

EEB 2245 & EEB 2245W
FINAL STUDY GUIDE EXAM 1
SPRING 2019

-Elucidation of patterns vs. elucidation of processes of evolution; general types of evidence for patterns (direct vs. indirect)

Geological Time Scale (GTS) and the Fossil Record

-Distinction between the GTS and the fossil record; why dates of intervals are not regular; understand that the majority of major biological events occur late in the GTS; distinguish biotic from abiotic events found in GTS.

-difference between age of the earth and beginning of GTS; approximate dates of beginning of each; events are concentrated in most recent ~550 million years; what determines boundaries of intervals? Why are the dates so irregular?

In terms of GTS dates: know beginning and end of Archean and Proterozoic Eons. Phanerozoic Eon—date of beginning; know the Phanerozoic Eras and Periods, in their relative sequence; know dates of beginning and end (± 10 my) of each; know major events (if discussed in class) marking temporal boundaries of each; know 5 major mass extinction events and timing of each; know examples of major taxa that went extinct as a result of each event; which is considered the greatest mass extinction and why?

-What is a fossil? 4 main types of fossils (i.e., molds, casts, trace, etc.); major modes of fossilization and how they occur (replacement, petrification/permineralization, carbonization, etc.); examples of each; which are organic? which are viable sources of DNA? ancient DNA—examples of ages and types of organisms from which ancient DNA has been extracted and sequenced (oldest?); number and proportion of extinct species represented by fossils.

-Limitations/biases of the fossil record: 3 major types of rocks (igneous, etc.) and type most likely to harbor fossils (and why); biased sample with respect to kinds of organisms (large/robust/hard, numerous, etc.) most likely to be preserved; circumstances under which fossils are most likely to be preserved (e.g., areas in which buried rapidly, wet periods, undisturbed areas, etc.); complete/continuous sequences rare; difficulties with correlations between sites/strata, sites, etc.

-Dating of the fossil record: relative dating methods (principle of superposition, index fossils); absolute dating methods—major principle on which they rely (i.e., radioactive decay); understand how parent/daughter isotope ratios are used in radiometric dating; C^{14}/N^{14} as a method of dating fossils themselves (of what age? Why age so limited?); K^{40}/Ar^{40} as a method of dating rocks around fossils (of what age? Why so old?); types of older rock that can be dated with such methods; problems with this strategy.

-Age of earth; formation of early atmosphere; type of environment through to 3.8 bya

"Precambrian"

-3 Domains of life on earth (i.e. Bacteria, Archaea, etc.); major differences between prokaryotic and eukaryotic organisms (unicellular vs. multi-cellular, etc.); is life considered to be monophyletic? Evidence? (e.g., all organisms share nucleic acids as hereditary material, etc.)

- Archean eon: when first chemical vs. fossil evidence of life? First evidence of photosynthesis-what? When? How did this process change the atmosphere? Initial fate of O_2 produced (iron oxide deposits); ultimate fate of O_2 produced (ozone)

-Proterozoic eon: When? What event marks beginning? 3 possible fates of anaerobic organisms alive at the time (extinction, retreat, etc.); serial endosymbiotic theory and the origin of eukaryotes: What is it? What does it explain? primary vs. secondary plastid endosymbiosis; how does origin of mitochondria (i.e. from purple bacteria; once) differ from origin(s) of chloroplasts (i.e., originally from cyanobacteria); evidence in support of endosymbiosis (organelles have their own DNA, etc.); first definitive fossil evidence of eukaryotes: What? When? What type of organisms were they? What and when was Rodinia? Evolution of metazoans (=animals): Features of metazoans (e.g., multicellular, heterotrophic, develop from embryos, etc.); first evidence of metazoans (i.e., Doushantuo embryos); What type of fossils? When? What type of metazoans? Ediacaran fauna: When? Why important? What types of fossils (impressions, etc.), no hard parts; taxa represented? some extinct phyla (e.g., fractile-like *Charnia*, etc.), some extant (e.g., *Kimberella* possible mollusc? Abiotic factors at end of Eon, e.g. break-up of Rodinia, "snow-ball" earth fully melted.

Phanerozoic Eon (=visible life) (what event marks beginning of this, the present, Eon?)

Paleozoic Era (=early animals)

Cambrian Period: When? Plant diversity at that time? Cambrian explosion: What was it? When was it? How long did it take? (i.e., 20 my) In what sort of environment did it occur? Burgess shale (and Chengjiang) faunas: types of body plan innovations seen (e.g., appendages, mouth, hard parts [skeletons]), examples of extant phyla (e.g., arthropods, annelids; most modern phyla); examples of extinct phyla (e.g. *Opabinia*, *Anomalocaris*); evolutionary significance of conodonts and *Haikuiichthyes* (What phylum do they represent? Is that phylum extinct today)? Explanation(s) for increased diversity? (i.e., evolution of predation, etc.); photosynthesizers at that time? **Ordovician Period:** When was it? Habitat? (i.e., animals? [marine]; plants? [on land]); position of continents? Kinds of invertebrates present (echinoderms, trilobites, eurypterids [=arthropods], etc.); types of vertebrates present (i.e., diversity of fish: ostracoderms, placoderms, early sharks and rays, bonyfish); what type of plants? (small, non-vascular, with spores [e.g., bryophytes, etc.]); desiccation remains a problem; ends with first of 5 mass extinction events. **Silurian Period:** When was it? Position of continents? Kinds of organisms present in oceans? (e.g., diversity invertebrates and vertebrates); life on land: well developed soil profile, first vascular plants (e.g., *Cooksonia*); advantages of vascular tissue? Non-vascular plants diversity. **Devonian Period** (= Age of what type of organisms?): When was it? Nature of the atmosphere? Position of continents? Animals: Key innovation in evolution of tetrapods (i.e., *Latimeria* with bones and muscles at base of fins); why was this important? Second key innovation in evolution of tetrapods: 1st amphibians (e.g., *Ichthyostega*); challenges faced by first vertebrates emerging on

to land (e.g. breathing, legs and wrap-around ribs to support body and organs respectively), environmental conditions that may have driven that change? (But were they truly terrestrial?) Plants diversify: seedless vascular plants (e.g., lycophytes) are large; evolution of progymnosperms with tree stems, roots, leaves; Key innovation in evolution of plants (i.e., the seed); why was this important? Period ends with second of 5 mass extinctions, possible cause? **Carboniferous Period**: When was it? Position of continents (Pangaea)? Climate? Land dominated by rich forests consisting of what types of plants? (e.g., large club mosses, lycophytes, tree ferns; gymnosperms appear); why is this period source of rich coal and oil deposits today? Animals: marine bonyfish and elasmobranchs diversity; on land insects diversify, some large (e.g., dragonflies), Why so large? Key innovation: evolution of first amniotes; amniotic egg; main components and their functions; what advantage did amniotes have over other vertebrates? First "reptiles" by end of Period. **Permian Period**: When was it? What was the environment like? Plant groups found on land? (i.e. still just 3 major groups); animals on land: most of modern insect orders, amphibians and "reptiles" diversify. Three major types of amniote skulls (anapsid, synapsid, diapsid); how do they differ? Modern representatives of each? Synapsids: dominated Permian (e.g., *Dimetrodon*; therapsids i.e., mammal-like "reptiles"). Why are they not considered to be dinosaurs? Diapsids: not diverse in Permian. End of Era marked by greatest extinction in history of earth; examples of groups that went extinct (e.g., trilobites); cause? (environmental perturbations-volcanism?).

Mesozoic Era (= Age of what type of organisms?)

-**Triassic Period**: When was it? Position of continents at beginning. On land: plants-still 3 major groups; animals-synapsids persisted (as therapsids), not very diverse; diapsids diversified substantially: 1st true dinosaurs-distinguishing features? (e.g. open acetabulum in hip, warm-blooded, etc.); 2 major clades of dinosaurs (Ornithischia vs. Saurischia) and diagnostic features of each (bird-hipped, mostly herbivorous, etc. vs. lizard-hipped, mostly carnivorous); members both groups small; how related to birds? First pterosaurs- no head crest, long tail, =sister taxon to dinosaurs (not dinosaurs); key innovation of pterosaurs? 4th of 5 major mass extinctions at end of Period. **Jurassic Period**: When was it? Position of continents? (i.e., Laurasia and Gondwana). Plants: gymnosperms dominate land; key plant innovation-evolution and diversification of first flowering plants (advantage?); all 4 major plant lineages present. Animals: synapsids persist in the form of therapsids, possibly also first mammals (small and likely nocturnal); diapsids diversify (both dinosaurs and pterosaurs); know one example of an ornithischian and one of a saurischian dinosaur that characterizes this period; Connecticut state fossil-*Eubrontes*- which lineage?; what is an ichnotaxon? key innovation?: feathers; *Archaeopteryx*- What is it? Why is it important? Features it shares with birds; features unlike birds. To which dinosaur lineage does it belong? Pterosaurs diversified: tail reduced; no head crest; why did pterosaurs diversify? Cope's Rule: What is it? Examples? **Cretaceous Period**: When was it? Position of continents? All 4 major plant lineages still present. Mammals small; diapsids diverse: example of 1 ornithischian and 1 saurischian that characterizes this Period; diversification of feathered dinosaurs and birds; pterosaur diversity: Why? how did Cretaceous pterosaurs differ from earlier pterosaurs? End of Era and Period marked by 5th mass extinction. Key major groups that went extinct? Cause of extinction?

Cenozoic Era (= Age of what type of plants? Age of what type of animals?) (**reminder: know sequence and dates of all Periods**). In general, you will be responsible only for the sequence and dates of Epochs as they relate to Primate evolution in Lecture 6.

-features shared by mammals (hair, mammary glands, perfectly occluded teeth, heterodonty); heterodonty as a key innovation? What is it? Why was it important? Three major mammal groups present and their basic features (i.e., monotremes, marsupials, etc.). **Paleogene Period** (with 3 Epochs) and **Neogene Period** (with 2 Epochs): When were they?; continents nearing modern positions; mammals dominated landscape; major trends, e.g., evolution of horses (4 to 3 to 1-toed); evolution of whales; evolution of proboscideans, and Cope's Rule. First primate fossils (45 mya). When was it?; Climate? Position of continents? **Quaternary Period** and its 2 Epochs: When were they? Position of continents? Punctuated by series of major glacial events separated by interglacial periods; great American interchange- what was it?; our current status with respect to glacial and interglacial events; current Period? Current Epoch?

Primate Evolution

-Order Primata: Primate features (nails, independent movement of digits, etc.) and their functional implications; Understand where humans fit in the scheme of primate classification (i.e., SO Anthropoidea, IO Hominoidea, F Hominidae, genus & species *Homo sapiens*). First primate fossils (i.e., *Diacronis*)- Features? When? First anthropoid fossils (i.e., *Aegyptopithecus*)- distinguishing features? When? Three modes of primate locomotion (brachiation, quadrupedal, etc.), relationship between locomotion and leg and arm length, modern examples of each. Hominoid features (large canines, gap between canines and incisors, etc.); first hominoids (i.e., *Proconsul*, *Gigantopithecus*)- Distinguishing features? When? Where? Hominid features (bipedal, loss of opposable toe, etc.); fossil hominids (i.e., *Australopithecus afarensis*, *Australopithecus africanus*)- When? Distinctive morphological (including cranial capacity), societal features, and basic distribution of each; distribution of each. *Homo* features (larger head, round birth canal, etc.); extinct *Homo* species (i.e., *Homo habilis*, *Homo erectus*, *Homo neanderthalensis*)- When? Distinctive morphological (including cranial capacity), societal features, and basic distribution of each; distribution of each. *Homo floresiensis*-Distinctive morphological (including cranial capacity) features. When? Where? (Note: for our purposes, **Hominoidea** includes orangutans, gorillas and chimps and humans; **Hominidae** includes several fossil lineages, but today only *Homo sapiens* remains.

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