GEOL 104 Dinosaurs: A Natural History
Exam Test II Review Sheet

Review Exam I

Life on Land Before the Dinosaurs

Colonization of Land: traits already present in vertebrates by the time of colonization of land; traits acquired during the process of colonization

Radiations of the Amniotes:

- 1st (Late Carboniferous – Early Permian): Basal Synapsids
- 2nd (Middle Permian – Early Triassic): Therapsid synapsids
- 3rd (Middle Triassic – Late Triassic): Pseudosuchian archosaurs
- 4th (Jurassic – Cretaceous): Dinosaurs

Permo-Triassic and Triassic-Jurassic Extinctions

Traits of:

Archosauria: Antorbital and mandibular fenestrae; semi-improved stance; belly-breathing; parental care of the young (including nest attendance); vocalization

Ornithodira: Elongate tibiae and metatarsi; bird-like necks

Dinosauromorpha: Parasagittal stance, digitigrade posture (striding locomotion)

Silesauridae Dinosauria's sister-taxon; herbivorous quadrupeds

Diversity of the Dinosauria:

Be familiar with the **lifestyle**, major **adaptations** and their **functions**, **geographic** & **stratigraphic** distributions, and **relationships** of (and ***BE ABLE TO RECOGNIZE BY PICTURE***) the following groups:

The base of **Dinosauria**: Small obligate bipeds of the Late Triassic, with perforated acetabula, enlarged deltapectoral crests, and hands with semi-opposable thumbs and reduced digits IV & V; possibly fuzz. Three main groups: **Ornithischia**, **Sauropodomorpha**, **Theropoda**. Traditional division into Ornithischia & **Saurischia**; alternatives (Sauropodomorpha & **Ornithoscelida**; Theropoda & **Phytodinosauria**).

Basal ornithischians: Small obligate bipeds with specializations for herbivory (predentary bone; phyllodont teeth; cheeks? (or reorganized jaw muscles); backwards-pointing pubis. Early representatives include **Heterodontosauridae** (with ornithopod-like jaws and deep skulls) & *Eocursor*: all of these retained big grasping hands. Later ornithischians divided into Thyreophora and the neornithischians (small obligate bipeds that themselves evolved into Thescelosauridae, Ornithopoda & Marginocephalia)

Thyreophora: Ornithischians with osteoderms as protection; as the dinosaurs became bigger and more heavily armored, shifted to obligate quadrupedality. Advanced thyreophorans split into **Stegosauria** and **Ankylosauria**. Stegosaurs emphasized active defense, with plates, spikes, and the thagomizer: their heyday was the Middle and Late Jurassic. Ankylosaurs emphasized passive defense, with osteoderms fused to the skull, heavy rings of armor on the neck and shoulders, and in general lots of osteoderms over the body. In **Ankylosauridae**, complex nasal passages; within ankylosaurids, in the **Ankylosaurinae** evolution of active defense in the form of tail clubs. Ankylosaurs heyday was the Cretaceous.

Thescelosauridae: Unspecialized small bipedal neornithischians. Common as small animals in the Cretaceous. Some are known to have been burrowers.

Ornithopoda: Evolution of the complex jaw hinge to increase chewing ability. Primitive ornithopods relatively small unspecialized bipeds; the more derived **iguanodontians** were

typically larger, and many were facultative bipeds. Among Iguanodontia, the **Styracosterna** were the largest, and evolved the Swiss Army Hand (spike thumb; metacarpals II-IV weight bearing supporting hoof-like unguals; opposable pinky). The most advanced styracosternans (and thus most advanced ornithopods) were the **Hadrosauridae** (duckbills), with expanded bills and a grinding dental battery (and no thumb). The diverse hadrosaurids divide into the hollow-crested **Lambeosaurinae** and the broad-billed **Hadrosaurinae**.

Marginocephalia: Had ridge extending posterior over back of skull. **Pachycephalosauria** were strictly bipedal, with thickened skull roofs eventually evolving into head-banging domes. **Ceratopsia** began as small bipedal herbivores with a rostral bone; neoceratopsians added the frill to increase the size of their jaw muscles. More advanced **Neoceratopsia** had even larger frill (for display), and became obligate quadrupeds. The most advanced evolved horns: first the postorbital (brow) horns, and then (among the **Ceratopsidae**) the nasal horn. Ceratopsids also evolved the shearing dental battery, and much larger size than all marginocephalians. Among ceratopsids were the deep-snouted **Centrosaurinae** with a pair of spikes sticking out of the frill, and the long-snouted **Chasmosaurinae** with long frills and an enlarged rostral bone.

Basal saurischians: Specialized joints between vertebrae; had hollow air sac chambers in their vertebrae, elongate necks, and modified hands with large thumb claws and long index fingers. Saurischians split into the herbivorous sauropodomorphs and the carnivorous theropods, plus several forms (like Herrerasauria) of uncertain position

Sauropodomorpha; Characterized ancestrally by small skull size and tall phyllodont teeth with large denticles. The "**core prosauropods**" evolved larger size, proportionately even smaller heads and longer necks, and possibly cheeks. These in turn evolved into the "**near-sauropods**": larger still, and quadrupedal. Actual **Sauropoda** had rounder snouts, and the **Eusauropoda** had even larger size and tooth-to-tooth occlusion. Eusauropod had hands that formed a horse-shoe curve and feet supported by large fleshy pads. Eusauropods lose the cheeks and gain a wider gape, allowing for "bulk-browsing". Eusauropods also had highly complex airsac chambers. Among the eusauropods the most specialized forms were the diverse **Neosauropoda**. Neosauropods include the long-skulled pencil-toothed **Diplodocoidea** and the big-nosed **Macronaria**. The diplodocoids included the **Rebbachisauridae** (with their grazing/gnawing dental battery), the short-necked tall-spined **Dicraeosauridae**, and the enormous long-necked whip-tailed **Diplodocidae** (which, because their forelimbs were much shorter than their hindlimbs, could probably rear up to feed very high in the trees). Among the more specialized macronarians were the enormous **Brachiosauridae** (with very long forelimbs, so that they were build uphill) and the diverse wide-bodied **Titanosauria** (which included the largest of all dinosaurs, and including the armored Lithostrotia).

Theropoda: Early theropods were long and slender, possessed ziphodont teeth, and evolved the promaxillary fenestra, grasping claws, and the intramandibular joint (for dealing with struggling prey in the jaws). Possible basal theropods of the Triassic include the Herrerasauria, *Eodromaeus*, and *Tawa.* The later theropods form **Neotheropoda**, and are characterized by the furcula (as a brace for stresses on the forelimb), an elongate ilium, loss of manual digit V, and a functionally tridactyl (three-toed) foot. **Coelophysoidea** were an early (Late Triassic-Early Jurassic) gracile clade of neotheropods, and "**Dilophosauridae"** a larger more robust Early Jurassic group (after the Triassic/Jurassic extinction, theropod size and relative tooth size increases). Derived theropods (Averostra) included the short-armed **Ceratosauria** (which in particular included the long-legged toothless **Elaphrosaurinae**, small digging **Noasaurinae**, and powerfully-skulled, stump-armed **Abelisauridae** (the top predators of Late Cretaceous Europe and Gondwana)) and the stiff-tailed big-handed **Tetanurae**. Basal tetanurine groups included long-faced **Megalosauroidea** (most especially the conical-toothed gigantic fish-eating

Spinosauridae) and the **Carnosauria** (which combined deep skulls with blade-like teeth and powerful gripping arms). Basal theropods up through Carnosauria used a "slice-and-bite" feeding mode. More advanced were the fuzzy agile **Coelurosauria** with their bigger brains and their long slender hands, feet, and tails. Early coelurosaurs were typically small predators. Among the more important coelurosaur groups were:

- **Tyrannosauroidea**: Initially small agile predators with stronger bites and U-shaped premaxillary teeth; over the Cretaceous they emphasized the skull over the forelimbs, eventually evolving into the gigantic two-fingered **Tyrannosauridae** (with their powerful skulls with a suite of adaptations for "puncture-and-pull" feeding, two-fingered hands, and arctometatarsi)
- More advanced coelurosaurs with even larger brains. Most of these have reduced skull size, long necks, and non-predatory snouts (tiny phyllodont teeth with no serrations or with big denticles), showing a shift away from flesh eating. **Pennaceous** feathers are present in these groups.
    - **Ornithomimosauria**: Small headed, long necked omnivores or herbivores, with modified hands in which all three metacarpals were the same length. The advanced Late Cretaceous **Ornithomimidae** were toothless and had an arctometatarsus; the also-toothless **Deinocheiridae** were enormous, slower-moving ornithomimosaurs.
    - **Maniraptora**: Coelurosaurs with enlarged forelimbs and strap-like feathers. Among the maniraptorans were:
        - Long-necked, big-clawed plant-eating **Therizinosauria** (with leaf-shaped teeth and (in advanced forms) a backwards pointing pubis and exceptionally short metatarsi
        - Small, fast ant-eating **Alvarezsauria** , with their enlarged thumb. In the derived **Alvarezsauridae** there are very short powerful arms ending with their essentially thumbs-only hands (and, in the advanced forms, backwards-pointing pubes and an arctometatarsus). Alvarezsauroids share with the remaining maniraptorans an enlarged bony sternum.
        - **Pennaraptora**, which share true pennaceous feathers on the arms and tail. From their sideways-oriented shoulders came very long arms which could fold up tight because of the semilunate carpal; these arms could be pulled in quickly because of the large bony breastbone. Pennaraptora is divided into:
            - Boxy-skulled **Oviraptorosauria** (all but the most primitive being toothless; some advanced forms with an arctometatarsus)
            - Tiny **Scansoriopterygidae**, with an extremely long third manual digit and (at least in one genus) an accessory bone coming out of the wrist and supporting a bat-like wing.
            - **Eumaniraptora**: Long arms, tails which were mobile at the base but stiff distally, long leg feathers, a distally-placed metatarsal I, and a retractable pedal digit II ending in a sickle claw. Early eumaniraptorans were crow-sized, and likely tree-dwellers. The main branches are **Deinonychosauria** and **Avialae**. Deinonychosaurs are characterized by a sickle claw on pedal digit II, and include: **Dromaeosauridae** (strictly carnivorous) and the swift-running small-toothed **Troodontidae** include at least some omnivores. Avialae have reduced tooth counts, even longer arms, & shortened tails: in all but the most primitive the distal caudals are fused together into a short pygostyle. Basal avialians were not any better fliers than were basal deinonychosaurs. **Ornithothoraces**, however, evolved the alula (thumb-feathers) and a very broad

sternum to become better fliers. One of the ornithothoracine branches—**Enantiornithes**—were primary upland dwellers, and very diverse. The other branch—**Euornithes**—were often associated with water-based feeding. These latter lost the long leg feathers and evolved the tail fan. Among the euornithines were the **Carinatae**: more derived birds which evolved a keeled sternum (becoming fully-modern fliers): however, the **Hesperornithes** became flightless swimming fisheaters (the only ocean-going dinosaurs of the Mesozoic). **Aves** (the modern birds) had entirely toothless beaks in which the fused premaxilla made up most of the upper jaw, entirely fused lower jaws, and many other specialized traits. Nearly all Late Cretaceous carninates (including the Cretaceous avians) were feeding from the marine communities.

<u>Evolution of Flight</u>
Know key terms: arboreal, cursorial, scansorial; integument; powered flight vs. gliding/parachuting; volant; pennaceous and plumulose feathers
Arguments for and against the arboreal and cursorial flight origin models
Examples of powered fliers: insects, pterosaurs, birds, bats
Feather origins
WAIR & CFD
Phases of bird flight origin

<u>Dinosaur Paleoecology</u>
Fauna, paleofauna, biogeography, paleobiogeography, cosmopolitan vs. provincial, Laurasia vs. Gondwana
Food webs, energy pyramids
How paleoecology is assessed: methods, evidence
Patterns of dinosaurian history:

- Late Triassic ("when dinosaurs shared the Earth"): pseudosuchians and therapsids important parts of the ecosystems, with most dinosaur groups (ornithischians, theropods) rare; only sauropodomorphs common among dinosaurs
- Early Jurassic (diversification): survivors of the Triassic/Jurassic extinction event, dinosaurs the dominant land animals. Dilophosaurids apex predators; prosauropods & basal thyreophorans most common herbivores
- Middle & Late Jurassic ("Golden age"): older groups evolve themselves out of existence. Carnosaurs & megalosauroids dominate as apex predators (ceratosaurs and early coelurosaurs as minor predators); sauropods & stegosaurs most common large herbivores (ankylosaurs, ornithopods, primitive marginocephalians present but rare)
- Early Cretaceous ("triumph of the low browsers"): carnosaurs & megalosauroids (spinosaurids) as the apex predators, with ceratosaurs and coelurosaurs diversifying; iguanodontians (esp. styracosternans) and ankylosaurs become much more common; sauropods and stegosaurs present but less common (and the latter dying out during this time); marginocephalians minor parts of the fauna. Coincides with the rise of flowering plants (angiosperms), but whether these are related or independent phenomena isn't known at present
- Mid-Cretaceous ("Hot times"): Circum-equatorial current and increased activity of the mid-ocean ridges means temperatures & sea-level reach a peak; increase in primary productivity allows giant size for many dinosaurs (especially carnosaurs, spinosaurids, and sauropods).

Mostly same groups as in the earlier phase. At end, lowering of sea level allows Asian dinosaurs to immigrate to North America & vice versa

- Late Cretaceous ("Many worlds"): separation of continents and high sea levels (with epicontinental seas) promotes provincialism. In Laramidia (western North America): tyrannosaurids as apex predators; hadrosaurids and ceratopsids dominate as large herbivores; other coelurosaurs, pachycephalosaurs, ankylosaurines, among more common remaining dinosaurs. Laramidia joined to Asia to form Asiamerica: wetter environments of Asia similar to Laramidian dinosaurs, but deserts with smaller dinosaurs (dromaeosaurids apex predators, protoceratopsians and ankylosaurines as main herbivores). Eastern North America with primitive tyrannosauroids and hadrosaurids. Gondwana with abelisaurids as apex predators, titanosaurs as main herbivores. European archipelago sees mixture of forms from eastern North America, Gondwana, and some unique local groups.