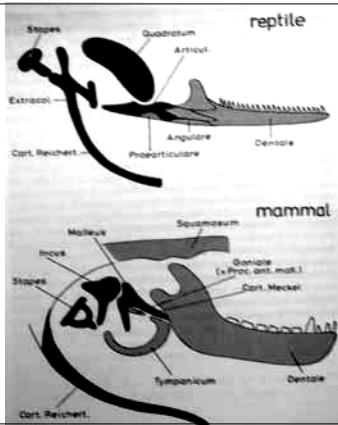




Reptiles	Mammals
More than one bone in mandible; with quadrate-articular articulation of jaw joint	Single bone in mandible; with squamosal-dentary articulation
One occipital condyle	Two occipital condyles
Long bones without epiphyses (indeterminant growth)	Long bones with epiphyses (determinant growth)
Unfused pelvic bones	Fused pelvic bones
Secondary palate usually absent	Secondary palate present
Middle ear with one ossicle (stapes-columella)	Middle ear with three ossicles (malleus, incus, and stapes)
Phalangeal formula 2-3-4 5-3 (4)	Phalangeal formula usually 2-3-3-3-3
Dentition homodont and polyphyodont	Dentition often heterodont and diphyodont
Epidermis with scales	Epidermis with hair
Oviparous or ovoviviparous	Viviparous (except for the monotremes)
Three-chambered heart in most	Four chambered heart with left aortic arch
Ectothermic with low metabolic rate	Endothermic with high metabolic rate
Nonmuscular diaphragm	Muscular diaphragm
No mammary glands	Mammary glands present
Relatively small, simple brain	Relatively large, complex brain

- Primární viscerokranium: mandibulare-quadratum-hyomandibulare (stapes)
- Dermální skelet:
  - Dentale, coronoideum, angulare, suprangular, prearticulare



## Historie Mammalia: Fosilní záznam

- Synapsida - nejstarší Amniota - od středního Karbonu (ca 320 My)
- Cotylosauria vs. Pelycosauria (nejhojnější skupina v permu a triasu)

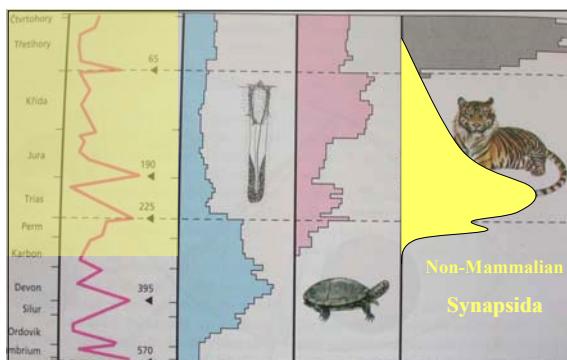
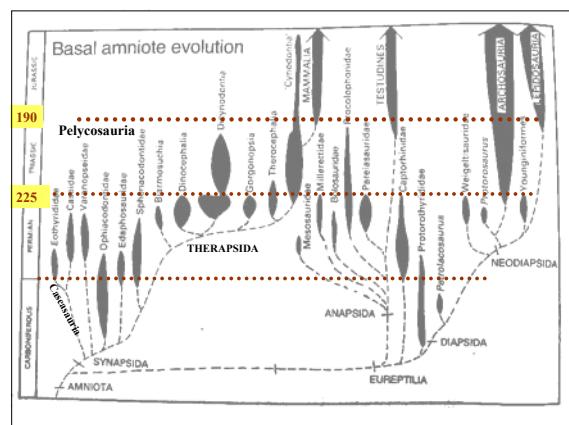
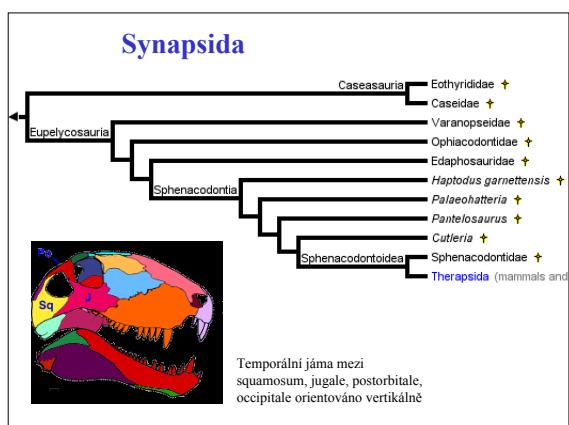
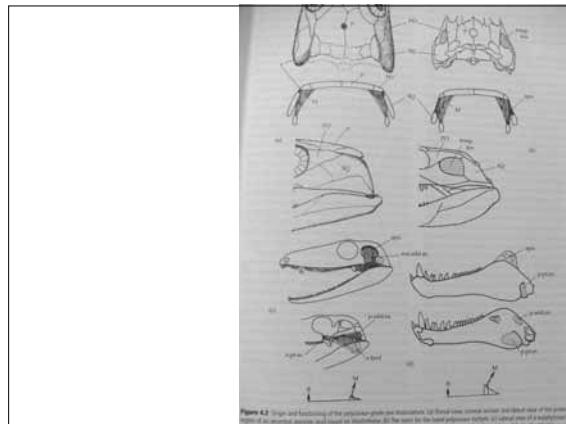
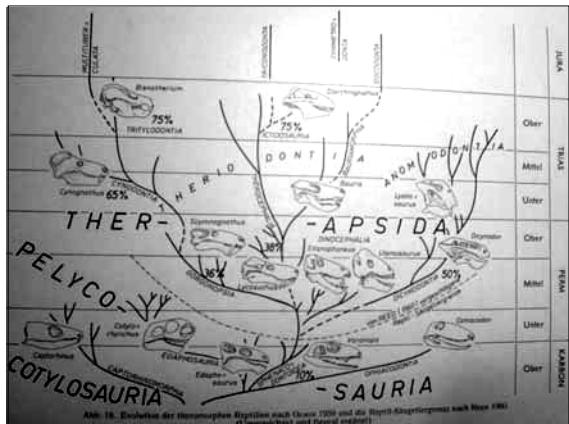


Fig. 9.28 Změny diverzity tří skupin živočichů (savci, plazi, ramenonožci) v geologické minulosti a k různé rychlosti vymírání. Šípky označují hlavní úseky masového vymírání a rozsáhlých přestaveb fauny. Židlo je datováno po milionech let.





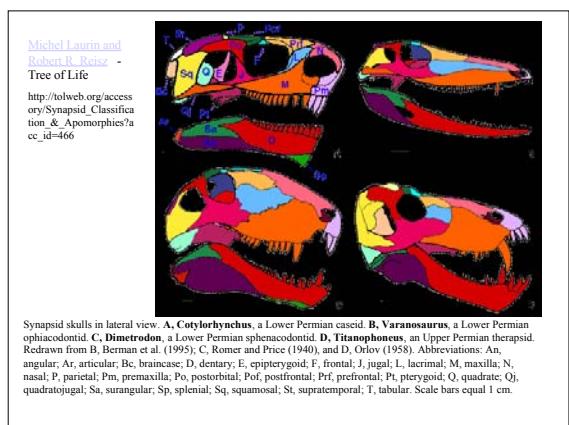
• Marie A. Laurin and Robert R. Reisz The classification of synapsids may be summarized as follows:

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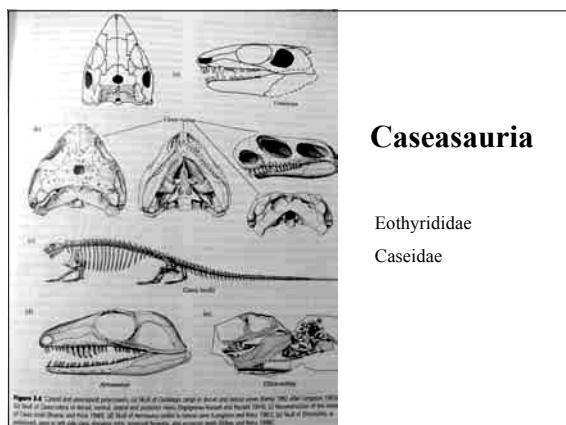
- Eothyrididae ==Casaeosauria ==| |
- Casaeidae ||
- Varanopseidae ||||
- Ophiacodontidae ||||||
- Edaphosaurusidae |||| ==||| |
- Haptodus garnettensis |||| ==Galepodosauria ==| |
- Palaeothyrididae ==| | ==| | ==| |
- Sphenacodontidae ==| | ==| | ==| |
- Cutleria ==| | ==| | ==| | Sphenacodontidae

==Sphenacodontoididae ==Therapsida This classification and the list of apomorphies given below is taken from recent studies by Reisz (1986), Hopson (1991), Reisz et al. (1992), Berman et al. (1995), and Laurin and Reisz (1996), to which the readers should refer for further information.

- **Casaeosauria** (eothyridids and casaeids) exhibits the following autapomorphies:
  - A long external narins with an external narinal shelf (Fig. 1A).
  - A pointed rostrum formed by the dorsal process of the premaxilla (Fig. 1A).



Synapsid skulls in lateral view. *A*, *Cotylorhinus*; *a*, Lower Permian caseid; *B*, *Vassourasaurus*, a Lower Permian aplocephalid; *C*, *Dimetrodon*, a Lower Permian sphenacodontid; *D*, *Thamnopeltis*, an Upper Permian therapsid. Redrawn from B., Berner et al. (1973); C., Romer and Price (1940), and D., Orlov (1958). Abbreviations: An, angular; Ar, articular; Ba, braincase; D, dentary; E, epitygoid; F, frontal; J, jugal; M, maxilla; Mx, maxilla; Nas, nasal; P, parietal; Pr, premaxilla; Po, postorbital; PoF, postfrontal; PrF, prefrontal; Pt, pterygoid; Q, quadrate; Sq, quadratoglossal; Sa, surangular; Sp, splenial; Sq, squamosal; Su, supratemporal; T, tabular. Scale bars equal 1 cm.

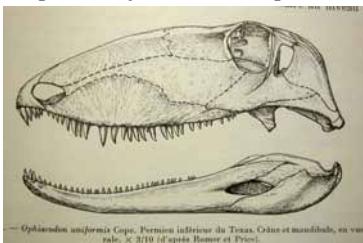


Caseasauria

Eothyrididae  
Caseidae

## Pelycosauria

- **Ophiacodontia** : nejprimitivnější Pelycosauria, 1-2 m, velké rostrum přímá čelist, spánková jáma malá, tropibasická 1.



— *Ophiacodon uniformis* Cope, Permien inférieur du Texas. Crâne et mandibule, en vue ventrale,  $\times 3/10$  (d'après Romer et Price).

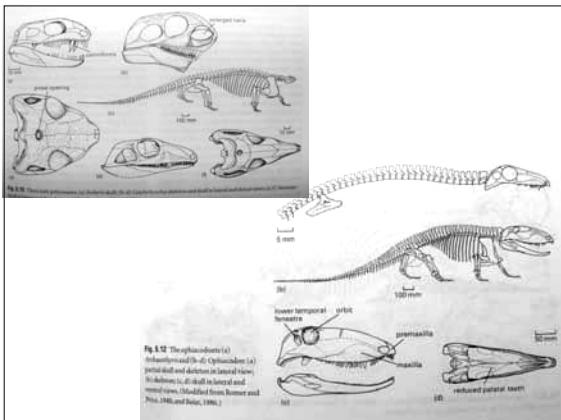


Fig. 32. — *Ophiacodon* (a) Crâne et mandibule; (b) Crâne (c) Vue latérale; (d) vue dorsale; (e) Crâne en vue latérale et ventrale. (Modifié de Romer et Price, 1940, et Baur, 1886.)

## Pelycosauria: Varanopseidae Pe1

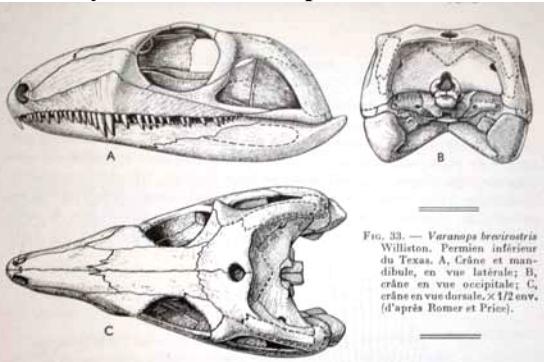


FIG. 33. — *Varanops brevirostris* Williston. Permien inférieur du Texas. A, Crâne et mandibule, en vue latérale; B, crâne en vue occipitale; C, crâne en vue dorsale,  $\times 1/2$  env. (d'après Romer et Price).

## Pelycosauria: Edaphosaura Pe1 (Am,Eu,As) 1-3 m

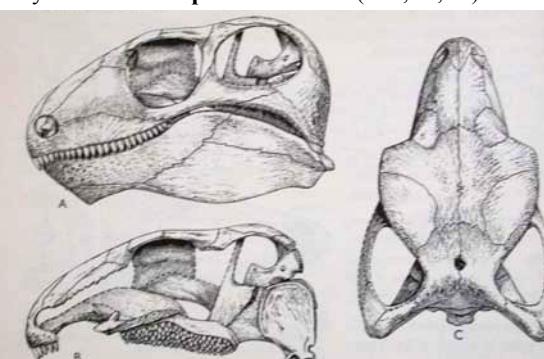


FIG. 34. — *Edaphosaurus pogonias* Cope, Permien inférieur du Texas. A, en vue latérale.

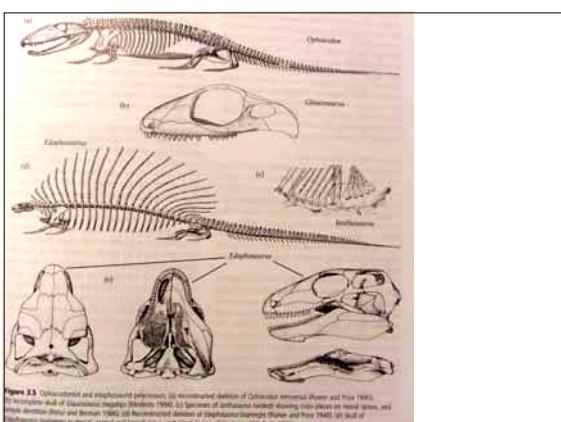


FIG. 35. — Ophiacodontid and sphenacodontid pelycosaures. (i) reconstitué de l'osmose d'*Ophiacodon uniformis* (Romer et Price 1940); (ii) le crâne d'*Glossocephalus macropus* Shadley 1940; (iii) spécimen de *Sphenacodon harrisi* (Shadley 1940) montrant trois placodes au niveau orbital; (iv) *Sphenacodon* (Romer et Price 1940). (ii) Reconstitué d'*Dimetrodon longiceps* (Romer et Price 1940). (iii) Crâne d'*Dimetrodon macrourus* (Shadley 1940) montrant les trois placodes orbitaires, les deux os nasaux et la cavité nasale (Baur 1886).

## Pelycosauria: Sphenocodontia

### Dimetrodon Pe1

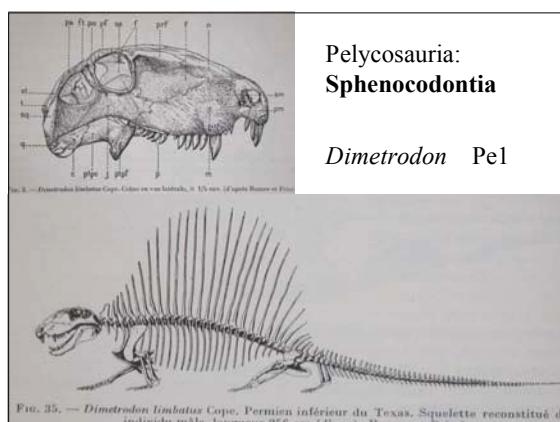
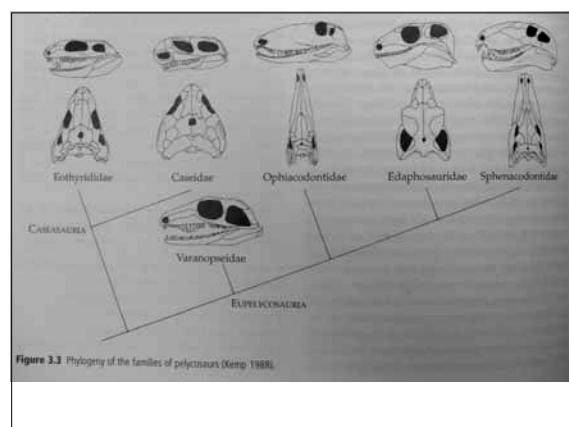
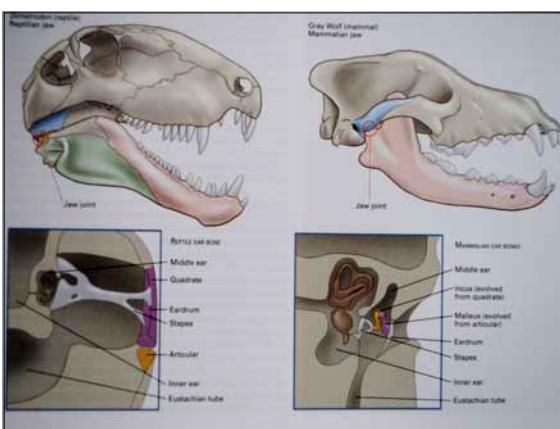
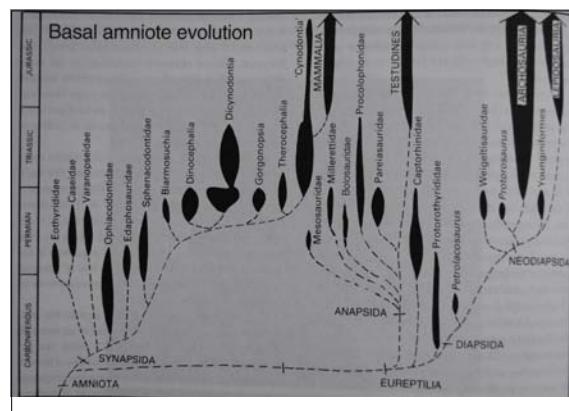
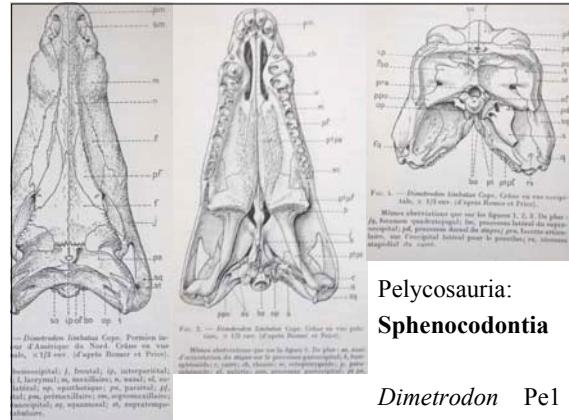
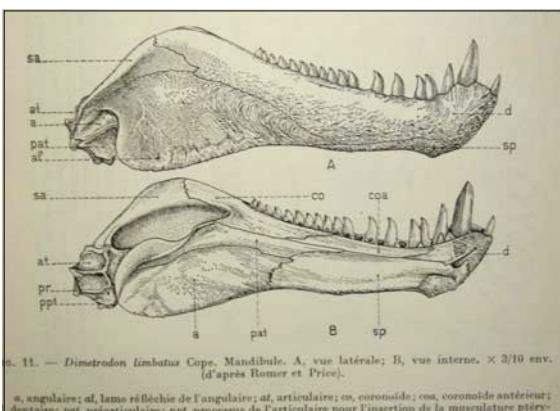
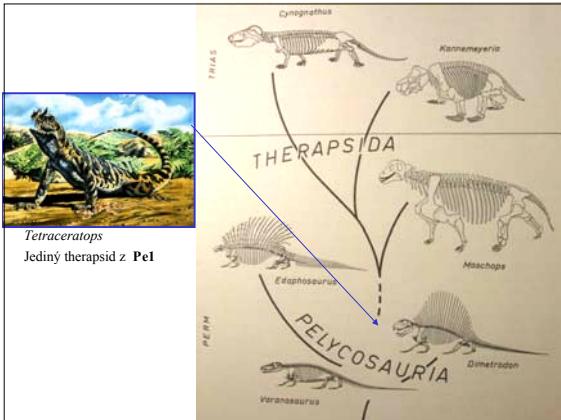


FIG. 35. — *Dimetrodon limbatus* Cope, Permien inférieur du Texas. Squelette reconstitué d'un individu mâle, longueur 256 cm (d'après Romer et Price).





Tetraceratops  
Jediný therapsid z Pe1

## Therapsida

- Extrémně diversifikovaná skupina **Pe2- Tr2**, herbivoři i karnivoři, lebka 3 - 100 cm
- Afrika (Karoo formation), J Rusko, Čína

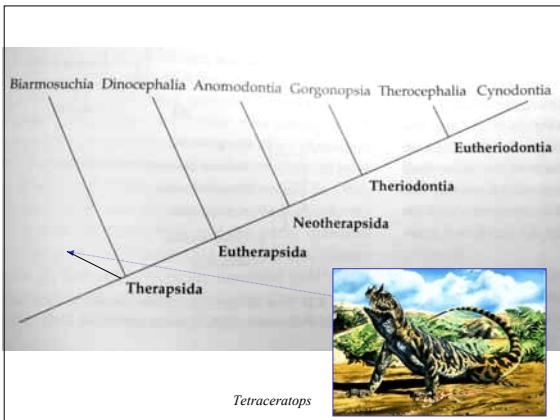
Autapomorphies of **Therapsida** include:

**Interpterygoid vacuity short** (less than 20 percent of the length of the palate, measured from its anterior end to the posterior edge of the transverse flange of the pterygoid).

In therapsids, the **braincase remains firmly sutured to the dermal skull elements**. **No more than twelve upper postcaniniform teeth**. Other synapsids have at least thirteen postcaniniform teeth.

**Exopterygoid teeth absent**. Other synapsids have small teeth (denticles) on the ectopterygoid.

This list of autapomorphies takes into consideration the recent discovery of Tetraceratops, the oldest known therapsid (Laurin and Reisz, 1990, 1996). Tetraceratops lacks many derived characters present in other therapsids. Therefore, this list differs from other published lists of autapomorphies of therapsids (Hopson and Barghusen, 1986; Gauthier et al., 1988; Kemp, 1988; Hopson, 1991).



Biarmosuchia: basální  
Therapsida  
*Proburnetia*

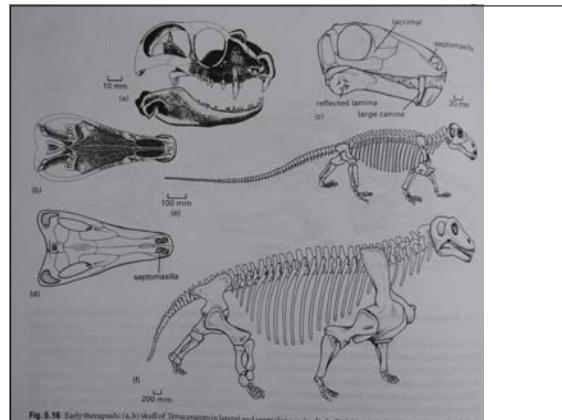


Fig. 5.16 Early therapsids: (a, b) skull of *Tritylodon* in lateral and ventral views; (c, d) skull of *Moschops capensis* in lateral and ventral views.



Biarmosuchia: basální  
Therapsida  
*Proburnetia*

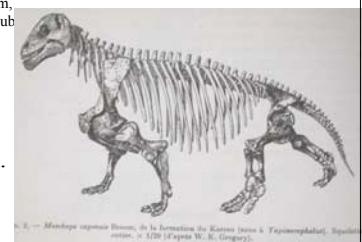
## Therapsida: Dinocephalia

Velká mozkovna (squamosum, masivní artic/sq/quad kloub etc., vzpřímená pozice

Deuterosauridae  
(dravci),

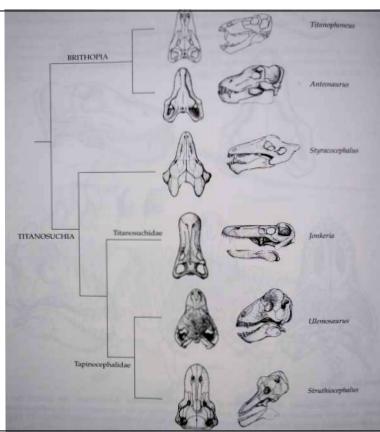
Moschopidae (býl.  
Karoo),

Tapinocephalidae



a, b — *Tritylodon capensis* Blainv., de la formation du Karoo (zone à Tapinocephalus), Septembre 1870 (espèce M. E. Gregory).

- Dinocephalia

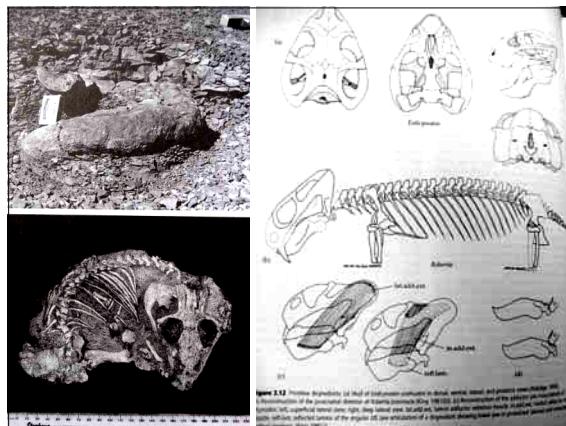
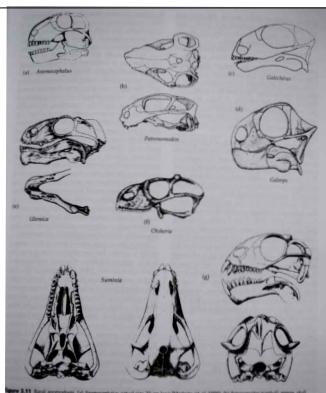


## Therapsida: Titanosuchia

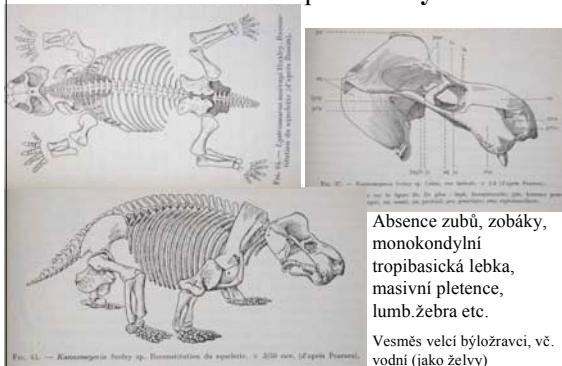
- Značný rozvoj dentale - Heterodontní unicuspitní zuby C
  - Druhotné patro dobře vyvinuto (patr. zuby)
  - Sklerotikální prstenec oka
  - Moderní autopodium (2-3-3-3-3 články)
  - Velcí až 4-5 m

- **Anomodontia**

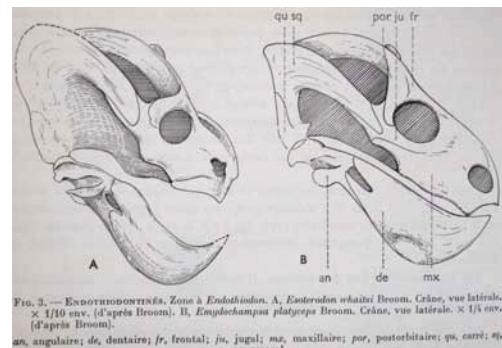
Vysoce specialisovaní býložravci,  
40 rodů - nejúspěšnější therapsidi (zejm. skupina Dicynodontia) -

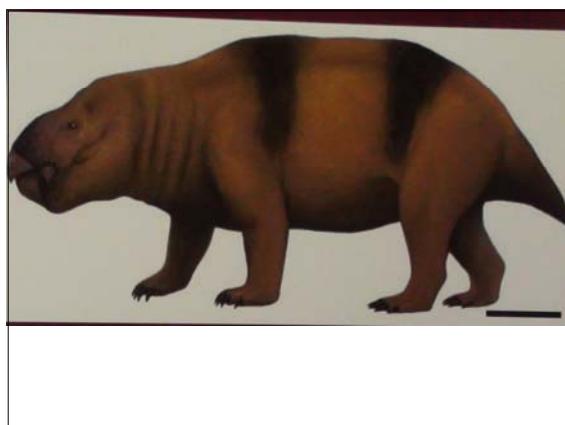
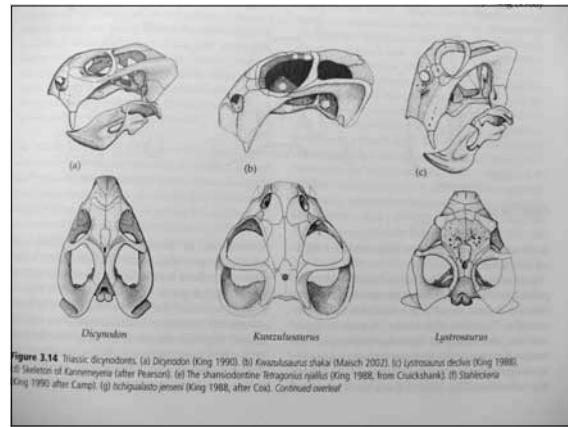
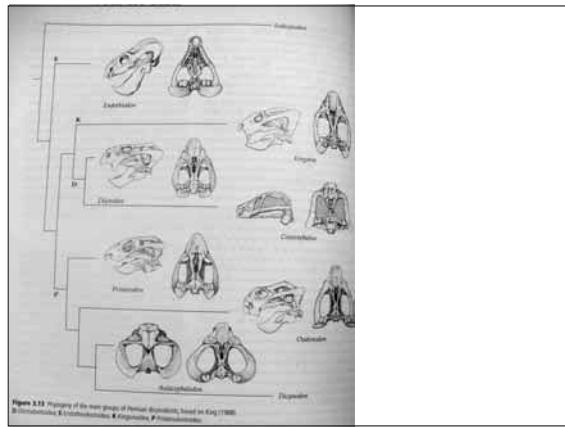


## Therapsida: Dicynodontia



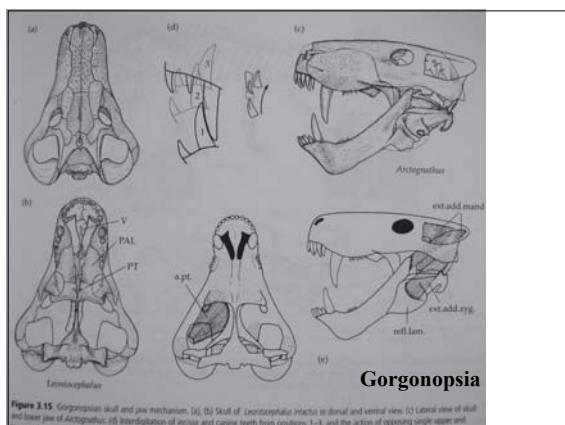
## Therapsida: **Dicynodontia**





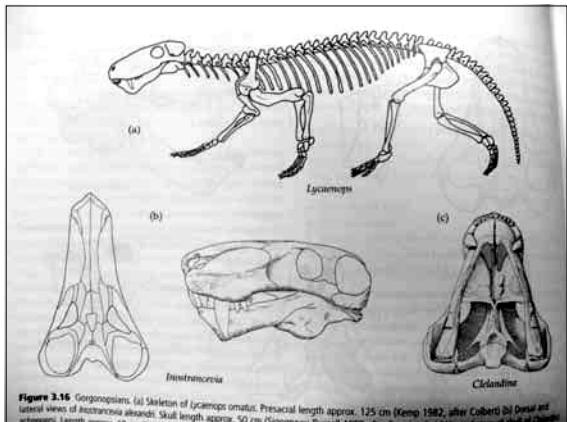
### Therapsida: Theriodontia

- Gorgonopsia
- Therocephalia
- Cynodontia:
  - Cynognathidae, Diademodontoidea, *Probaenognathus*, Triphodontia, Tritlodontia, Mammala

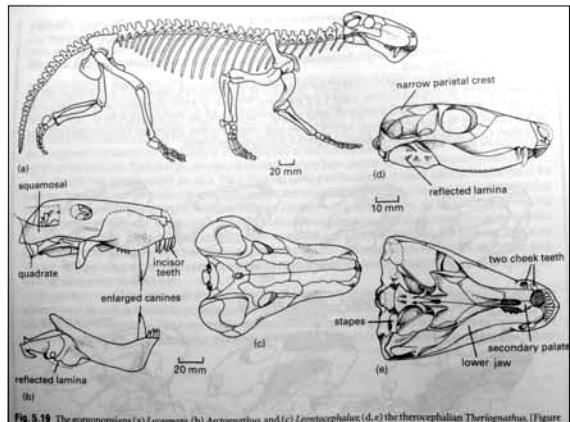


### Therapsida: Theriodonta - Gorgonopsia

- Vysoké končetiny
- Caninisovaná dentice (u některých extrémně vč. redukce postcaninů - *Smilesaurus*, *Scymnognathus*), vysoké rostrum, prostorná nosní dutina
- Pohybově aktivní dravci - cf. psi, Ca 1-2 m ,



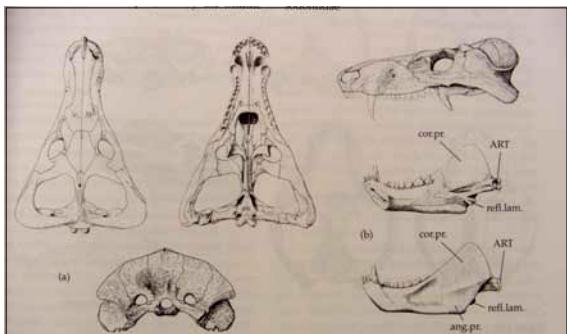
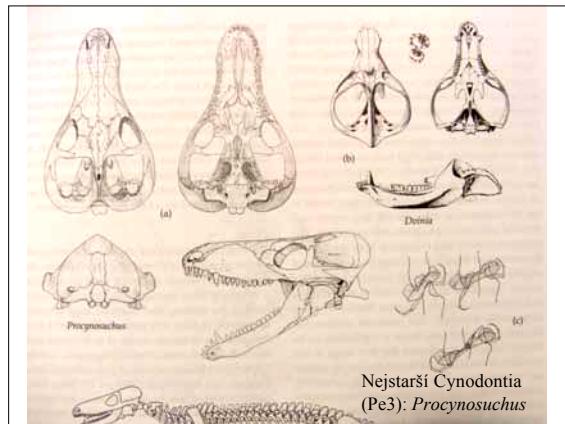
**Figure 3.16** Gorgonopsians. (a) Skeleton of *Gorgonops omatus*. Presacral length approx. 125 cm (Kemp 1982, after Colbert) (b) Dorsal and lateral views of *Anomiaurus alexandri*. Skull length approx. 50 cm (Kemp 1982).



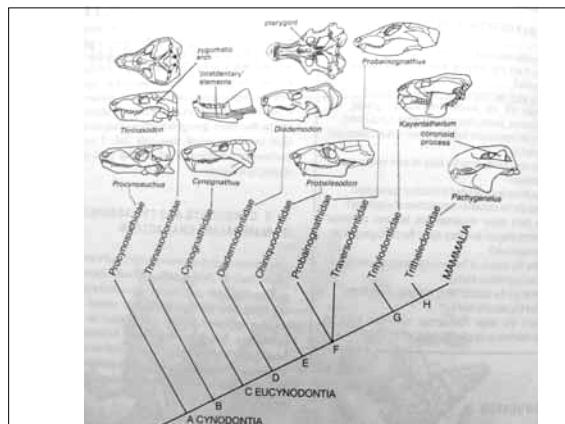
**Fig. 5.19** The gorgonopians (a) *Lycaenops*, (b) *Arctognathus*, and (c) *Leptolemus*; (d, e) the theropeltidian *Theriognathus*. [Figure]

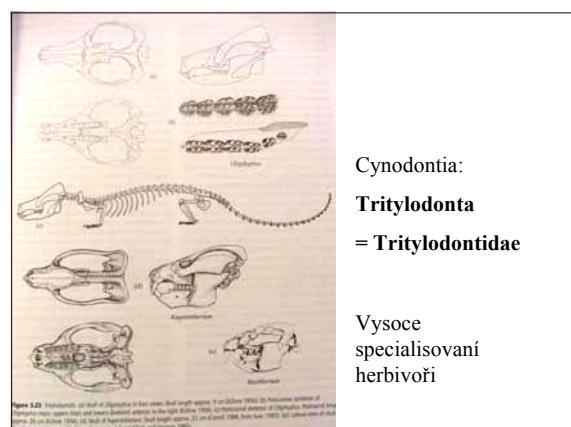
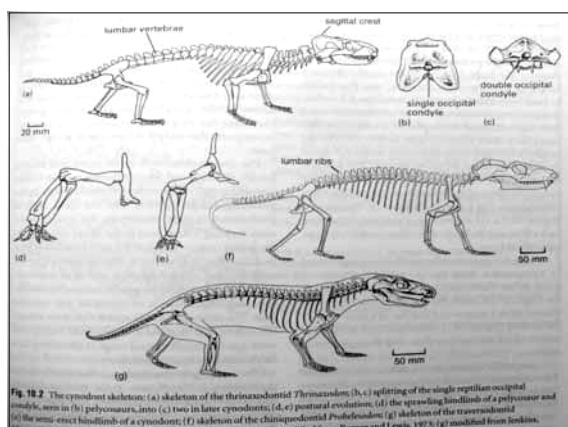
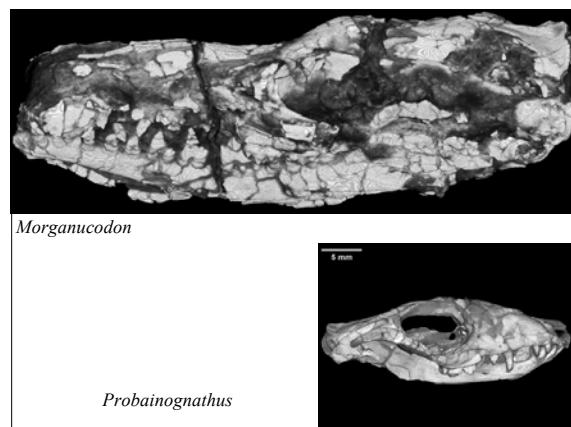
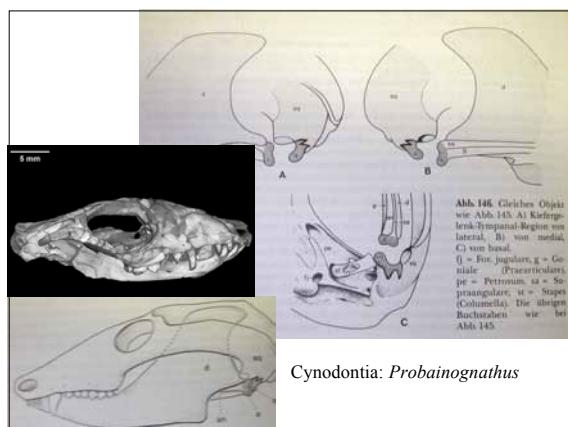
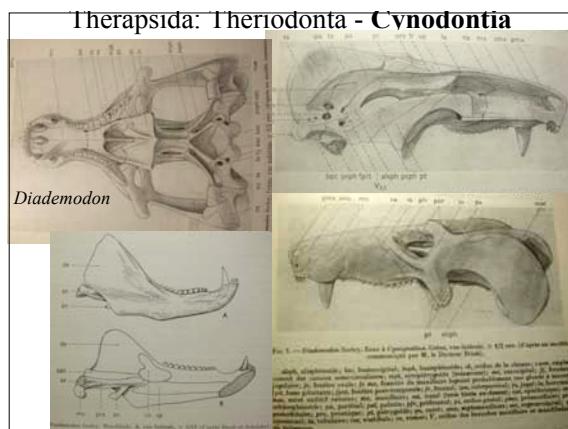
## Therapsida: Theriodonta - **Cynodontia**

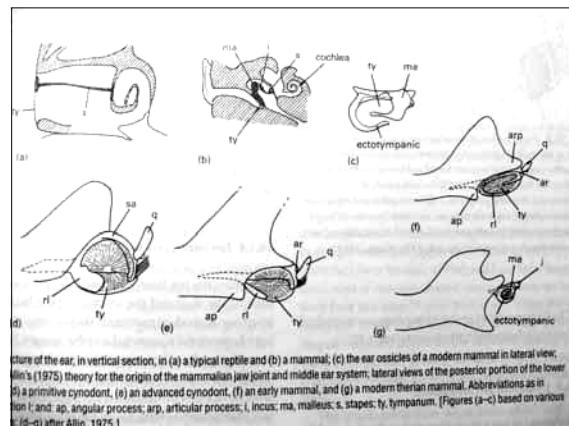
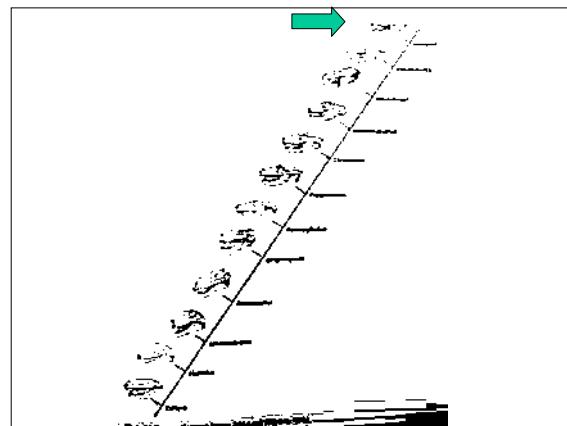
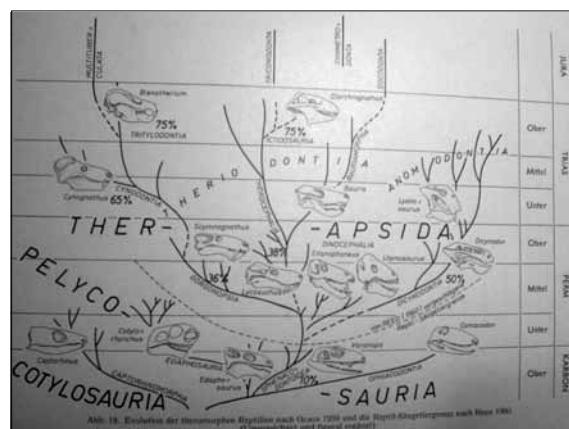
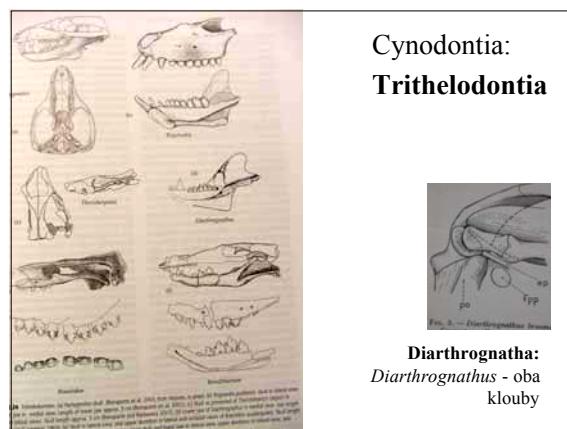
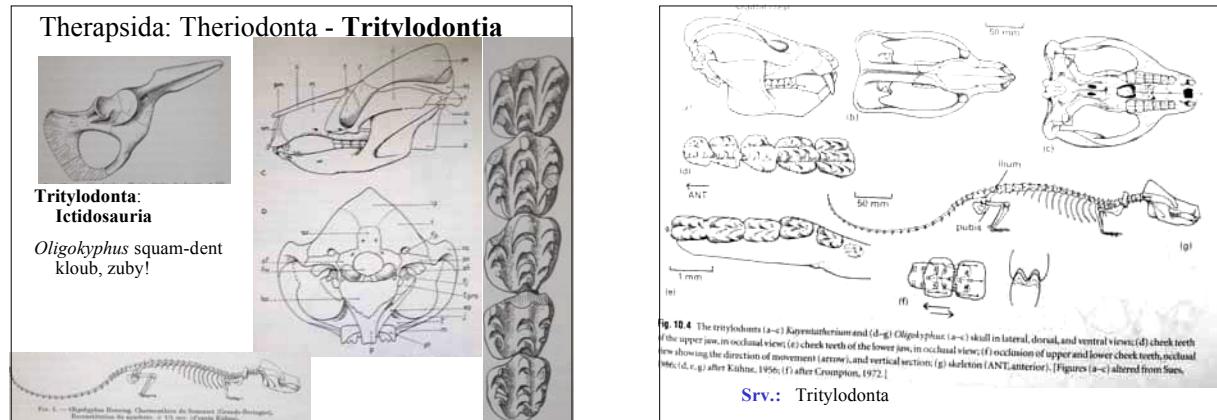
- Drobní, výrazně heterodontní dentice, I, C, dominují postcaniny - vícehroté, dokonalé druh.patro, uzavřená štěrbina, for. incisivum prox.,
  - Terminální posice nozder
  - Efektivní čelistní kloub - válcovité quadratum, masivní osvalení,
  - Značný rozvoj dentale - proc.coronoideus,
  - Redukce lumb. žeber (?životrodost)

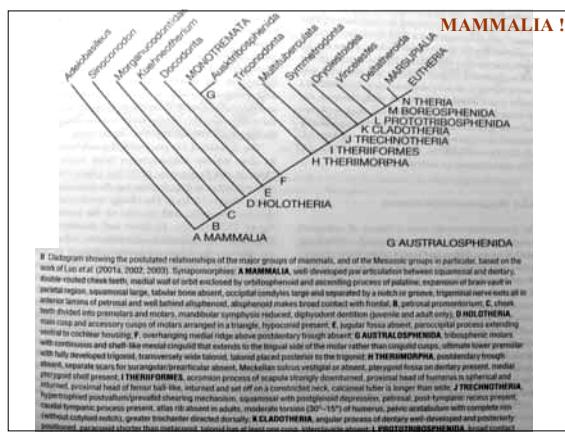
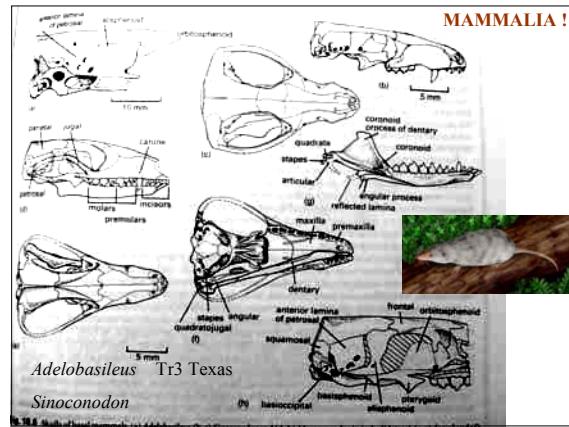
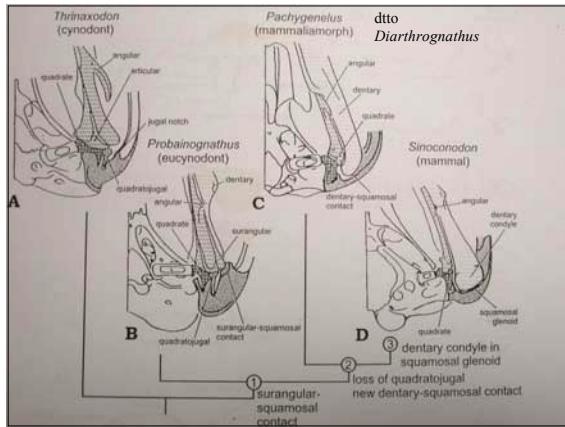


**Figure 3.21** (left) (a) skull of *Cynognathus* in four views. Approx. skull length: 29 cm (Broili and Schröder 1934). (b) Medial and lateral views of lower jaw (Kermack et al. 1973). (right) Probainognathus cynodont. skull of *Lunukia fuscus* in four views. Skull length approx. 6 cm (Hislop and Kitching 2001). (c) skull of *Probainognathus jenisi* in four views (Carroll 1988; from Romer 1970). (d) Chiniquodon (Probainognathus) skull length approx. 11 cm (Romer 1961). (e) Lateral view of skull of *Eretosternon lunatum*. Skull length approx. 12.5 cm (Martinez et al. 1996). ART, articular; ang, angular process; cor, coronoid process; reflam, reflected lamina of the angular. Continued overleaf.



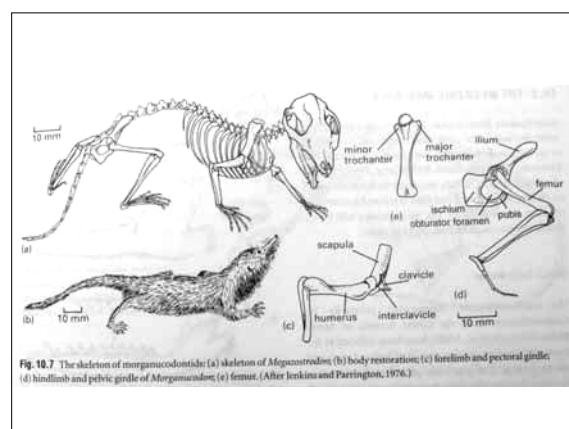


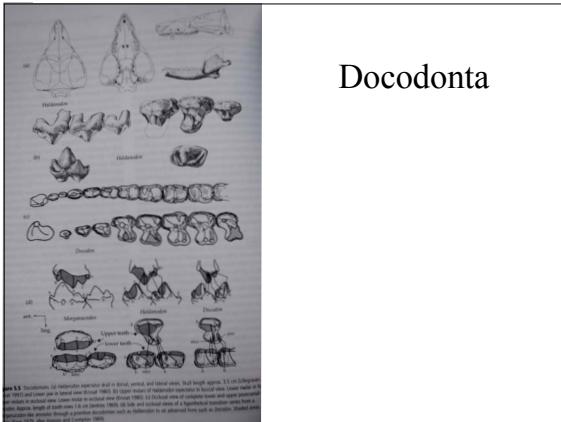




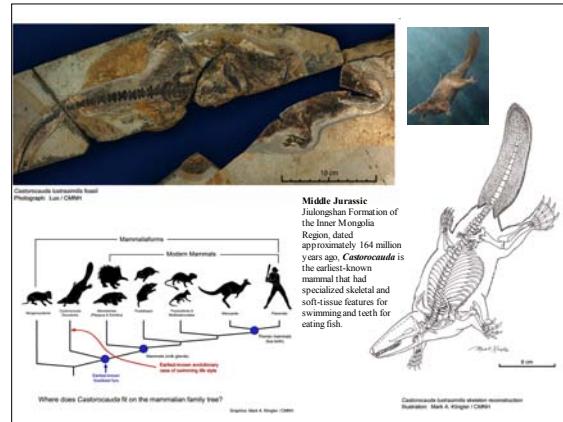
## Docodonta / Morganucodonta:

- *Morganucodon watsoni* Tr3 Rhaet (lom Duchy, GB)
  - drobný
  - Postcaniny s 3 seriálními hrotý
  - 5I, 5 molariformů, premoláry
  - Mandibulární zářez s foramen mandibulae (chrupavčité articulare)
  - Končetiny savčí, pletence pokročilé



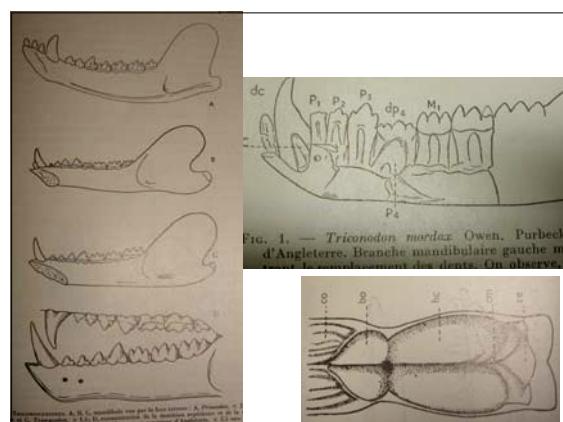
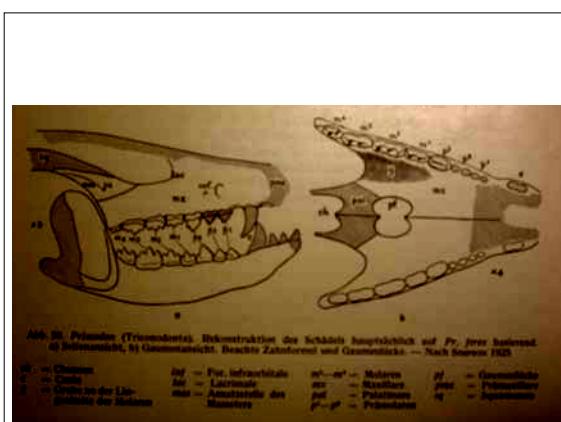
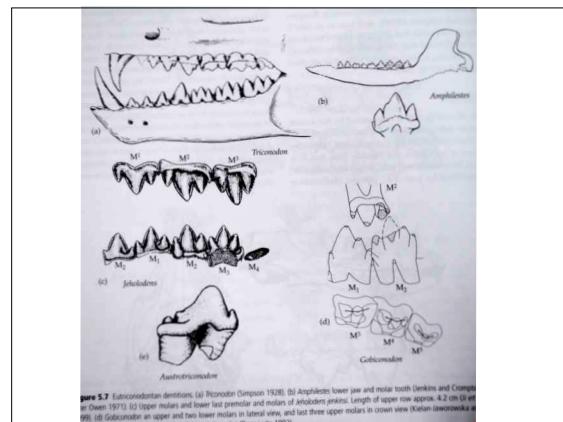


## Docodonta



## Triconodonta (Jura)

- Heterodontní chrup: trituberkulární postcaniny, velký P4/4, : střížný efekt (alterace max/md. cuspů)
- fosa temporalis na ramus mand.,
- Mastikace moderní: m.temporalis, m.masseter, m.pterygoideus
- Vnitřní mandibuální zářez jen nepatrny
- Etmoturbinalia, cribiformní destička



## Pantotheria:

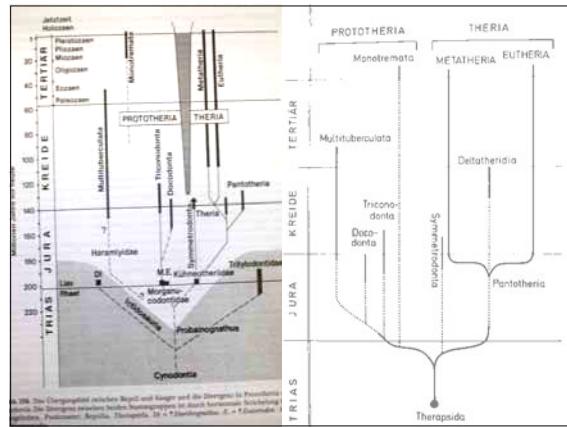
**Symmetrodonta** (např. Amphidontidae, Spalacotheriidae)

**Eupantotheria:** Amphitheriidae, Dryolestidae, Aegialodontidae etc.

- savci s triangulárním uspořádáním cuspů na postecaninech,

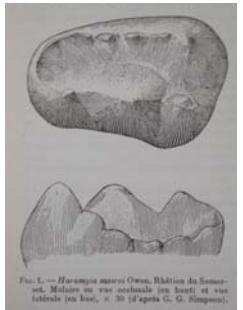


- První již s *Morganucodonem* Jura 1: **Kuehnotheriidae** (Symmetrodonta s.str. nebo předkovská skupina Pantotheria, sesterská Morganucodon?)



## Haramyidae - Jura 1

- Vícehrbolkaté stoličky s centrální fossou - pouze isol. zuby

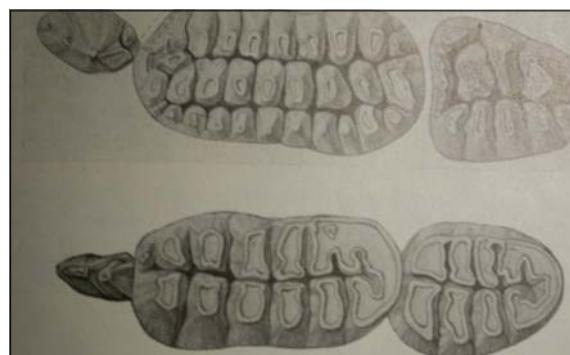
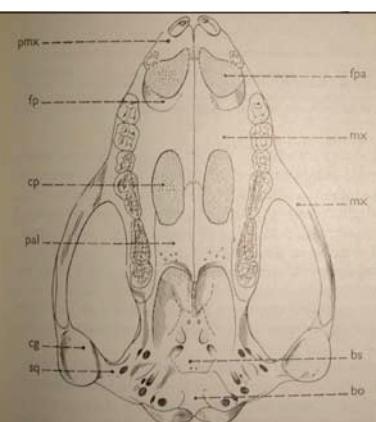


Haramyidae=Microlestidae  
=Microleptidae (G, CH, GB)

## Multituberculata

- Vysoce specializovaná dentice a čelistní aparát:
- Veliké premaxily s 1-3 I (I2/ největší), diastema
- Multituberkulátní zuby (6-3/5-3)
- Chybí septomaxila
- Distální extenze maxil, palatinum vytěsněno do středu patra, nevstupuje do orbity
- Převaha plasiomorfí (Mammalia i Pelycosauria) např. tyčkovitá cochlea, ?absence vnějšího zvukovodu, ale
- 3 ušní kůstky

### Ptilodus



*Tæniolabis taeniensis* Cope. Niveaux supérieurs du Puerco, New Mexico supérieures gauches (en haut) et inférieures droites (en bas).  $\times 2$  (d'après G. G. Simpson).

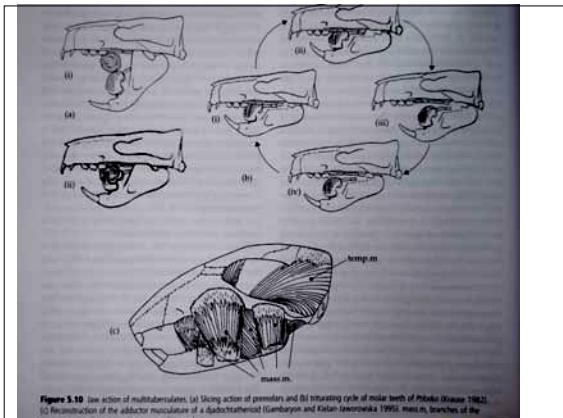
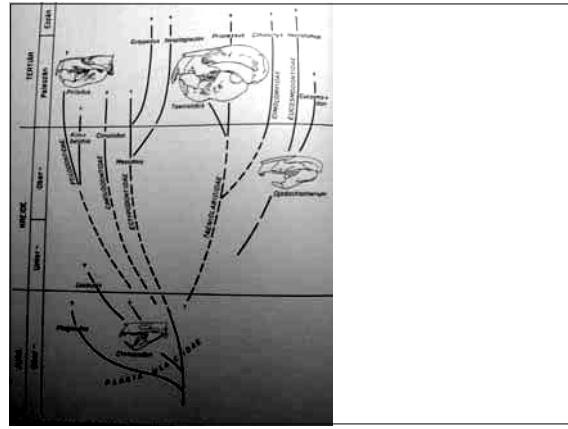
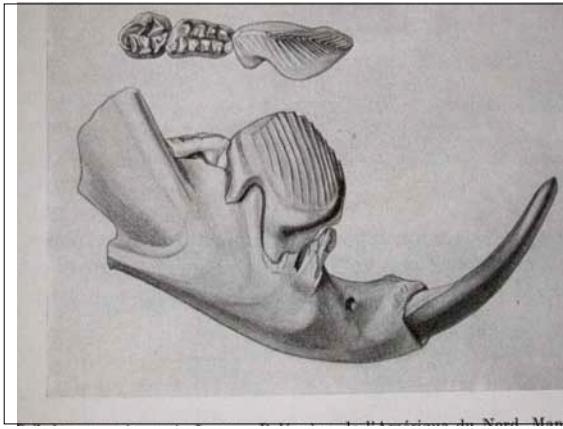
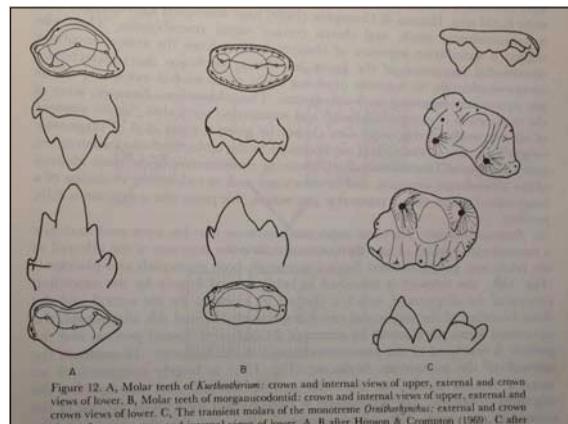
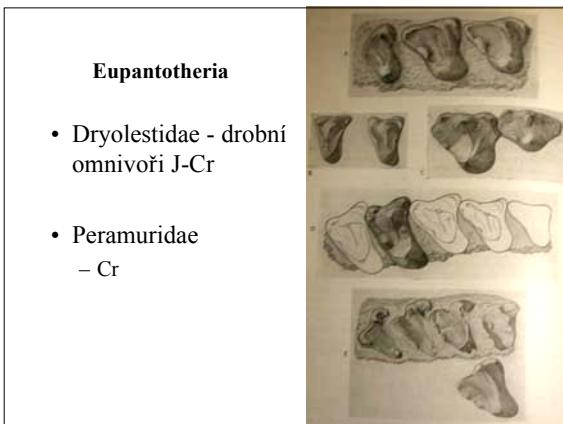
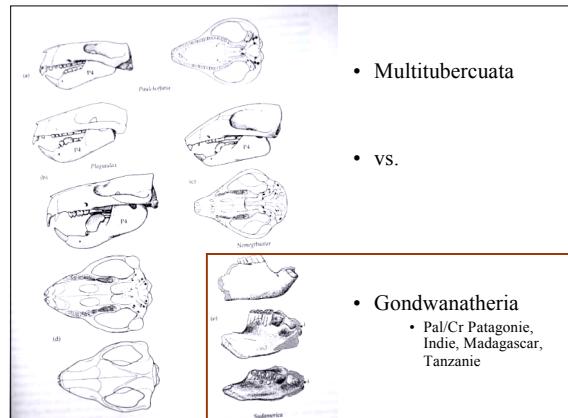


Figure 5.10 (a) Slicing action of premolars; (b) mastication cycle of molar teeth of *Pithecius* (Krause 1982). (c) Reconstruction of the adductor musculature of a diprotodontid (Gambaryan and Kutan-Tsvetkova 1995). mass.m., branches of the masseter musculature; temp.m., temporalis muscle.



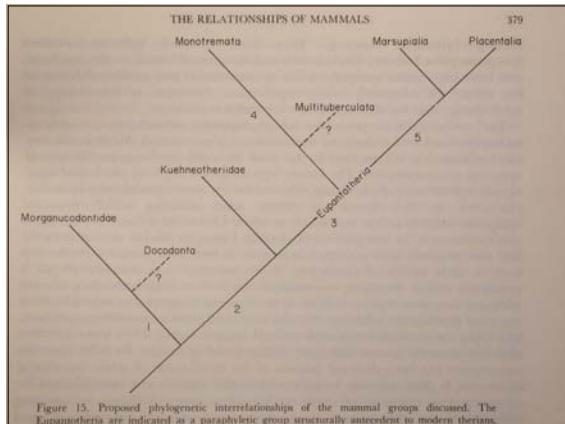
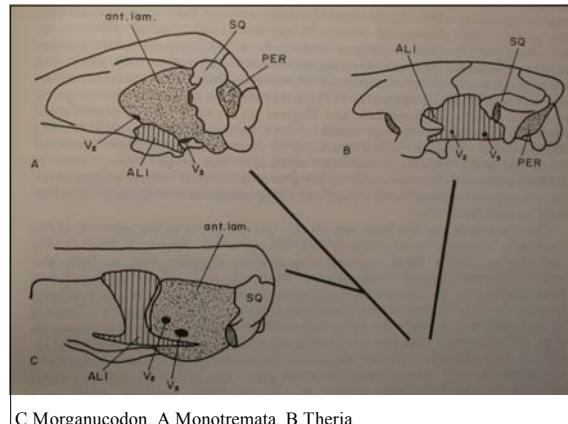
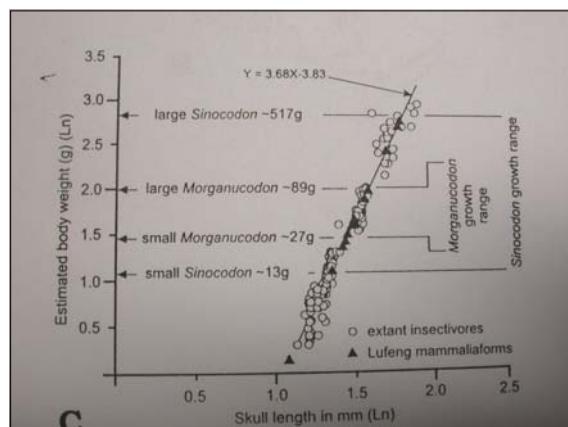
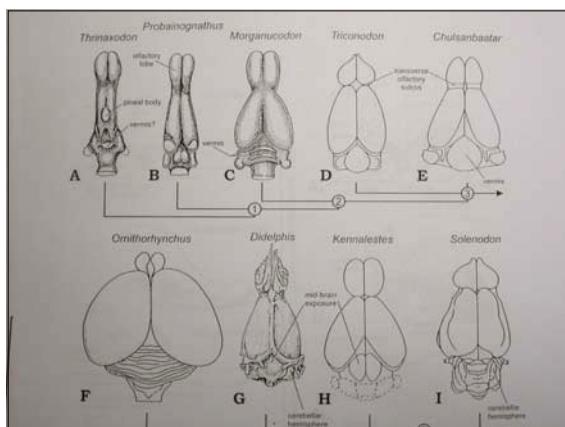
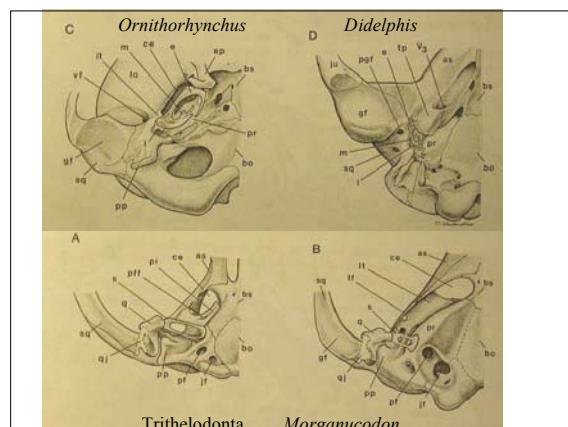
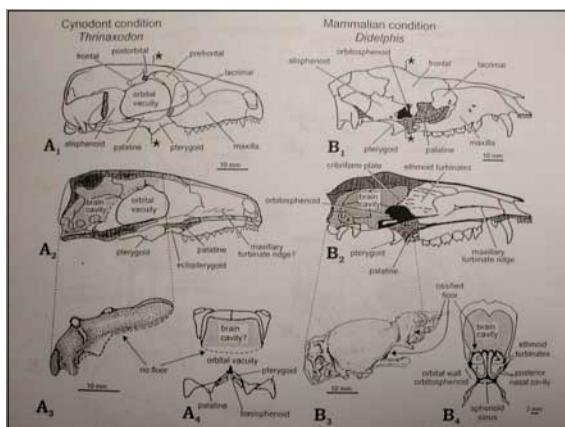
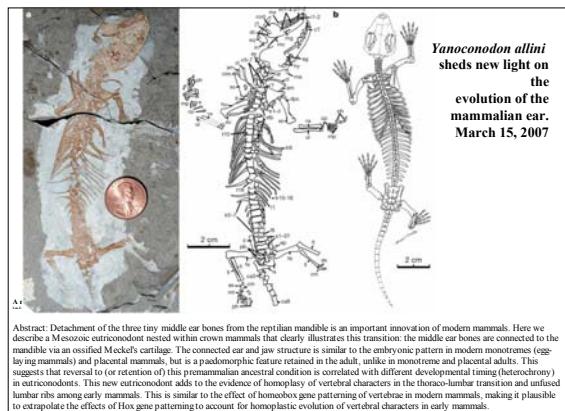
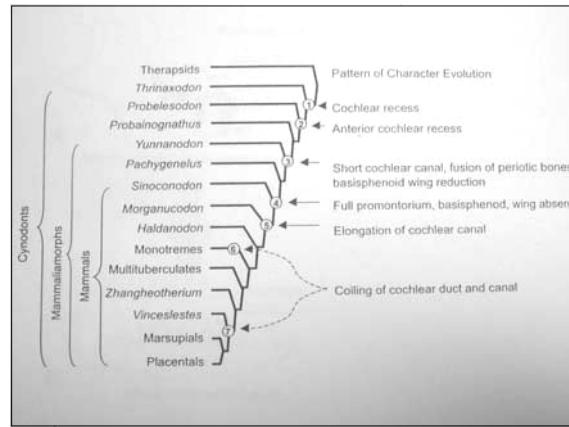
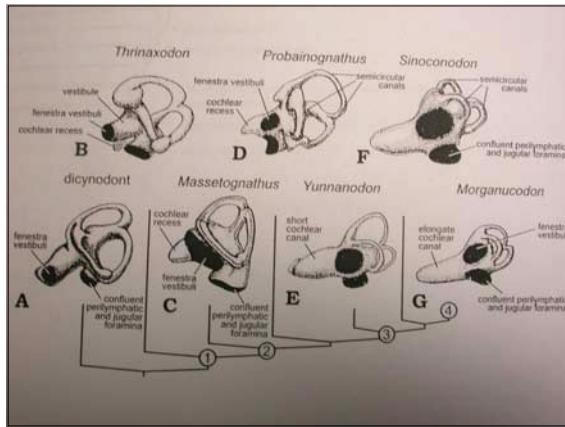


Figure 15. Proposed phylogenetic interrelationships of the mammal groups discussed. The Eupantheria are indicated as a paraphyletic group structurally antecedent to modern therians.

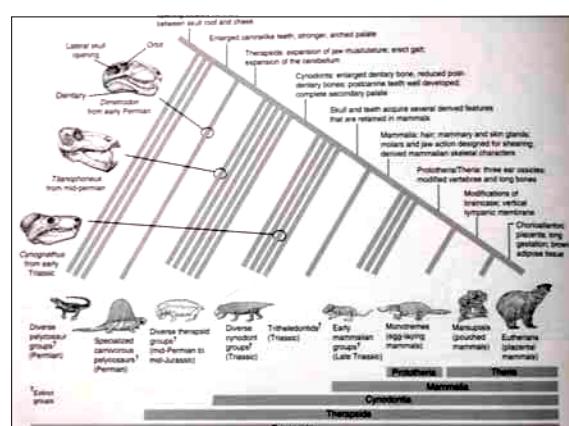
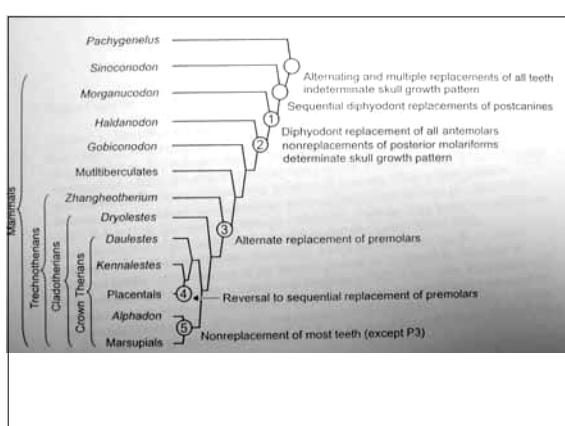
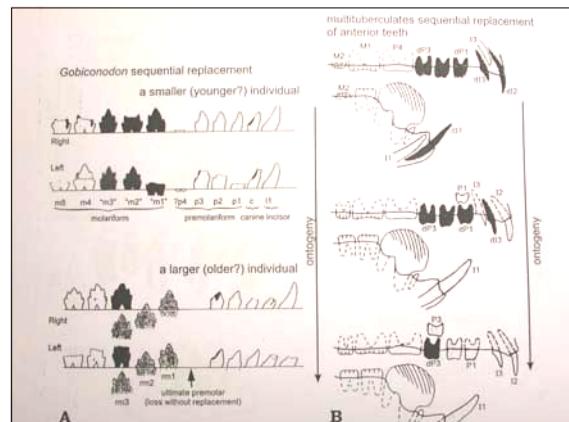


C Morganucodon, A Monotremata, B Theria



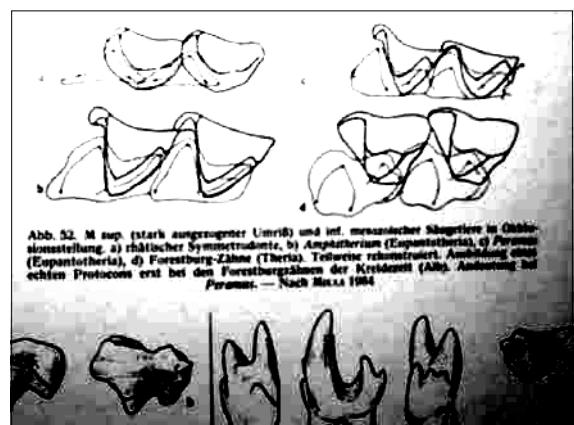
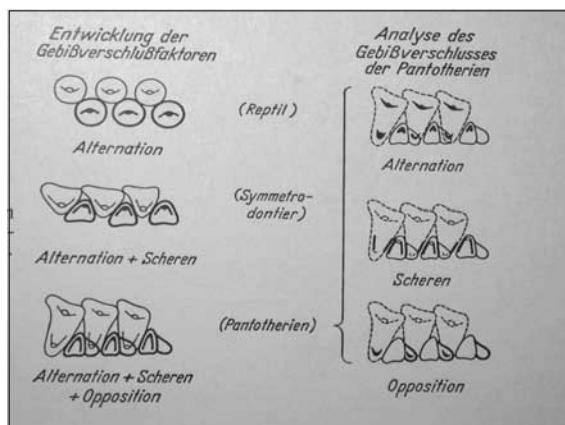
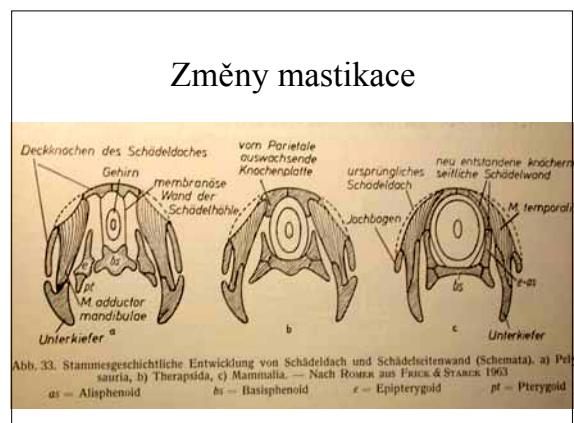
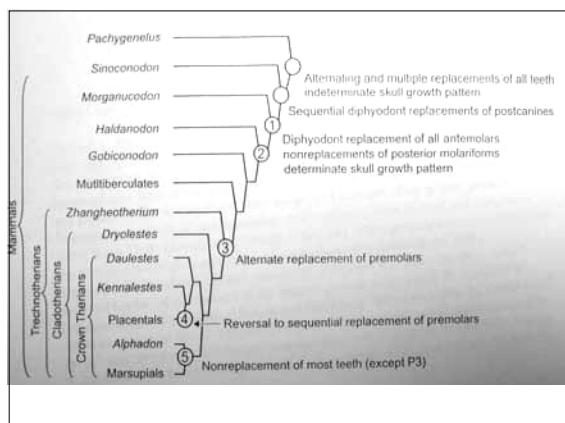
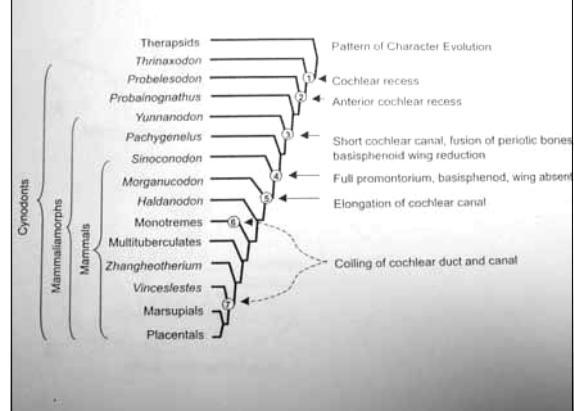


**Abstract:** Detachment of the three tiny middle ear bones from the reptilian mandible is an important innovation of modern mammals. Here we describe a Mesozoic eutrichodont nested within crown mammals that clearly illustrates this transition: the middle ear bones are connected to the mandible via an ossified Meckel's cartilage. The connected ear and jaw system is similar to the middle ear patterns in many nonmammals (e.g., living moles and shrews). Yanoconodon is a pachygenelid feeding retains the adult skull in immature and phasmat adult. This suggests that retention (or reversion of) this nonmammalian ancestral condition is correlated with different developmental timing (heterochrony) in eutrichodonts. This new eutrichodont adds to the evidence of homoplasies of vertebral characters in the thoraco-lumbar transition and unfused lumbar ribs among early mammals. This is similar to the effect of homeobox gene patterning of vertebrae in modern mammals, making it plausible to extrapolate the effects of Hox gene patterning to account for homoplastic evolution of vertebral characters in early mammals.



## Závěr

- Jednotlivé savčí znaky se objevují ve fylogenesi nezávisle
- Typická je mozaika odvozeného stavu některých znaků a ancestrálního stavu u znaků jiných
- Srv. Prototheria



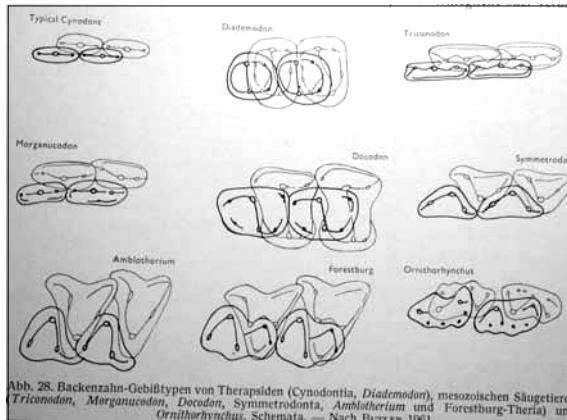


Abb. 28. Backenzahn-Gebißtypen von Therapsiden (Cynodontia, Diadectodon), mesozoischen Säugetieren (Tritylodon, Morganucodon, Docodon, Symmetrodonta, Amblotherium und Forelsburg-Theria) und Ornithorhynchus. Schemata. — Nach BUTLER 1961.

## Cope-Osborn

tuberculosectoriální + trituberkulátní

= tribosfénický molár  
Simpson (1936)

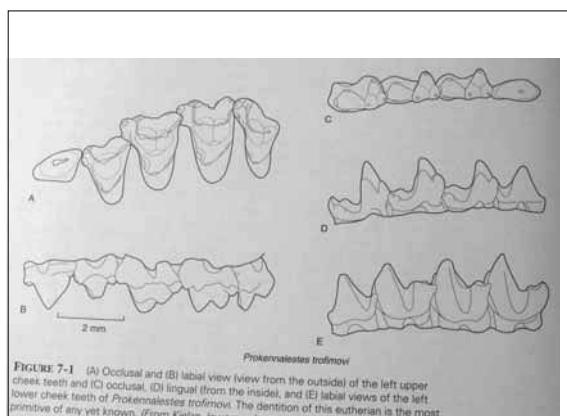
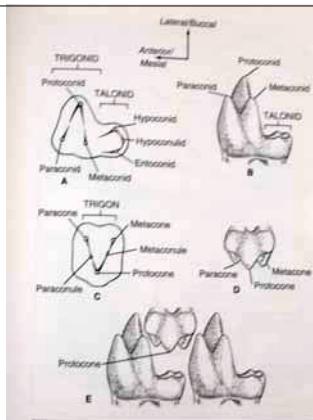
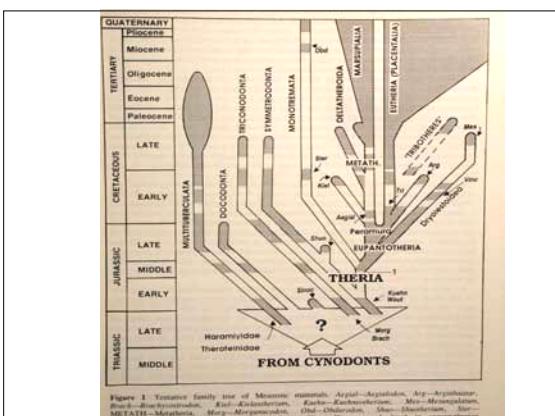


FIGURE 7-1 (A) Occlusal and (B) labial view (view from the outside) of the left upper cheek teeth and (C) occlusal, (D) lingual (from the inside), and (E) labial views of the left lower cheek teeth of *Prokennalestes trofimovi*. The dentition of this eutherian is the most primitive of any yet known. (From Kielan-Jaworowska and Dashzeveg, 1989)



## Klasický obraz časné evoluce savců: e.g. Crompton 1971

- Tr3/Jura1: Non-mammalian Pantotheria (*Morganucodon*) vs.
- Direct mammalian ancestors: *Kuehneotherium*
- Jura 3: pretribosphenic *Peramus*
- Cr 1: tribosphenic *Aegialodon*
- Masivní žebra a obratle - savčí pohyb. modus
- Cr 2/3: nejstarší doklady Theria s.str.: *Deltatheridium*, *Holoclemensia*, *Prokennalestes*
- **souběžně**: Multituberculata a Monotremata
- Takřka všechny doklady ze severních kontinentů: **evoluce savců na severu**

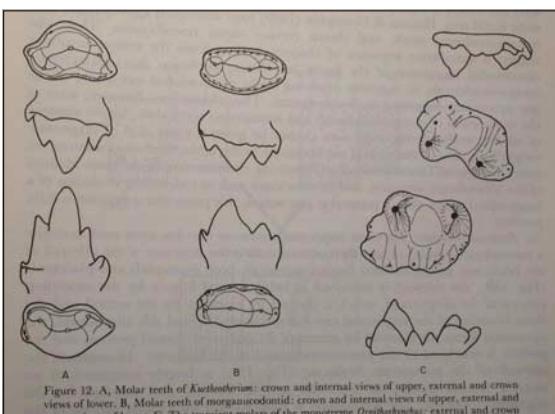
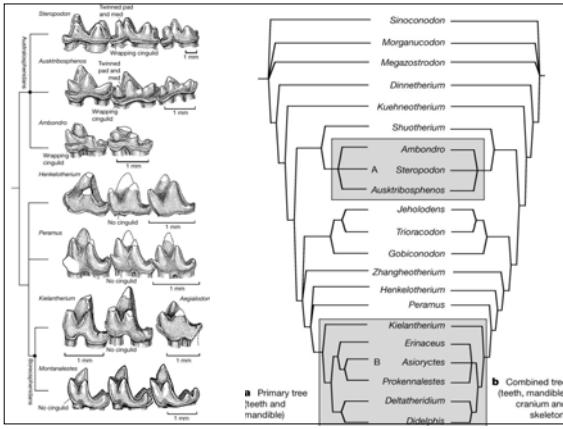


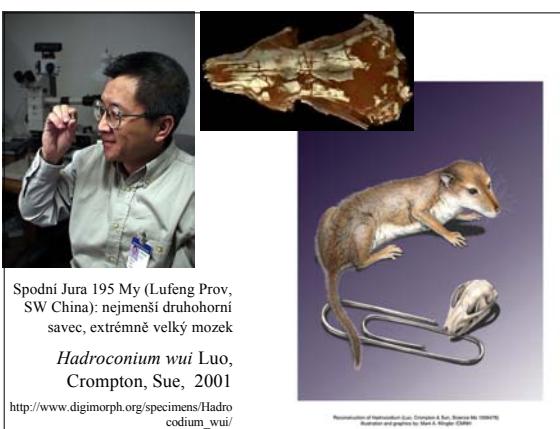
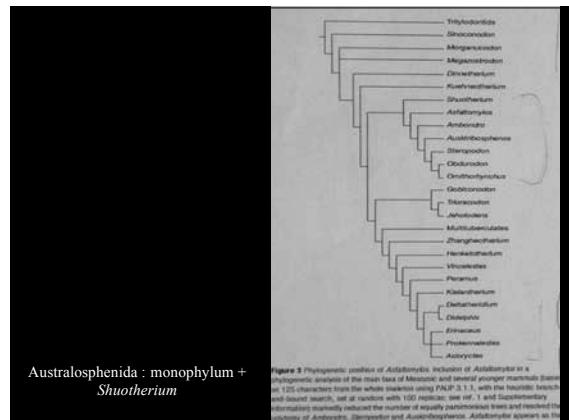
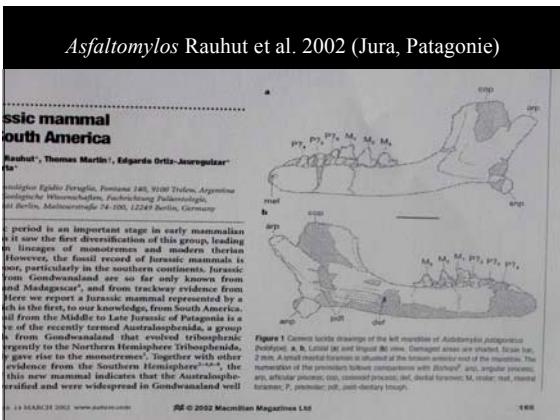
Figure 12. A, Molar teeth of *Kuehneotherium*: crown and internal views of upper, external and crown views of lower. B, Molar teeth of morganucodontid: crown and internal views of upper, external and crown views of lower. C, The transient molars of the monotreme *Ornithorhynchus*: external and crown views of upper, external and internal views of lower. A, B after Huxley & Crompton (1969). C after





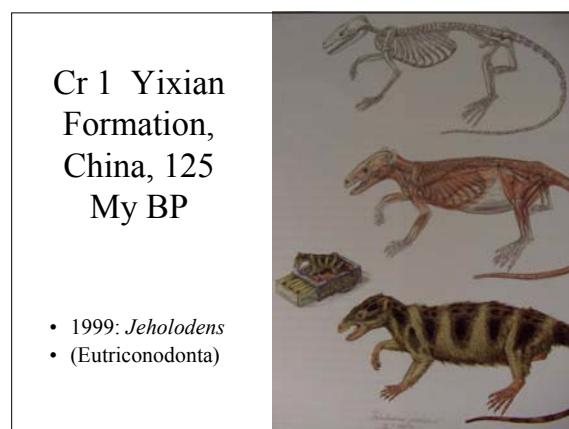
### Luo, Cifelli et Kielan-Jaworowska 2001: Dual origin of tribosphenic mammals

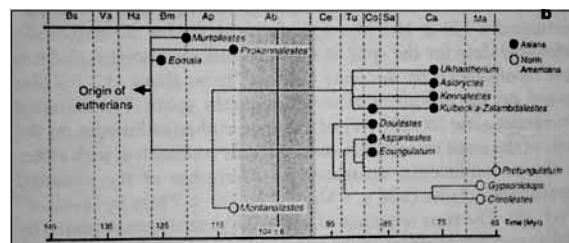
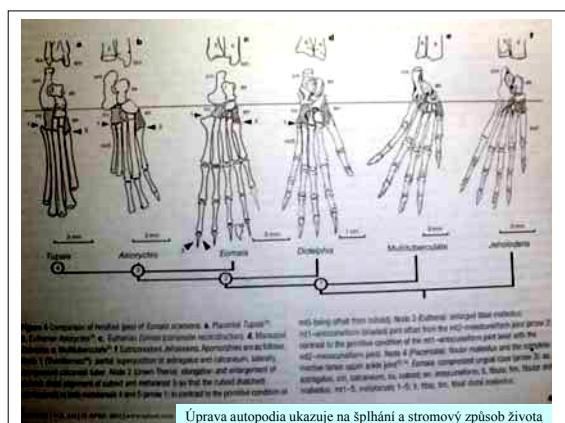
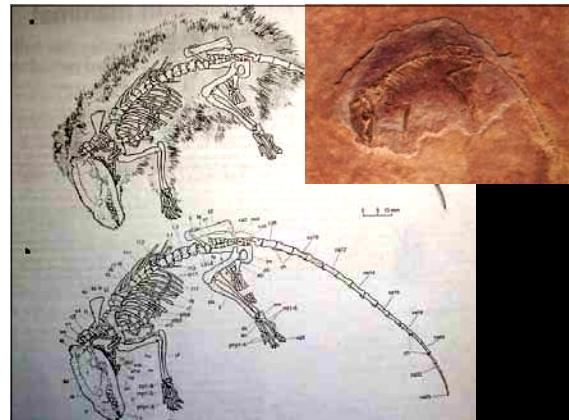
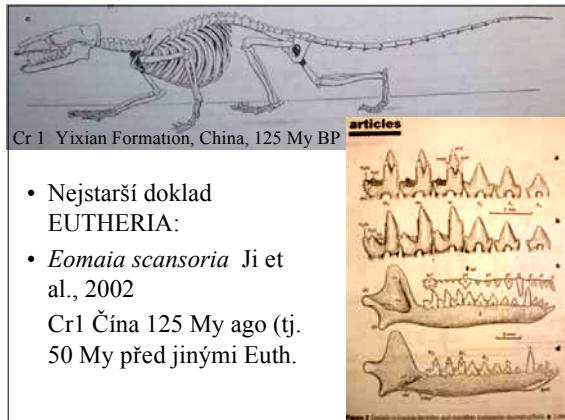
- Australosphenida:** Monotremata (incl. *Steropodon*), *Ausktribosphenida*, *Ambodro* - *apomorfie*: spojity cingulární záhyb na linguální straně spodních stoliček, poslední premolár s trigonidem (tj. 5 M!?) - ditto u *Obdurodon*, *plesiomorf*: postdentální zářez (u *Ausktribosphenos*)
- Boreosphenida** (incl. *Tribosphenida* McKenna, 1975): nemají mesiální ani linguální cingulum na M/x, ale cingulární cuspidy, etc. *Biogogr.*: CrI-N-hem., Cr3-migrace do S Am, Indie a Af



### Cr 1 Yixian Formation, China, 125 My BP

- 1999: *Jeholodens*  
• (Eutriconodonta)





**Figure 6** Phylogeny of eutherian *Eomaia scansoria* (a) and timing of the earliest evolution of eutherians (b). The phylogeny of mammals is based on a strict consensus of 50 equal parsimonious trees (tree length = 919, consistency index = 0.508, retention index = 0.740) from a PAUP analysis (version 4.0b, 1,000 runs of heuristic search, with unorderd multistate characters) of 268 dental and skeletal characters that can be scored for the comparative taxa (the topology from searches with some ordered multistate characters is presented in Supplementary Information). The minimal age of *Eomaia* is at

