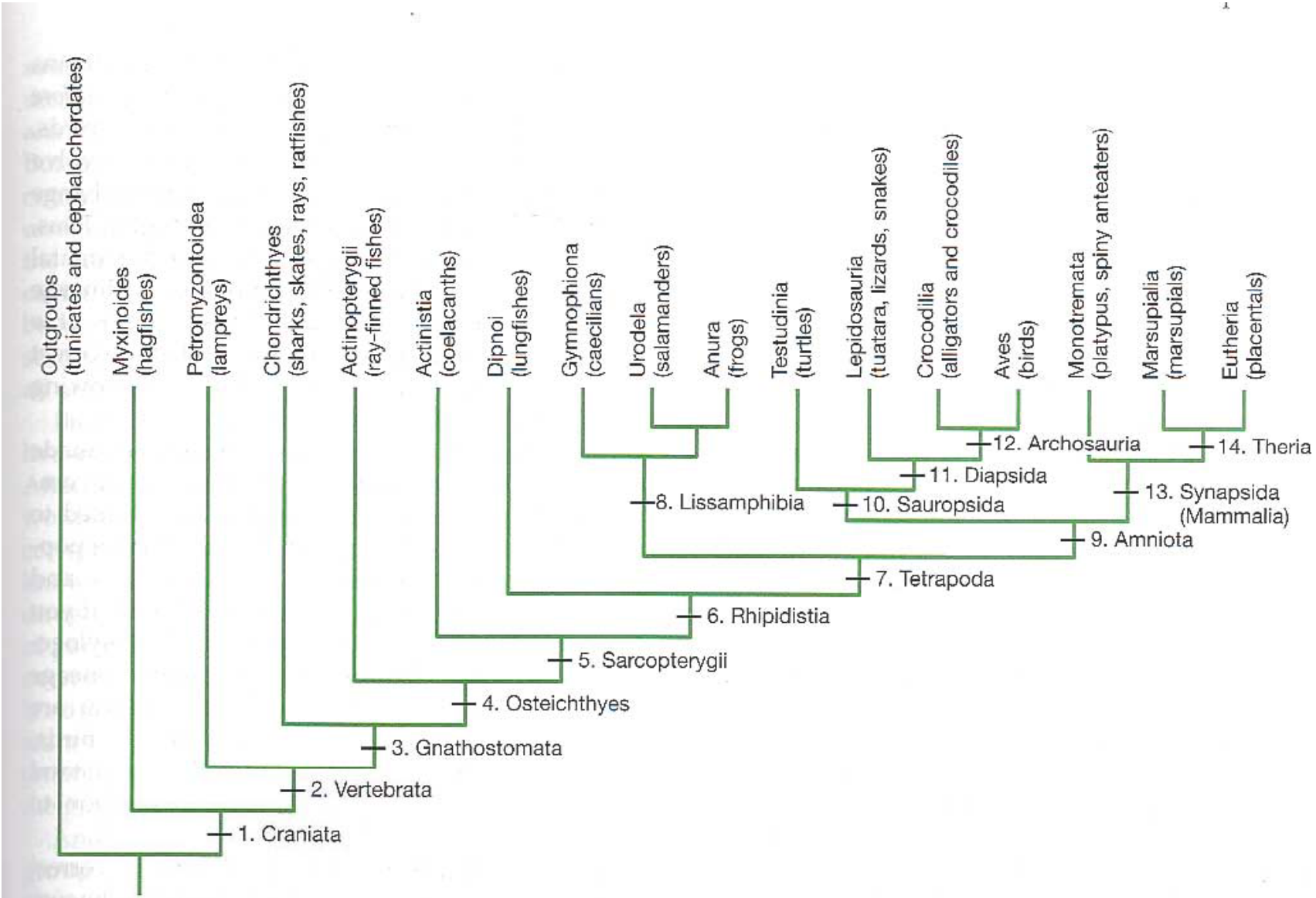
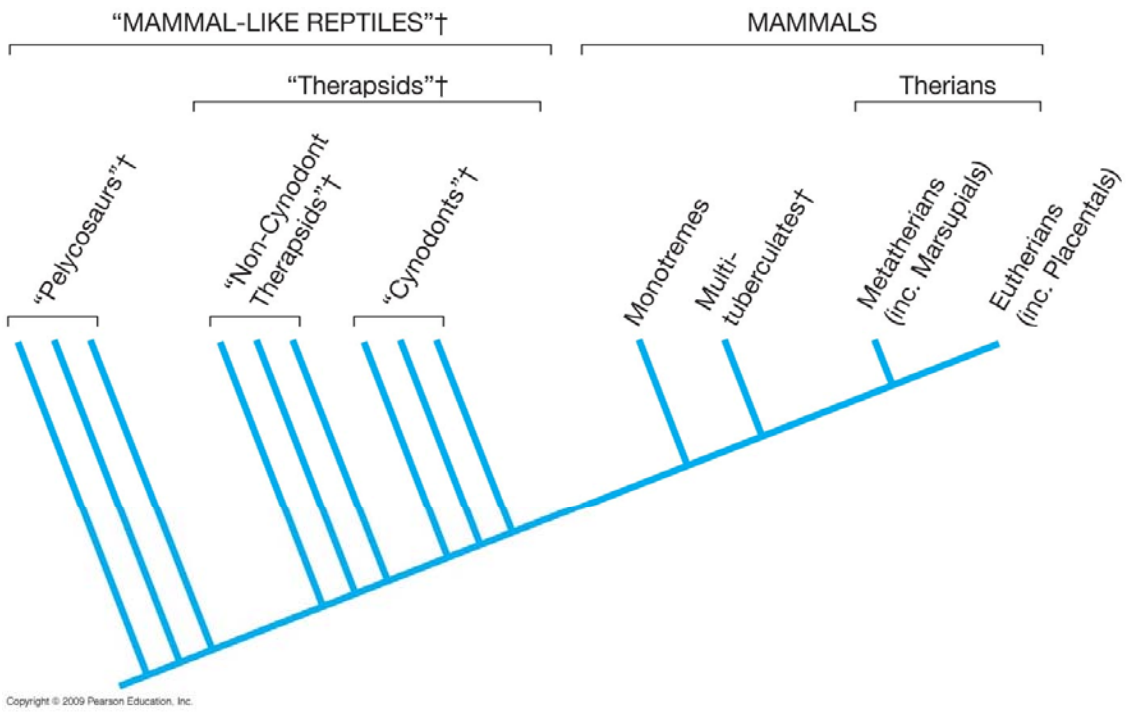
Synapsids and evolution of mammals

Readings: Chapter 18; pp. 487-507



▲ **Figure 1–4** Phylogenetic relationships of extant vertebrates. This diagram shows the probable relationships among the major groups of extant vertebrates. Note that the cladistic groupings are nested progressively; that is, all placental mammals are therians, all therians are synapsids, all synapsids are amniotes, all amniotes are tetrapods, and so on.

- Synapsida includes all amniotes with synapsid skull.
- Synapsid clade includes:
  - Nonmammalian synapsids, or “Mammal-like reptiles” (extinct)
    - This is not a very scientific term, it actually refers to a paraphyletic group.
    - It’s probably better to refer to nonmammalian synapsids
  - Mammals



Nonmammalian synapsids;

know three main groups that existed; main features

- Pelycosaurs – sailbacks of late Paleozoic
  - – *Dimetrodon*
  - – Generalized carnivores
- Therapsids- 2 groups
  - – Noncynodont therapsids
  - – Cynodont therapsids
- Refer to Table 18.1 page 490.

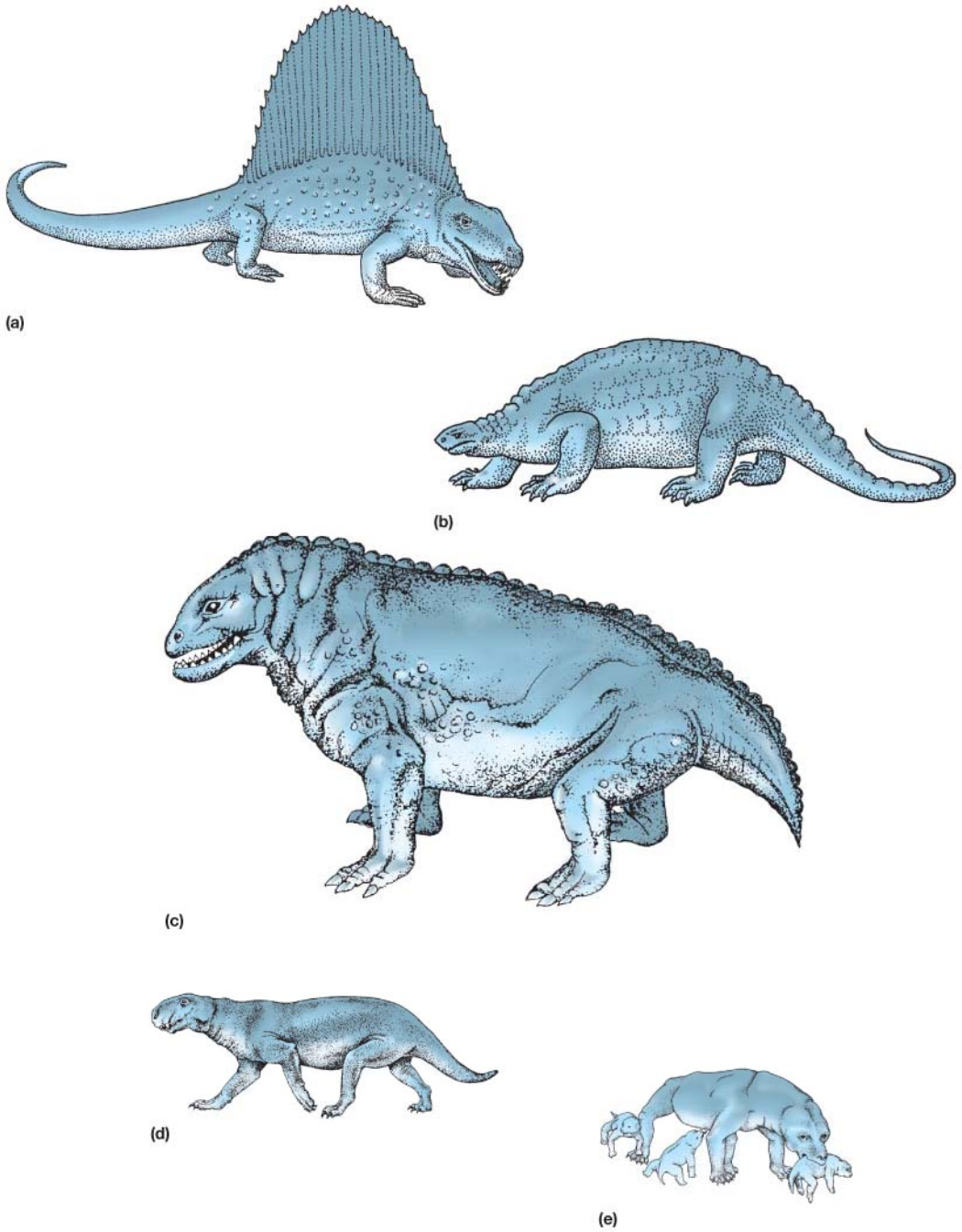
Nonmammalian synapsids

- **Pelycosaurs:**
- *Dimetrodon*, a sphenacosaurid therapsid
  - Size of a St. Bernard dog

- A Caseid pelycosaur

- **Noncynodont therapsids**:
  - Dinocephalian therapsid
    - Size of a cow
  - Gorgonospid therapsid
    - Size of a Labrador retriever

- **Cynodont therapsid**
- *Probolesodon*
  - Size of a terrier



Therapsid features

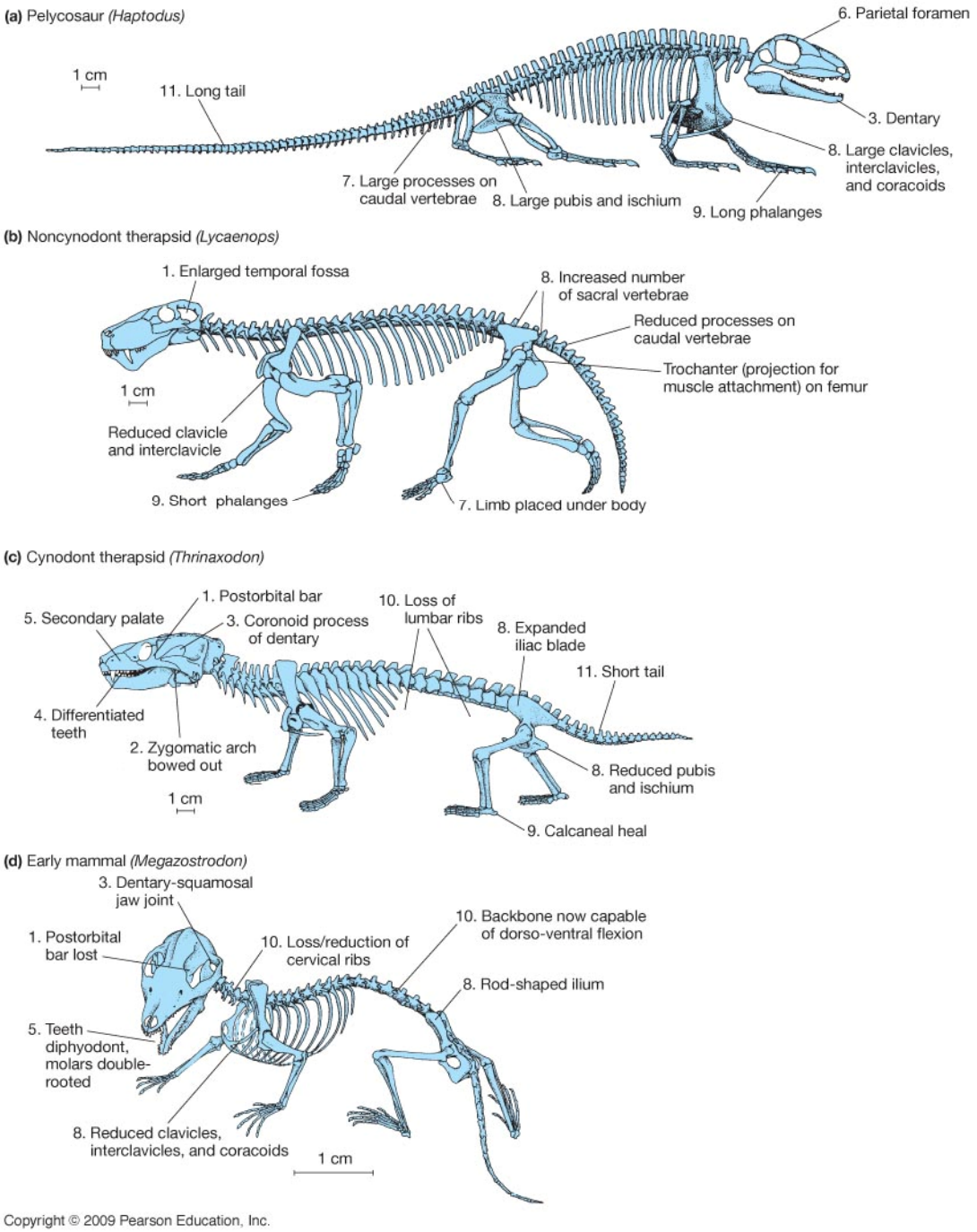
- Increase in metabolic rate compared to Pelycosaurs;
- Carnivorous and herbivorous forms;
- Some may have lived in herds;
- Major extinction of therapsids during Permian-Triassic boundary. Only a few lineages survived into Triassic.
- Cynodont lineage of therapsids is the one that gave rise to mammals;

Therapsid features (cont'd)

- Larger temporal fenestra for larger jaw muscles;
- More differentiated dentition
  - Incisors, canines, postcanine teeth;
- Slender limbs, more movement in pectoral and pelvic girdles;
- Cynodonts showed general reduction in body size. Early cynodonts were size of large dogs, by mid-Triassic the carnivorous cynodonts were size of rabbits.
  - Earliest mammals were small, about 100 mm long, shrew-size.

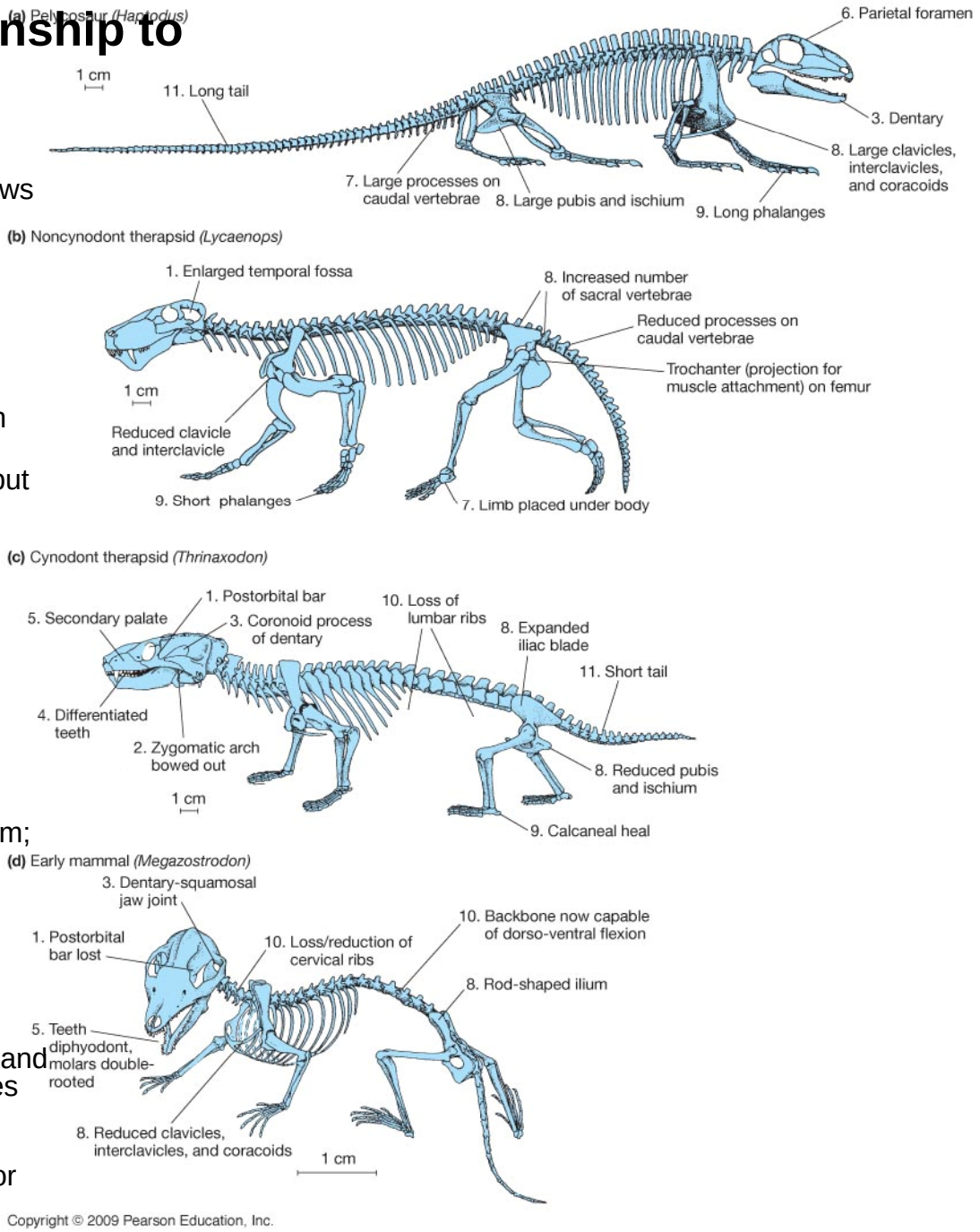
Skeletal modifications and relationship to metabolic rate

- Larger temporal fenestra
  - More jaw muscles to eat more food!
- Lower temporal bar
  - Presence of masseter muscle, for more efficient food processing
- Lower jaw and jaw joint
  - Dentary bone, which supports teeth is greatly expanded;
  - In mammals, dentary bone forms new joint with skull.
- Teeth
  - Specialized dentition; pelycosaurs had homodont dentition, derived synapsids had heterodont dentition, which facilitates food processing.



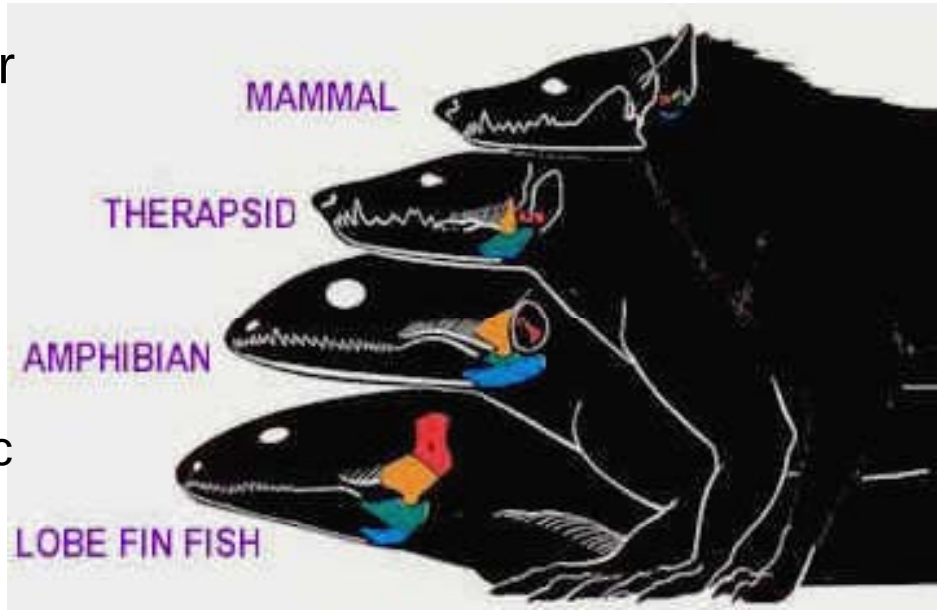
Skeletal modifications & relationship to metabolic rate (cont'd)

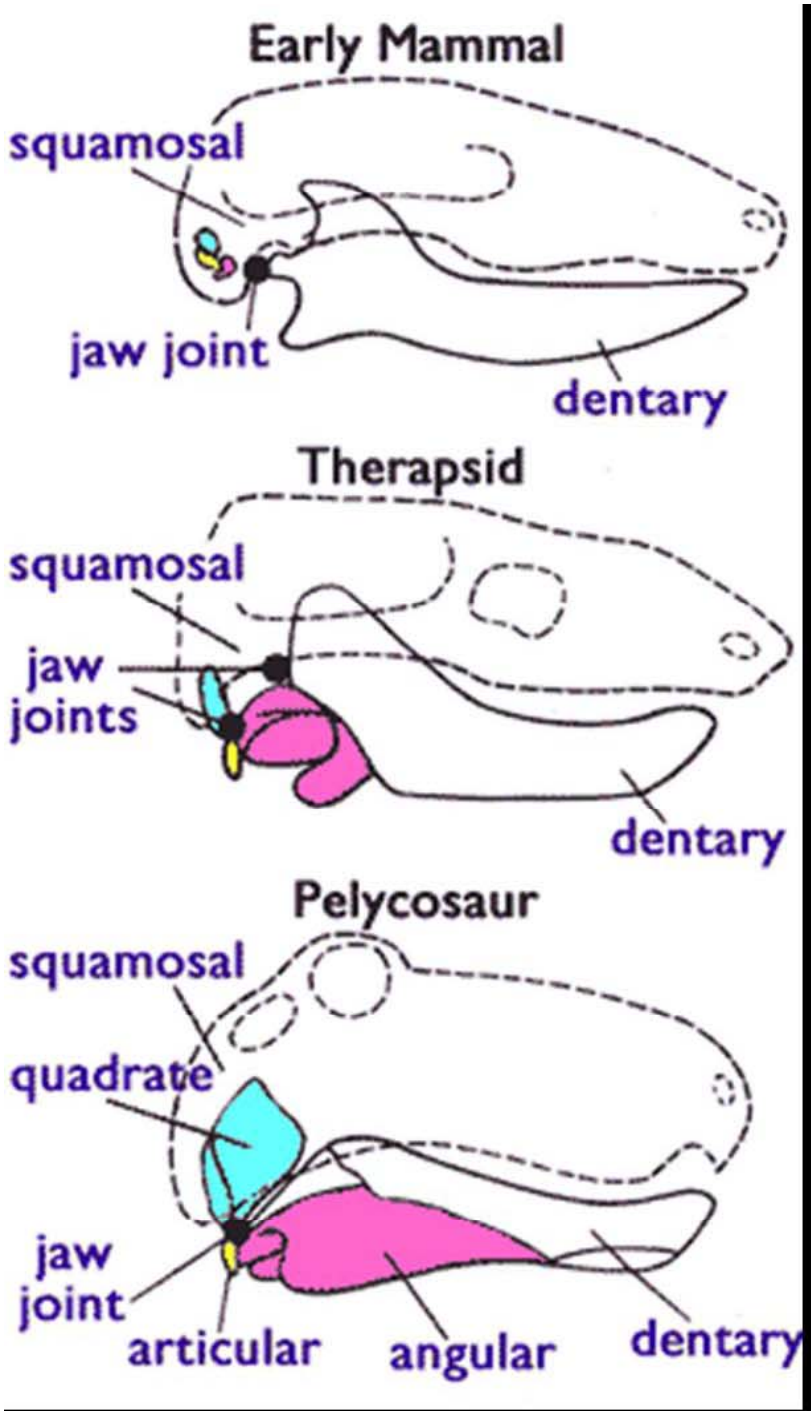
- Secondary palate
  - Separates nasal passage from mouth and allows breathing and eating at same time.
    - Secondary palate absent in Pelycosaurs,
    - incomplete in noncynodonts,
    - complete in derived cynodonts and mammals.
- Cynodonts had nasal turbinates
- Parietal foramen (parietal eye)
  - Associated with behavioral thermoregulation in ectotherms
  - Present in pelycosaurs and other therapsids, but lost in cynodonts and mammals.
- Position of limbs under body
- Shape of limb girdles
  - Lighter built, rod-shaped ilium
- Shape of feet & **calcaneal heel**
  - Short toes in mammals and therapsids;
  - Calcaneal heel allows for push-off using calf muscles.
- Vertebral column
  - No lumbar ribs indicates presence of diaphragm;
  - Lumbar ribs present in pelycosaurs and noncynodonts, absent in cynodonts and mammals;
  - Only 7 neck vertebrae in therapsids, same as mammals.
- Tail
  - Long heavy tail is ancestral amniote condition and this is what pelycosaurs had. Long tail indicates axial flexion is important in locomotion.
  - Cynodonts and mammals have short tails, indicative of upright posture and greater role for limb propulsion.

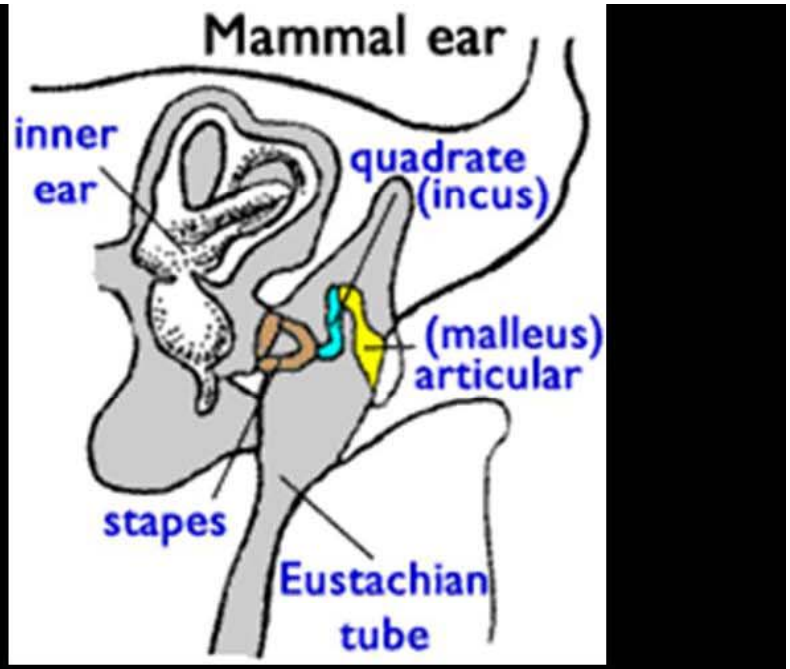


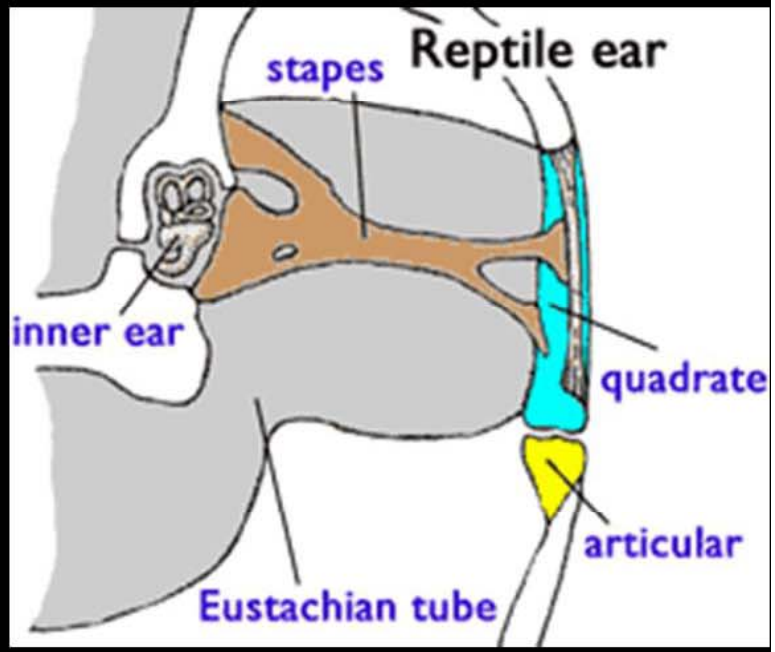
Mammalian middle ear

- Original synapsid condition
  - Teeth on dentary bone, and various postdentary bones in lower jaw.
  - Also the condition in bony fishes and other tetrapods.
- “INNER EAR BONES:
  - Evolutionary history of the inner ear bones in mammals can be charted through various groups from Paleozoic to Cenozoic time.
  - These mammalian ear bones (stapes, malleus and incus) were originally jaw bones, but have changed in size and function.
  - The reduction in number of lower jaw bones is easily traced through fish, amphibian and reptile.
  - Although mammals have only one lower jaw bone, they have three inner ear bones.” http://www-rohan.sdsu.edu/~rhmiller/chordates2/Chordates2.htm




Early Mammal
squamosal
jaw joint
dentary
Therapsid
squamosal
jaw joints
dentary
Pelycosaur
squamosal
quadrate
jaw joint
articular
angular
dentary


Mammal ear
inner ear
quadrate (incus)
(malleus) articular
stapes
Eustachian tube


Reptile ear
stapes
inner ear
quadrate
articular
Eustachian tube

First Mammals

- Extant mammals characterized by two salient features: hair and mammary glands.
  - Neither of these are directly preserved in fossils
- Traditionally we use the dentary-squamosal joint, derived skull features allowing for enlargment of the brain and inner ear area, and post-canine teeth with divided roots.
- Oldest well-known mammal is *Morganucodon* from the Jurrasic
  - Most early mammals known mainly

  From their teeth thanks to enamel

Early mammal teeth

- Most vertebrates are **polyphyodont** (have multiply replacing sets of teeth), early mammals are **diphyodont** (two sets of teeth)
- Molars with precise occlusion
- Allows for mastication of food for more rapid digestion

Lactation

- Two roles, immune system and nutrition
- What is the advantage?
  - Production of offspring is no longer seasonal
  - Not as dependent on paternal care
  - Young can be born at a relatively undeveloped stage

Suckling

- Unique mammalian character
- Can effectively seal off the functions of breathing and swallowing
- The second seal is lost in adults with shifts in the location of the larynx
- The second seal allows babies to suckle and breathe through the nose simultaneously