Although the principal focus of the mural is on the momentous evolutionary developments taking place in the warm-blooded, hairy, milk-giving vertebrates known as mammals, the painting also depicts the striking changes that were transforming the landscapes.

The Quaternary Period was officially recognized by the International Commission on Stratigraphy in June , [9] and the former term, Tertiary Period , became officially disused in due to the need to divide the Cenozoic into periods more like those of the earlier Paleozoic and Mesozoic eras. Knowledge of this era is more detailed than any other era because of the relatively young, well-preserved rocks associated with it. Paleogene Period[edit] The Paleogene spans from the extinction of non-avian dinosaurs, 66 million years ago, to the dawn of the Neogene, It features three epochs: Basilosaurus The Paleocene epoch lasted from 66 million to 56 million years ago. Modern placental mammals originated during this time. The Paleocene is a transitional point between the devastation that is the K-T extinction , to the rich jungle environment that is the Early Eocene. The Early Paleocene saw the recovery of the earth. The continents began to take their modern shape, but all the continents and the subcontinent of India were separated from each other. Afro-Eurasia was separated by the Tethys Sea , and the Americas were separated by the strait of Panama, as the isthmus had not yet formed. This epoch featured a general warming trend, with jungles eventually reaching the poles. The oceans were dominated by sharks [11] as the large reptiles that had once predominated were extinct. Archaic mammals filled the world such as creodonts extinct carnivores, unrelated to existing Carnivora. The Eocene Epoch ranged from 56 million years to In the Early-Eocene, species living in dense forest were unable to evolve into larger forms, as in the Paleocene. There was nothing over the weight of 10 kilograms. At the top of the food chains were huge birds, such as Paracrax. The temperature was 30 degrees Celsius with little temperature gradient from pole to pole. This disrupted ocean currents worldwide and as a result caused a global cooling effect, shrinking the jungles. This allowed mammals to grow to mammoth proportions, such as whales which, by that time, had become almost fully aquatic. Mammals like Andrewsarchus were at the top of the food-chain. The Late Eocene saw the rebirth of seasons, which caused the expansion of savanna-like areas, along with the evolution of grass. The Oligocene Epoch spans from The Oligocene featured the expansion of grass which had led to many new species to evolve, including the first elephants, cats, dogs, marsupials and many other species still prevalent today. Many other species of plants evolved in this period too. A cooling period featuring seasonal rains was still in effect. Mammals still continued to grow larger and larger. Mammals are the dominant terrestrial vertebrates of the Cenozoic. The Neogene spans from It features 2 epochs: Kelp forests evolved, encouraging the evolution of new species, such as sea otters. During this time, perissodactyla thrived, and evolved into many different varieties. Apes evolved into 30 species. Many new plants evolved: The Pliocene featured dramatic climactic changes, which ultimately led to modern species and plants. The Mediterranean Sea dried up for several million years because the ice ages reduced sea levels, disconnecting the Atlantic from the Mediterranean, and evaporation rates exceeded inflow from rivers. Australopithecus evolved in Africa , beginning the human branch. The isthmus of Panama formed, and animals migrated between North and South America , wreaking havoc on local ecologies. The world map has not changed much since, save for changes brought about by the glaciations of the Quaternary, such as the Great Lakes , Hudson Bay , and the Baltic sea. It features modern animals, and dramatic changes in the climate. It is divided into two epochs: Megafauna of the Pleistocene mammoths , cave lions , woolly rhino , Megaloceros , horses The Pleistocene lasted from 2. This epoch was marked by ice ages as a result of the cooling trend that started in the Mid-Eocene. There were at least four separate glaciation periods marked by the advance of ice caps as far south as 40 degrees N latitude in mountainous areas. Meanwhile, Africa experienced a trend of desiccation which resulted in the creation of the Sahara, Namib, and Kalahari deserts. Many animals evolved including mammoths , giant ground sloths , dire wolves , saber-toothed cats, and most famously Homo sapiens. All the continents were affected, but Africa to a lesser extent. It still retains many large animals, such as hippos. All recorded history and "the history of the world " lies within the boundaries of the Holocene epoch. This is sometimes referred to as the " Sixth Extinction ". It is often cited that over recorded species have become extinct due to human activity since the Industrial Revolution, [22] [23] but the rate may be as high as veterbrate species alone, the majority of which have occurred after From a geological perspective, it did not take long for mammals and birds to greatly diversify in the absence of the dinosaurs that had dominated during the Mesozoic. Some flightless birds grew larger than humans. These species are sometimes referred to as " terror birds ," and were formidable predators. Early animals were the Entelodon a so-called "hell pig" , Paraceratherium a hornless rhinoceros relative and Basilosaurus an early whale. Tectonics[edit] Geologically , the Cenozoic is the era when the continents moved into their current positions. Australia-New Guinea , having split from Pangea during the early Cretaceous , drifted north and, eventually, collided with South-east Asia ; Antarctica moved into its current position over the South Pole ; the Atlantic Ocean widened and, later in the era 2. The cooling trend continued in the Miocene , with relatively short warmer periods. The Cenozoic is just as much the age of savannas , the age of co-dependent flowering plants and insects , and the age of birds. One group that diversified significantly in the Cenozoic as well were the snakes. Evolving in the Cenozoic, the variety of snakes increased tremendously, resulting in many colubrids , following the evolution of their current primary prey source, the rodents. In the earlier part of the Cenozoic, the world was dominated by the gastornithid birds, terrestrial crocodiles like Pristichampsus , and a handful of primitive large mammal groups like uintatheres , mesonychids , and pantodonts. But as the forests began to recede and the climate began to cool, other mammals took over. The Cenozoic is full of mammals both strange and familiar, including chalicotheres , creodonts , whales , primates , entelodonts , saber-toothed cats , mastodons and mammoths , three-toed horses , giant rhinoceros like Indricotherium , the rhinoceros-like brontotheres , various bizarre groups of mammals from South America, such as the vaguely elephant-like pyrotheres and the dog-like marsupial relatives called borhyaenids and the monotremes and marsupials of Australia.

Chapter 6 : Age of Mammals | Natural History Museum of Los Angeles

The Call of Distant Mammoths: Why the Ice Age Mammals Disappeared Apr 1, by Peter D. Ward. Hardcover. $ $ 12 96 $ Prime. FREE Shipping on eligible orders.

Dentition Last Updated on Mon, 15 Jan Age of Mammals Probably more than any other part of the skeleton, the dentition of fossil mammals plays a critical role in taxonomy, assessment of phylogenetic position, and interpretation of behavior primarily diet, but also such activities as grooming, gnawing, or even digging. In part, this reflects the durability of teeth enamel, the hard outer layer of most mammal teeth, is the hardest substance in the body , which accounts for why they are generally more common than other skeletal remains. But it is also because the dentition usually exhibits species-specific differences, not so readily distinguished in other parts of the skeleton, that can often be detected even in individual teeth. Especially useful general accounts of the dentition in vertebrates generally, and mammals in particular, include Gregory , Peyer , and Hillson One of the characteristics of mammals inherited from their nonmammalian cynodont ancestors is the regional differentiation of the dentition into incisors I , canines C , premolars P , and molars M , known as heterodonty Fig. The postcanine teeth are collectively called cheek teeth. Incisors are typically involved in procuring and ingesting food. Canines usually function for stabbing or holding prey, for aggression, or for display. Premolars hold or prepare food for the molars, which shear, crush, and grind the food. In most mammals, the antemolar teeth are replaced once during life, a diagnostic mammalian condition called diphyodonty. The first set of teeth, the deciduous or milk teeth indicated by "d," such as dP4 , erupts more or less in sequence from front to back, followed by the molars, which are actually part of the first generation of teeth. Most of the antemolar teeth are sequentially replaced by permanent teeth after some or all of the molars are in place. The number of teeth present in each part of the dentition varies among mammals and is an important taxonomic characteristic. It is expressed in shorthand by the dental formula, I. M, which specifies the number of teeth in each quadrant, that is, on each side, above and below. Thus the dental formula of primitive extant placentals is 3. The dental formula of primitive marsupials e. Generalized marsupials typically differ from primitive living placentals, then, in having more incisors and more of them in the upper jaw than in the lower , one more molar, and one less premolar. The postcanine teeth are conventionally identified as P, M in both upper and lower jaws , although some accounts use a different numbering system. Obviously the number of teeth has varied considerably among mammals. As a general rule, however, no mammal has more than one canine, and living marsupials and placentals rarely increase the number of premolars and molars beyond the primitive state. Fossil evidence suggests, however, that the primitive eutherian dental formula was 5. To achieve the dental formula common in the most generalized living placentals, it is probable that incisors were lost from the back of the series and a premolar was lost from the middle P3 , very early in the history of placentals McKenna, a; Novacek, b. This hypothesis suggests that the four premolars present in most primitive extant placentals could be dP1. P5, although the last two are conventionally identified as P3 and P4. This convention has been adopted because there is little direct evidence of how the reduction to four premolars took place, and whether it represents a single event in eutherians or occurred multiple times. Whatever position was lost, there is general agreement that the remaining teeth are probably homologous, and they continue to be almost universally identified as d P1. This practice is also followed here, acknowledging that it is an assumption. Nearly all Cenozoic placentals have no more than three incisors and four premolars, hence a dental formula of 3. Although the dental formula is an important characteristic of mammals, equally or more important are the homologies of the teeth. For example, an enlarged central incisor evolved in many clades of mammals, but the tooth involved is not always homologous. In some cases it is I1, whereas in others it is I2 or a retained deciduous I2. When all the incisors are present, homologies are easily determined, but deciphering true homologies when the number of incisors is reduced to one or two requires developmental or evolutionary evidence. Unusually specialized premolars have also arisen independently in various lineages, as demonstrated by their occurrence at different tooth loci in different clades. Several positional and other descriptive terms are commonly used when describing teeth. The anterior end of the toothrow is also called mesial, the posterior end distal. Tooth length is measured mesiodistally whereas width is measured transversely buccolingually. Teeth are implanted in the alveoli sockets of the jaw by the root s ; the neck is approximately at the gum line, and most of what is exposed is the crown, usually covered by enamel. Enamel is an extremely hard, largely inorganic substance composed of hydroxyapatite crystallites. The underlying dentine is an avascular tissue consisting of hydroxyapatite, collagen, and water, and is softer than the enamel. Cemen-tum is a bonelike tissue usually found covering the roots of teeth, but it is also found in the crowns of the teeth of many herbivores. Teeth with relatively low crowns are characterized as brachydont , whereas those with high crowns higher than the roots, or higher than the length or width; Simpson, c are hypsodont. Teeth that grow continuously throughout life and never form roots are called hypselo-dont e. The most obvious examples of hypselodont teeth are the incisors of rodents, but the condition has evolved independently in multiple lineages, and at different tooth loci. Incisors may be small to very large and ever-growing, and the crowns vary from pointed to broad and spatulate, chisel-like, bilobed, or multicuspate; upper incisors tend to be larger than lowers. Canines are usually relatively large, conical teeth, but in some forms they are reduced or lost, whereas in others they are huge and saberlike or gliriform like rodent incisors and may be ever-growing. Both incisors and canines are almost always single-rooted. Premolars may be simple with one main cusp, or more complex, sometimes closely resembling molars. They usually increase in size and complexity posteriorly. In some mammals the posterior premolars are greatly enlarged, and in this case they may be swollen or bladelike. Despite these interesting variations in antemolar teeth, which are sometimes diagnostic of particular taxa, the crown morphology of molars is particularly distinctive and almost always carries substantial weight for taxonomy, phylogenetic assessment, and dietary inference. Extant mammals, as well as most of the fossil groups dealt with in this book, have molars derived from the basic tribosphenic condition that evolved in the Mesozoic ancestors Fig. Structure of tribosphenic molars anterior to the left: A left upper; B left lower. From Bown and Kraus, Some more primitive groups, discussed in the chapter on Mesozoic radiations Chapter 4 , were not yet tribosphenic. Here I focus on the structure of tribosphenic molars Fig. In general, tri-bosphenic molars have divided roots, two for each lower molar, located below the trigonid and talonid, and three for each upper, under each of the three main cusps. Generalized tribosphenic upper molars are transversely wider than they are long, and the three main cusps form a triangle with two cusps arranged buccally and one lingually. On the buccal side, the paracone is anterior, the metacone posterior; the lingual cusp is the protocone. Between the para-cone-metacone and the buccal margin of the tooth is the stylar shelf, on which smaller cusps may be present, such as the parastyle , stylocone, mesostyle , and metastyle. Conules paraconule and metaconule are commonly present between the paracone or metacone and the protocone. A hypocone is frequently developed posterolingually, especially in herbivores, and may result in a quadrate upper molar. It is generally assumed that these cusps on adjacent teeth of an individual are serially homologous. Mammalian cusp nomenclature is largely topographic: Indeed, developmental evidence has shown that relatively small changes during tooth formation can result in substantial changes in the size or number of small cusps Jernvall, Although this instability helps to explain the frequent appearance of new cusps in different clades, it also means that variations in small cusps may have little phylogenetic significance, which should be remembered when using minor variations in cusp pattern as evidence for or against relationship. Cusps are often joined by crests, and in some teeth crests predominate. The centrocrista is the crest between the paracone and metacone in generalized molars. When this crest is better developed, or when it links the centrocrista to the parastyle, metastyle, or mesostyle, it is called the ectoloph. Other crests are usually named with respect to the cusps they join. For instance, the preprotocrista and postproto-crista run anteriorly and posteriorly to the protocone, from the paracone or paraconule, and metacone or metaconule, respectively. Parallel transverse crests joining the paracone to the protocone and the metacone to the hypocone are the protoloph and metaloph, respectively. They are particularly well developed in herbivorous forms. A low basal shelf on any margin of the tooth is a cingulum. Tribosphenic lower molars are longer than wide and consist of a trigonid anteriorly and a talonid posteriorly. As its name implies, the trigonid consists of three cusps, but in tribosphenic molars these cusps are arranged in a triangle that is inverted compared to that of the upper molars. Lower molar features end in the suffix -id; the two lingual cusps of the trigonid are the paraconid and metaconid, and the buccal cusp is the protoconid. The trigonid is almost always taller than the talonid. When it first evolved, the talonid was little more than a short "heel" with a single cusp, but in tribosphenic molars it usually has two or three cusps, the en-toconid lingually hypoconid buccally, and the hypoconulid in between. As in the upper molars, crests commonly join various cusps: The cristid obliqua is a crest that runs from the hypoconid anteriorly to the back of the trigonid, often oriented obliquely toward the metaconid. An entocristid may be present mesial to the entoconid. The crests of the talonid usually encircle a depression of variable size, forming a talonid basin that occludes against the protocone. Additional talonid cusps are sometimes present, including a metastylid behind the metaconid really an accessory trigonid cusp , an entoconulid anterior to the entoconid, or a mesoconid on the cristid obliqua. A basal cingulum cingulid is often present on the buccal side, sometimes extending to the mesial or distal ends but almost never lingually. Molars with sharp or bladelike cusps or crests are described as secodont or sectorial; specialized sectorial teeth called carnassials are characteristic of carnivorous mammals. Teeth with low, rounded cusps are bunodont. An occlusal pattern dominated by crescentic crests with a mesio-distal long axis is selenodont , whereas a pattern characterized by transverse ridges is lophodont. These and other Fig. Comparison of various dentitions and molar types not to scale: The microscopic structure of the enamel also provides information relevant to phylogeny and function e. Enamel is composed of long, needlelike crystallites of carbonate hy-droxyapatite. In the most primitive Mesozoic mammals, the crystallites are parallel and radiate from the enamel-dentine junction to the surface. This relatively simple type of enamel is called aprismatic or nonprismatic enamel. In most mam mals, however, the crystallites combine into bundles called prisms, each of which is surrounded by a prism sheath, also composed of crystallites. Although there is considerable variation in the morphology of the prisms and their sheaths, the significance of this variation is unknown. Groups of prisms are often arranged in the same orientation. In some cases all the prisms are oriented similarly and are either arranged radially from the enamel-dentine junction radial enamel or bend together tangential enamel.

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This left the relatively tiny mammals to seize the larger land niches. The mammals rapidly evolved larger sizes. This is called the Paleocene-Eocene Thermal Maximum. Many species went extinct as a result. It is the official explanation that the heat got them. Even after the hot spell the Eocene was very warm. From the Eocene through the Pleistocene, the world generally became colder. In the tropical world of the Eocene the mammals were somewhat smaller than before or after the Eocene. The mammals were on average only 60 percent of the size of the late Paleocene mammals. The earliest fossils of most of the modern mammalian orders are found in the Eocene. The earth may have been hit by a large object. As the earth became cooler and dryer the mammals became very large. This was the era of indricotherium, the giant hornless rhino which is the largest land mammal that ever lived. It is also the era of brontotherium, the giant animal that looks like a rhino with a forked horn. This period of relatively unsophisticated giants seems to be similar to the Jurassic for the age of dinosaurs, which was also an age of unsophisticated giants. The climate was cooling but still warmer than ours. Much of the Miocene was as warm as the earlier Oligocene. Glaciers advanced and it was very cold most of the time. But there were also warmer interglacial periods, like the one we are in now. Perhaps because of man, this interglacial period has lasted longer than previous ones. Agriculture developed fairly early in the Holocene, and for about the last half of the Holocene there have been human civilizations and written language. One might suspect that the Pleistocene would have continued without us.

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In examining the fossil record of the early Cenozoic, one finds the early beginnings of present day plant life. Among the early trees are Birch, Beech, Holly, Sweet Gum and others.

Chapter 9 : I wish I could save the world: The Age of Mammals

Because, Mammals, which had been around since the Jurassic, diversified greatly throughout the Cenozoic Era. We're mammals, so that's really important to us.