



# Obecná a srovnávací odontologie

VI

# Gnathologie a biomechanické souvislosti dentálních adaptací (savců)

- kinetika čelistního aparátu
- strukturní design
- funkční koreláty

# Připojení čelistí k mozkovně

- **Primární autostylie** (jen palatoquadratum),  
rec. chiméry
- **Amfistylie** (palatoquadratum + hyomadibulare)
- **Hyostylie** (hyomadibulare)
- **Sekundární autostylie** (jen palatoquadratum,  
hyomandibulare = collumela auris)
- **Osteognathostomata:** čelistní kloub zůstává,  
avšak centrální role dermálních kostí -

# Placodermi

- Dominantní skupina v devonu, masivní endoskelet, kostěný pancíř, hlavové desky, čelisti – endoskelet (svaly zevnitř), bez zubů, bentičtí, litorální, Placodermi je parafylum

# \* Vesloploutví – **Antiarchi**

# Drobní, veslovité prsní ploutve – archipterygia

**\*Kloubnatci –  
Arthrodira  
(=kloubo-krk)**

# Velká hlava-kloub-prsní pncíř, sex-dimorf., vztahy k chimérám

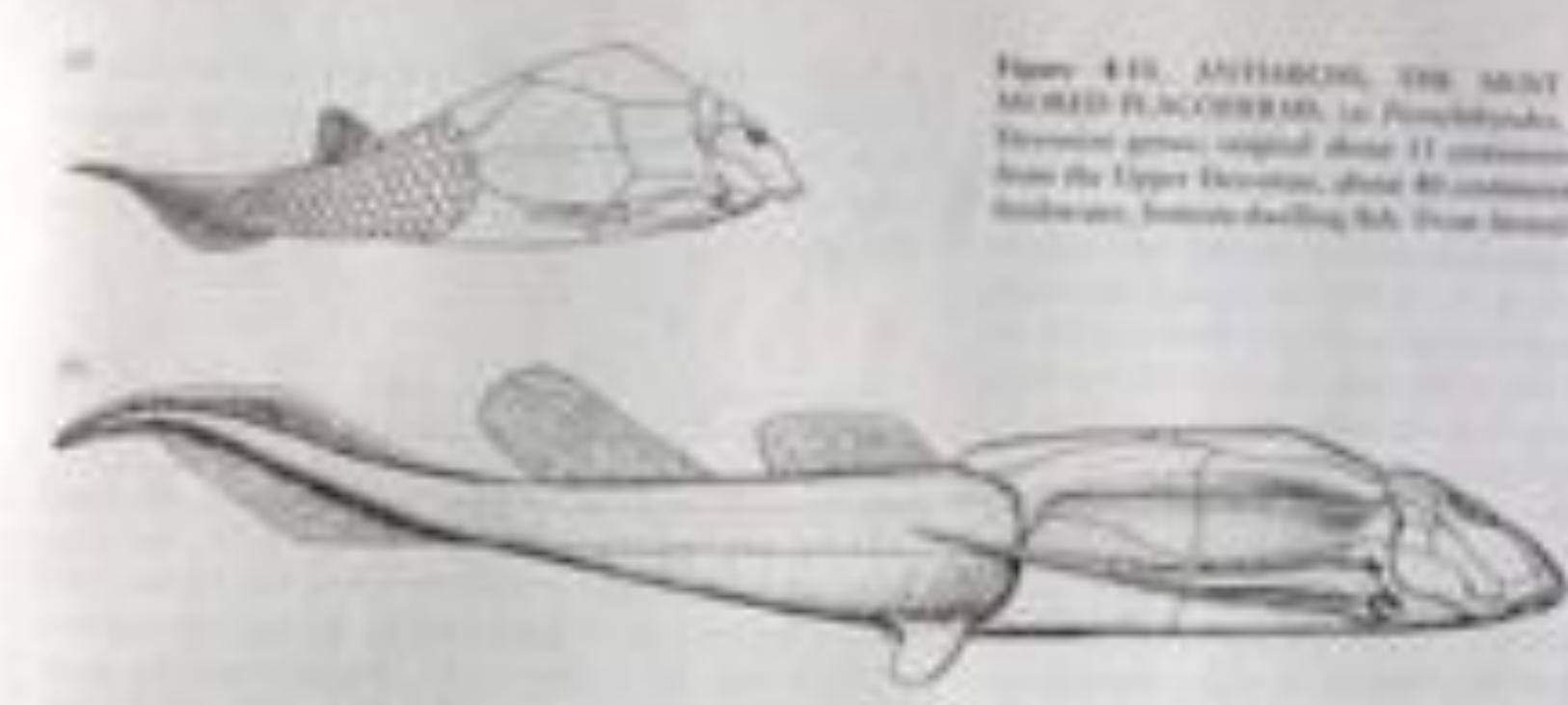
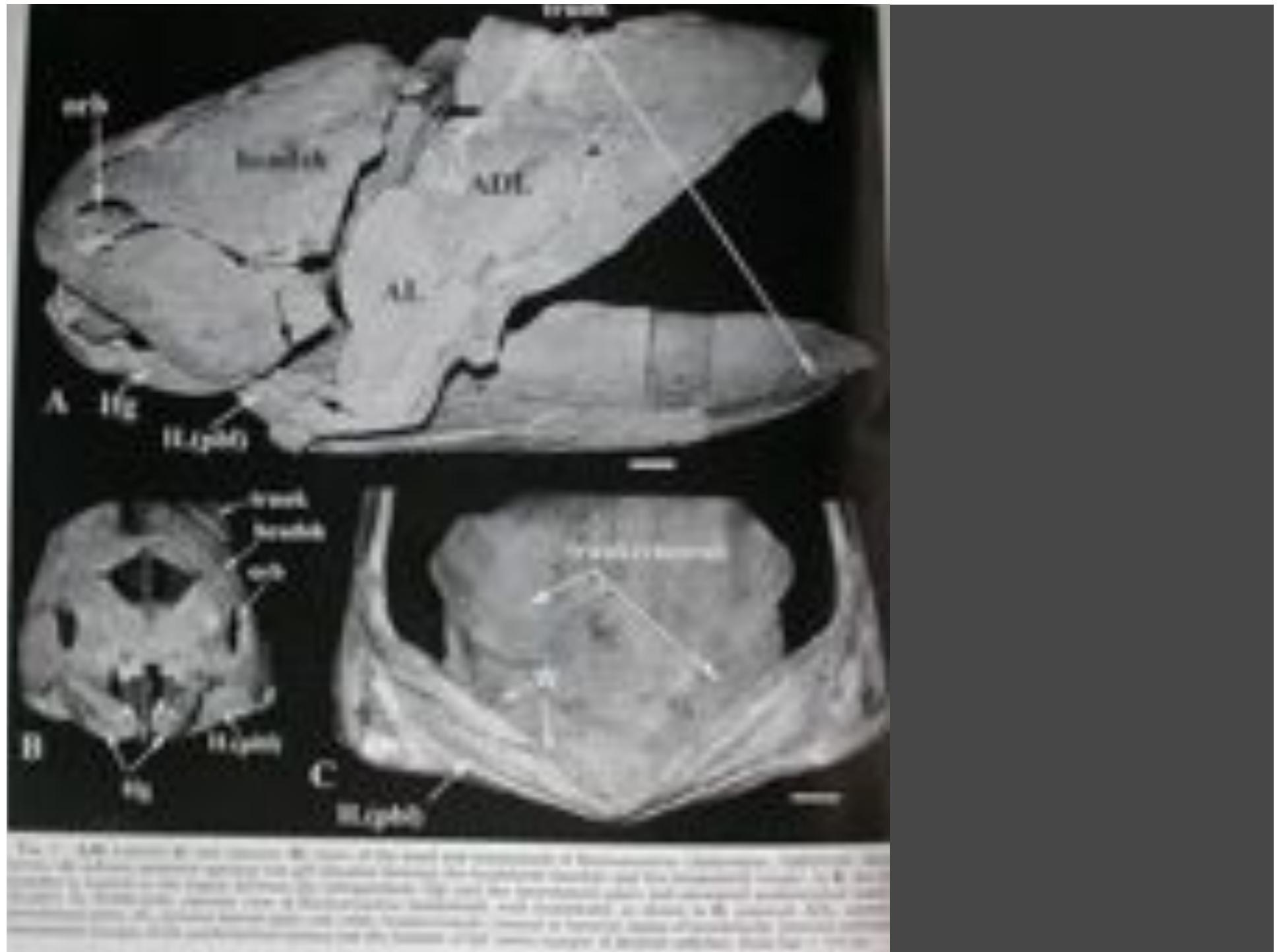


FIGURE 418. ANTIARCHUS, THE MOST EXTENSIVE OF ALL PLACODERMS, i.e., Pterypterus, A CRETACEOUS FISH. Dorsal view original about 11 centimeters long. (2) Ventral view original about 11 centimeters long. (2) Illustrations from the Upper Cretaceous, about 80 million years ago. Illustrations after (left) from Scott, 1900.

Placodermi: Antiarchi - masivní krunýř, dlouhé prsní ploutve (archipterygium) - drobní 10-40 cm



- Placodermi:
- Závěsná čelist,  
svalový aparát –  
vnitřní strana  
dermálních čelistí

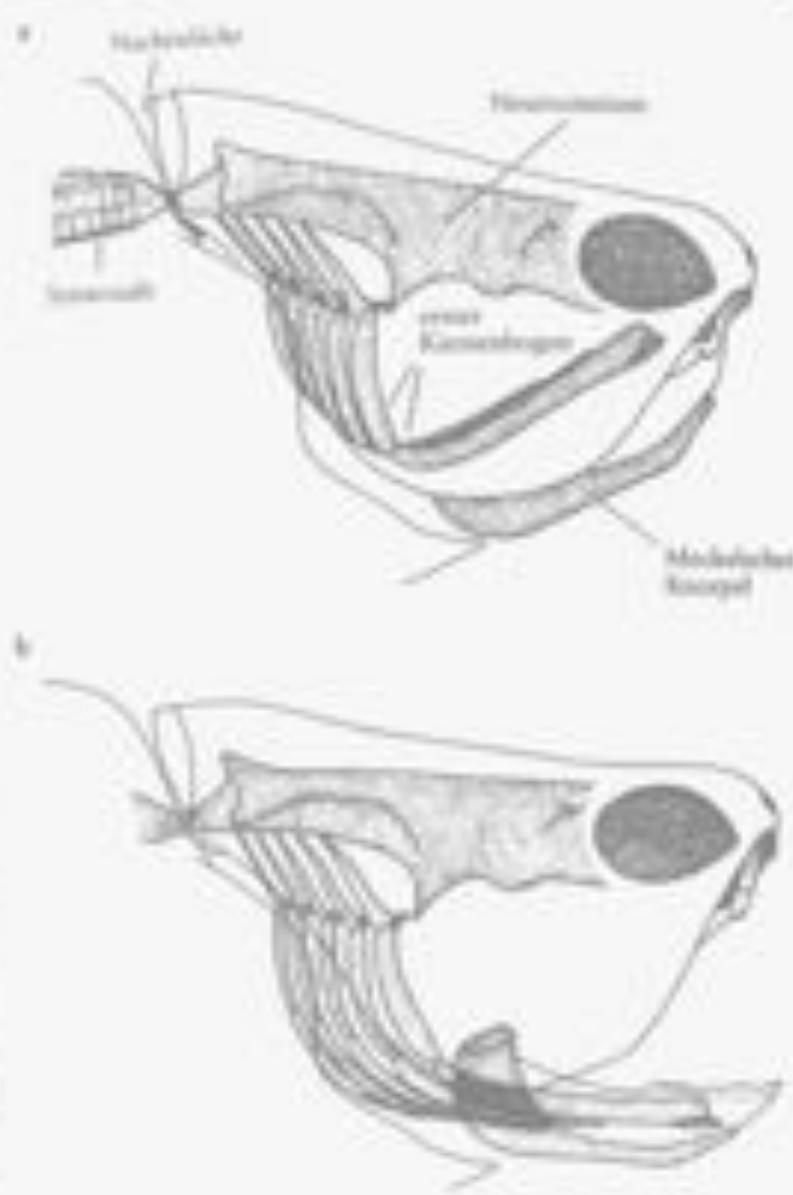


Abb. 4.8: Die Eisernik des endoskeletalen Schädels von *Cephalaspis* bei der Anfangs- und Endstadium (lateralisches und ventrales Schädel abgebildet).

a: Schädel zu Ruhesposition (grauiert), Mund geschlossen.  
b: Angehobener Schädel mit ausgeweiteter Kiemenspalte und weit geöffnetem Mund (aus Jäger 1960).

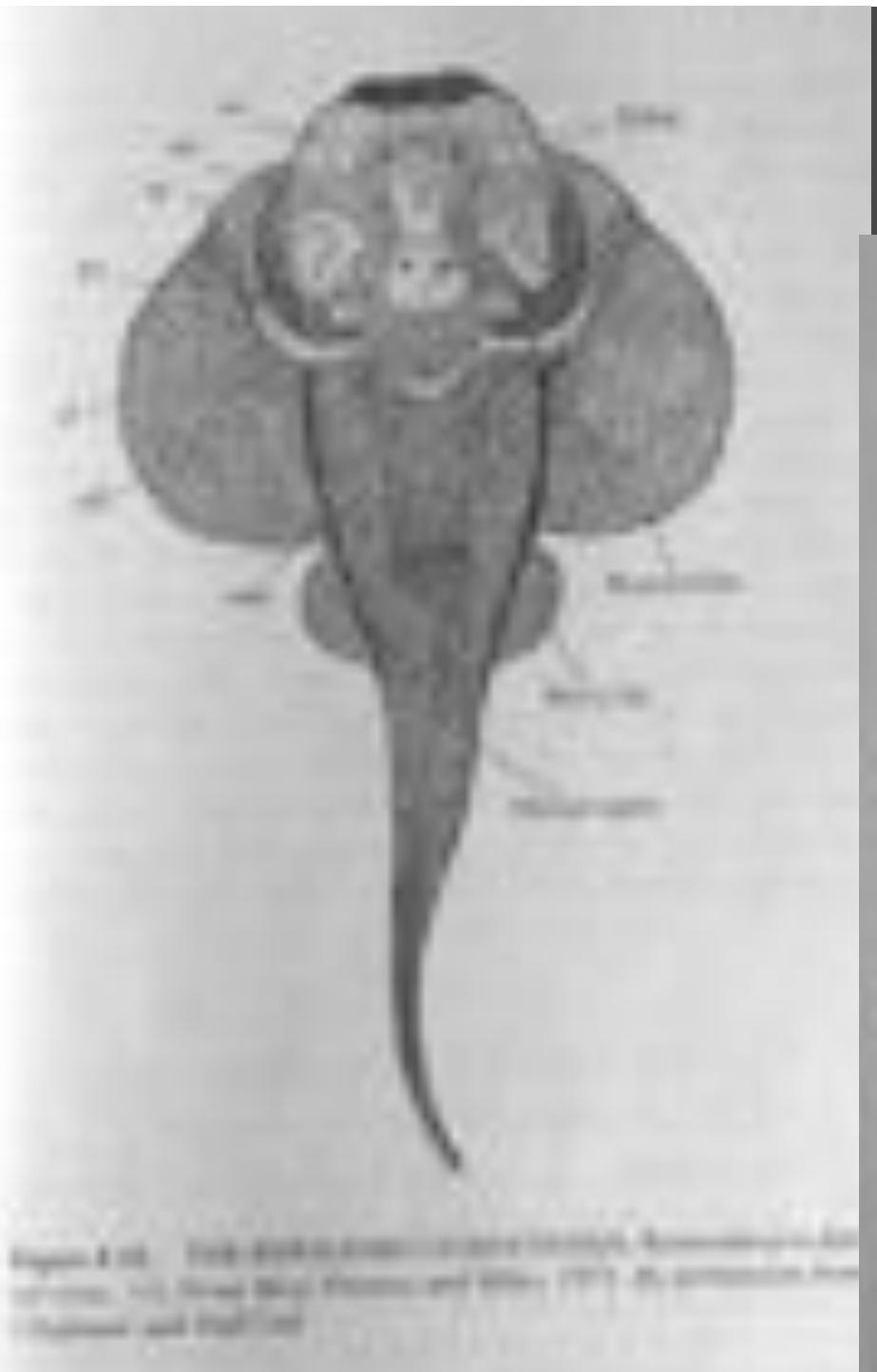
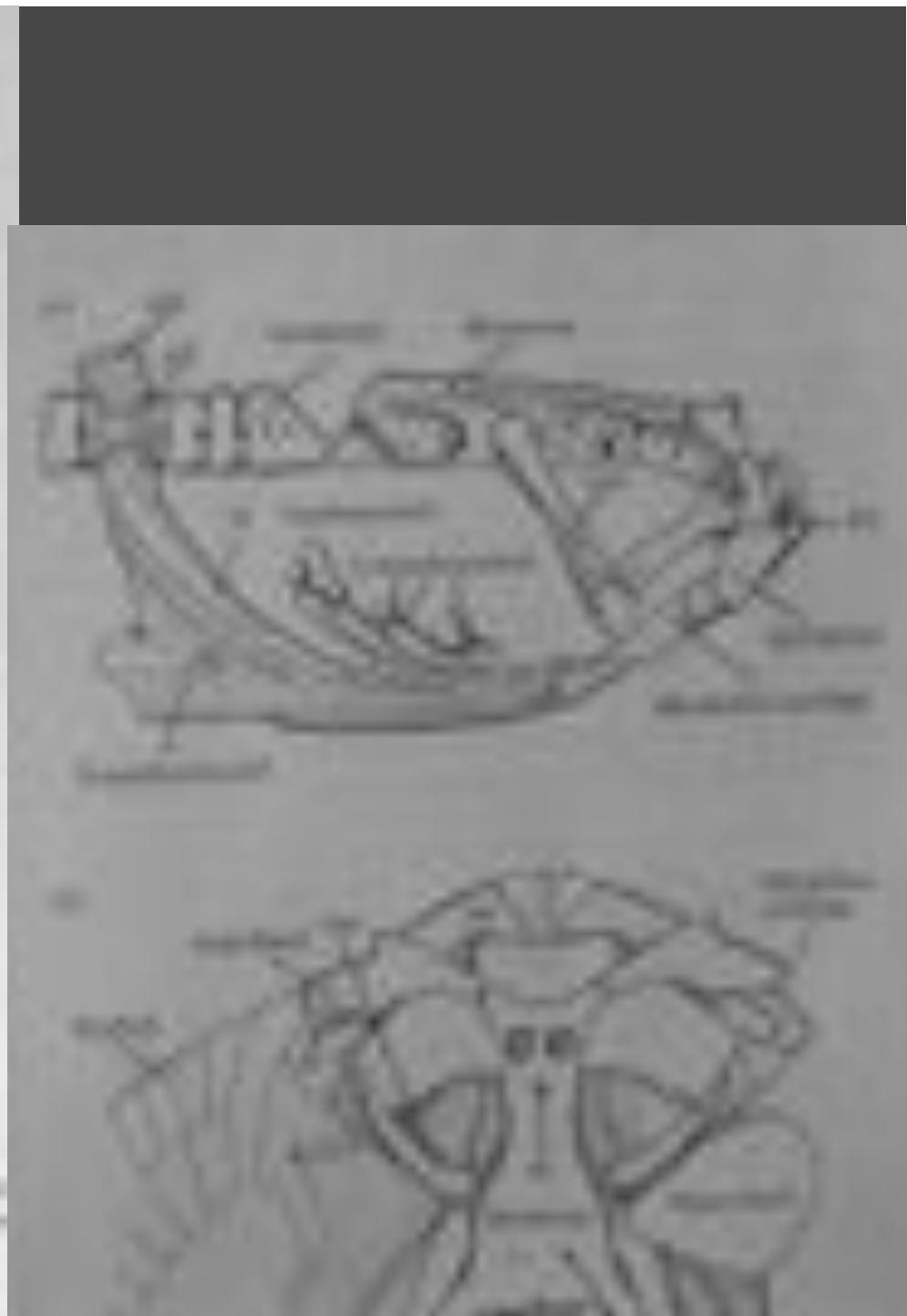


Figure 4-10. Fossils from the Lower Cretaceous of the  
Cayman Islands. (Left) *Leptaena*, ventral view; (right) *Leptaena*, dorsal view.





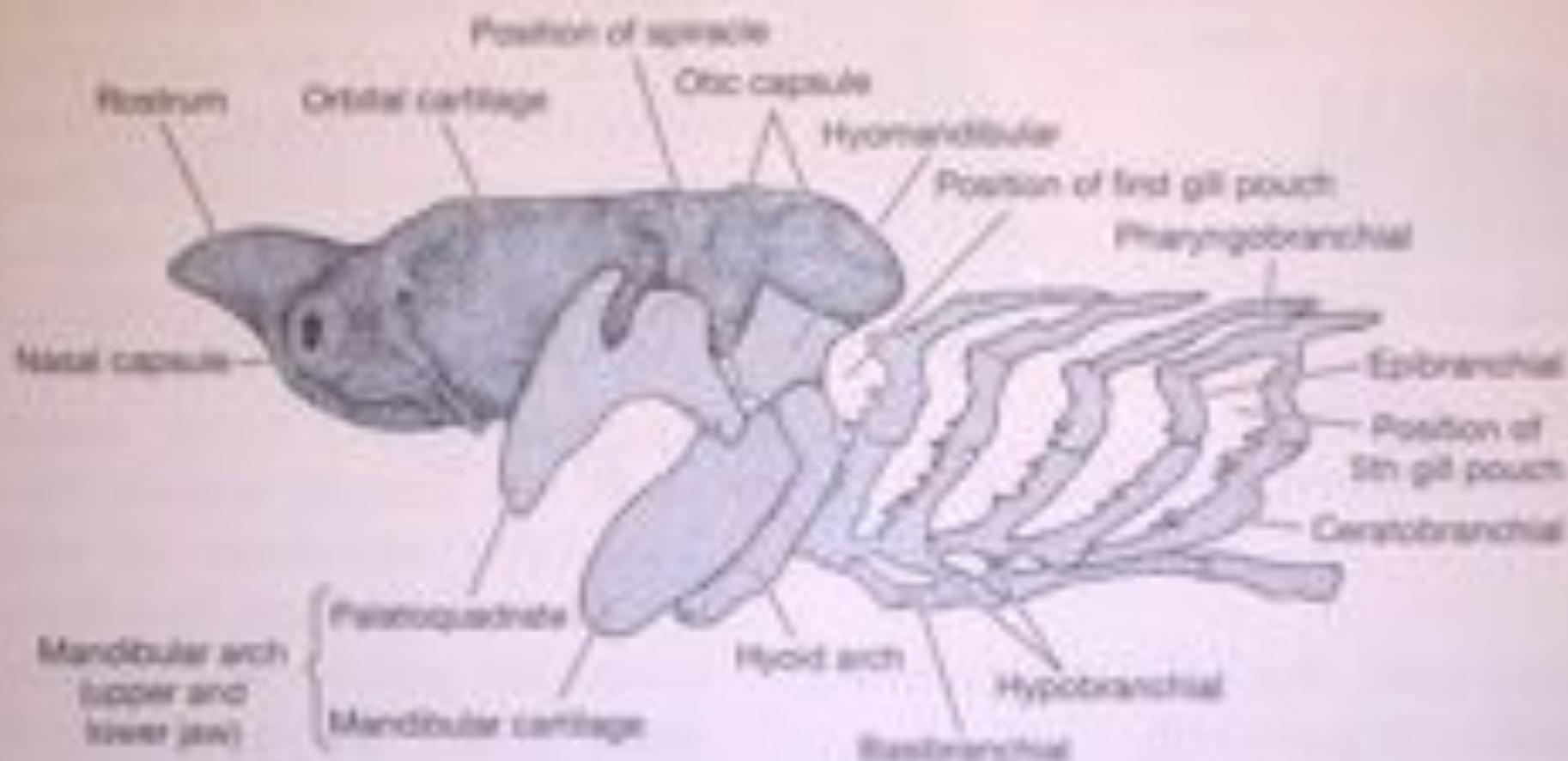
*Chimaera monstrosa*

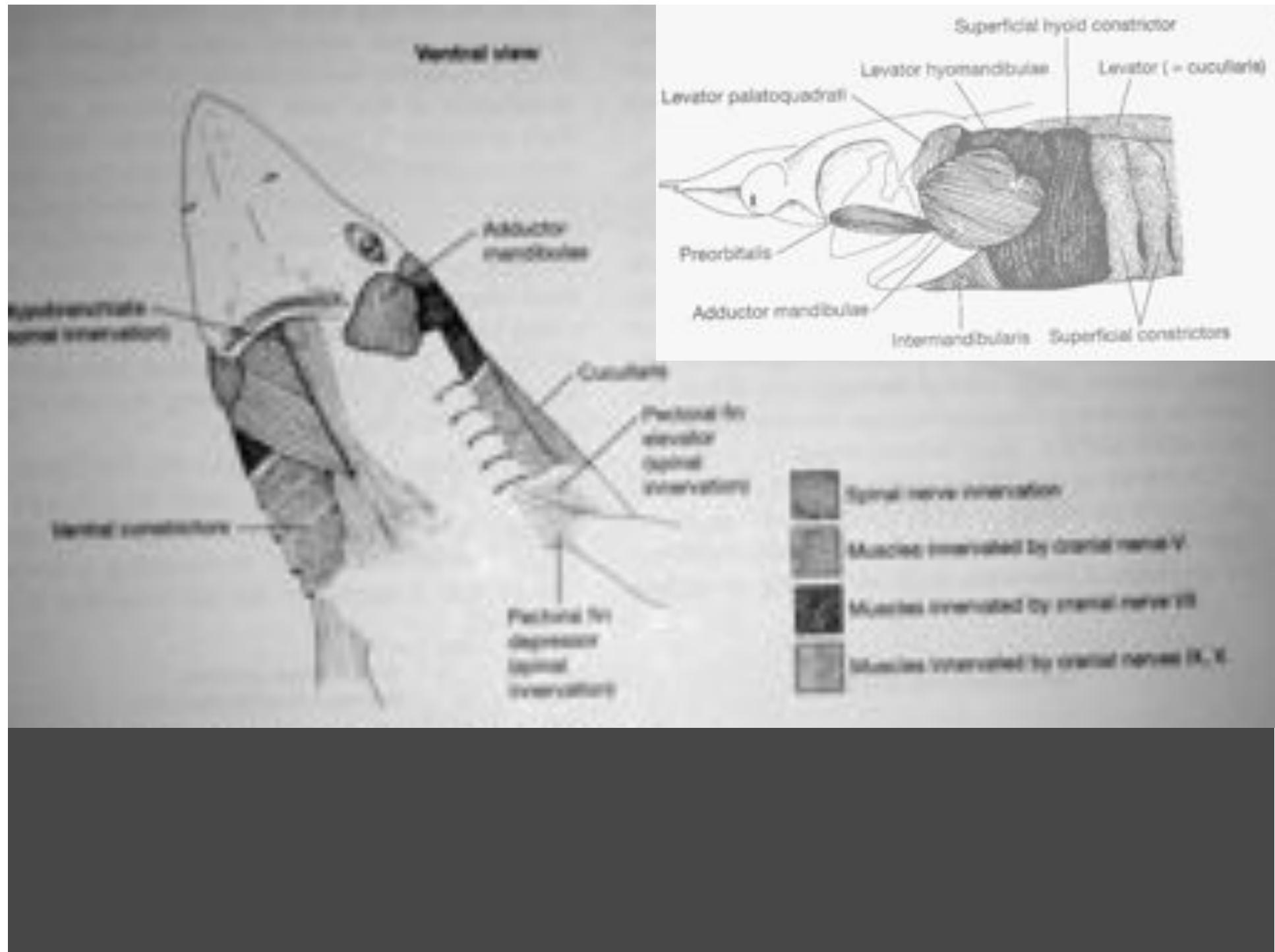






## Chondrocranium and splanchnocranum of a shark





# Připojení čelistí k mozkovně

- **Osteognathostomata:** centrální role dermálních kostí - s výjimkou savců - primární kloub (mandibulare = articulare, quadratum)
- Typický trend: redukce počtu kostí, sekundární autostylie (quadratum+squamsum), vs. streptostylie - uvolnění jednotlivých kostí - zásadní role quadratum (hadí, ptáci, etc.)

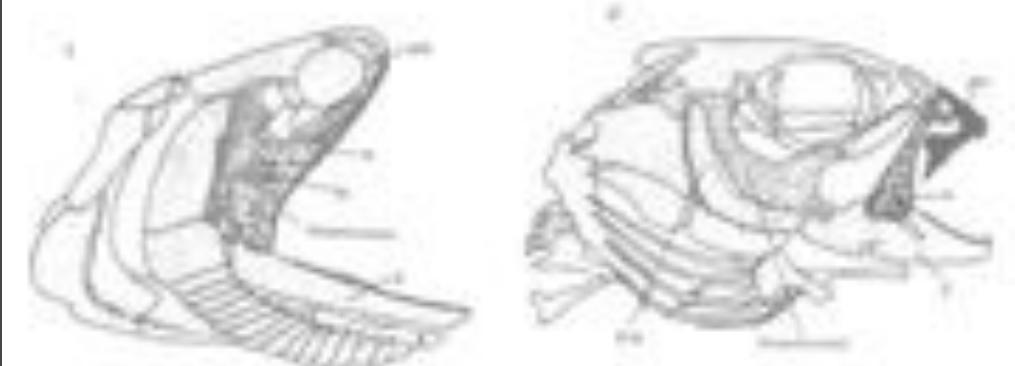
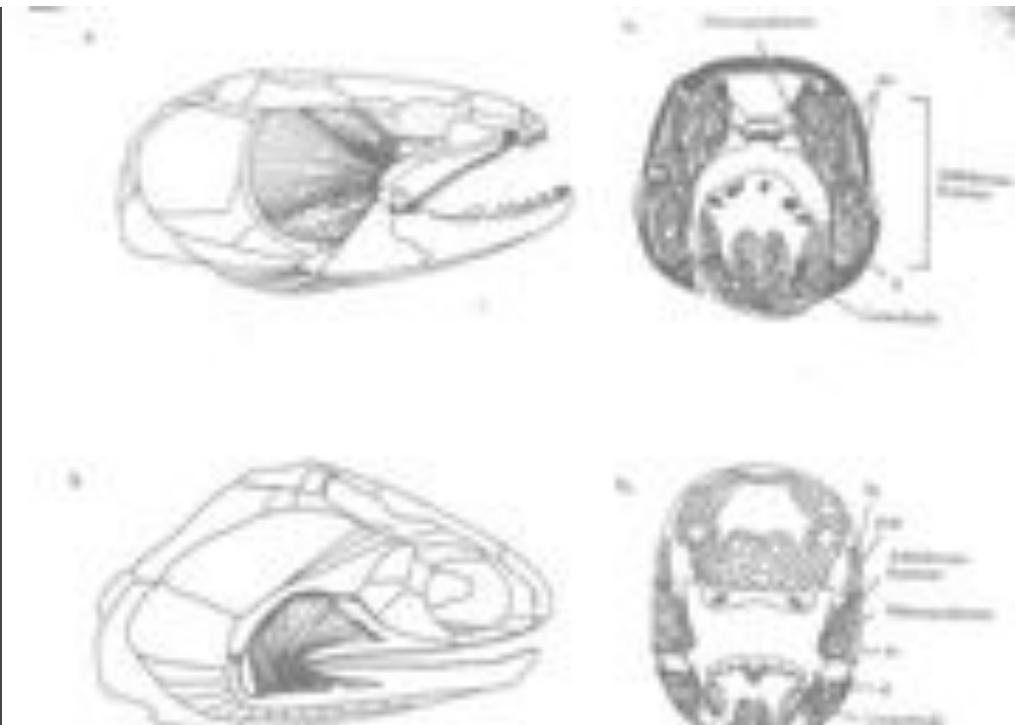


Abb. 44-45. *Oryctolagus cuniculus* (Linnaeus).  
a) Schädel eines weißen Exemplars aus dem Zoologischen Museum der Universität Bonn.  
b) Schädel eines braunen Exemplars aus dem Zoologischen Museum der Universität Bonn.  
Die Abbildungen sind so gezeichnet, dass die Ausbildung der Hirnhäute und des Hirns im Verhältnis zu den Knochenstrukturen möglichst genau wiedergegeben ist. Die Hirnhäute sind durch gestrichelte Linien dargestellt. Die Hirnmarkierung ist durch einen Kreis gekennzeichnet. Die Hirnventile sind durch Pfeile gekennzeichnet. Die Hirnvenen sind durch gestrichelte Pfeile gekennzeichnet. Die Hirnarterien sind durch durchgehende Pfeile gekennzeichnet. Die Hirnvenen sind durch gestrichelte Pfeile gekennzeichnet. Die Hirnarterien sind durch durchgehende Pfeile gekennzeichnet.

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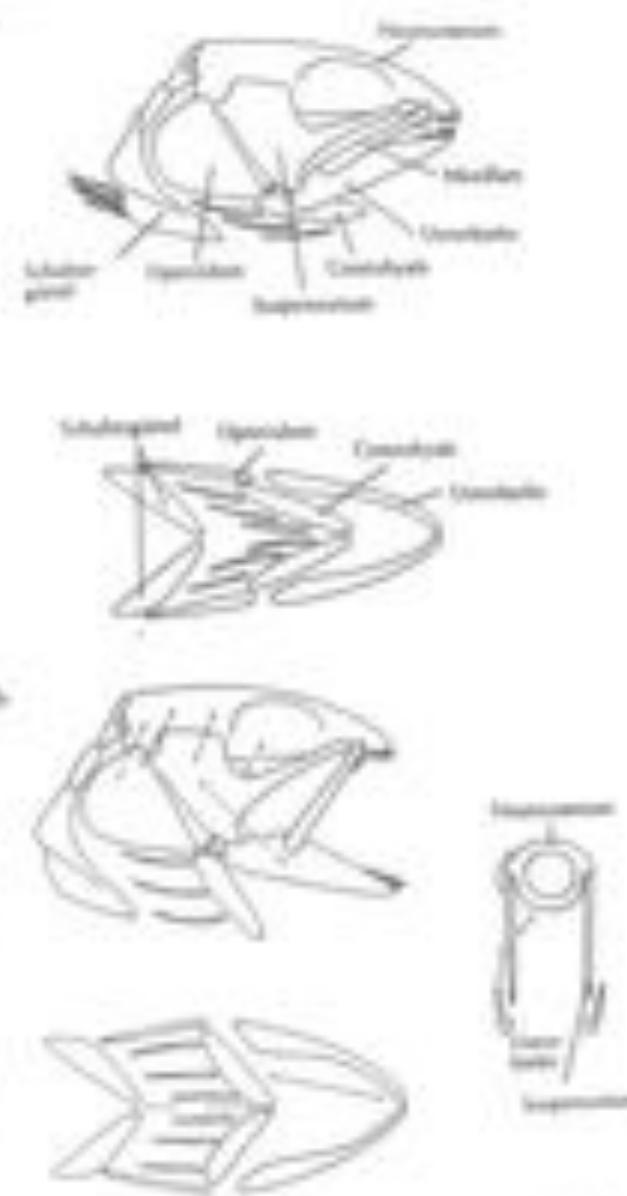


Abb. 4, 13: Die Anatomie von Schädel und Schläfenregion bei *Sceloporus*. Die Unterscheidung Nasen- und Orbitaplatzmauer des Schädels ist ebenso abgrenzbar wie die Beugungslinie des Mandibeln, auch wenn dies abweichen kann als Beugungslinie des Schädels, auch wenn dies abweichen kann.

- + Der ventrale und laterale Bereich des Schädels bei gewöhnlichen *Sceloporus*-Arten ist für größeres Maul.
- + Der symmetrische vertikale Teil der Beugungslinie des Schädels ist bei *Sceloporus*-Arten eine Längsstellung eines Nasenmauers (nach Arribalz 1970).

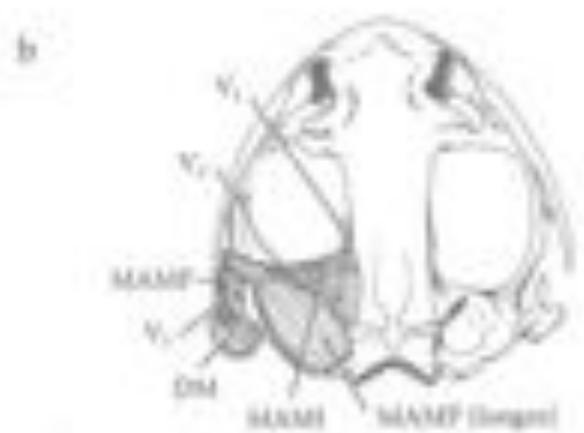
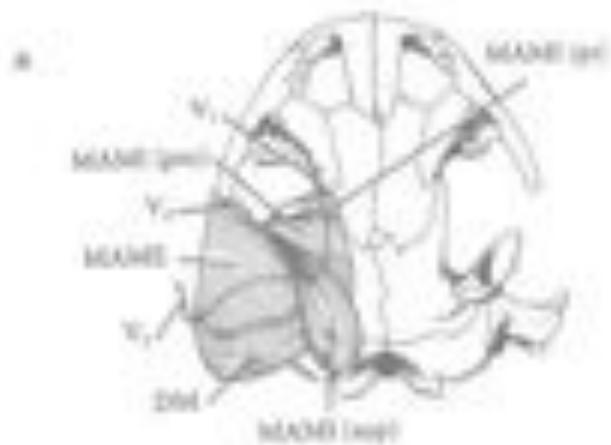
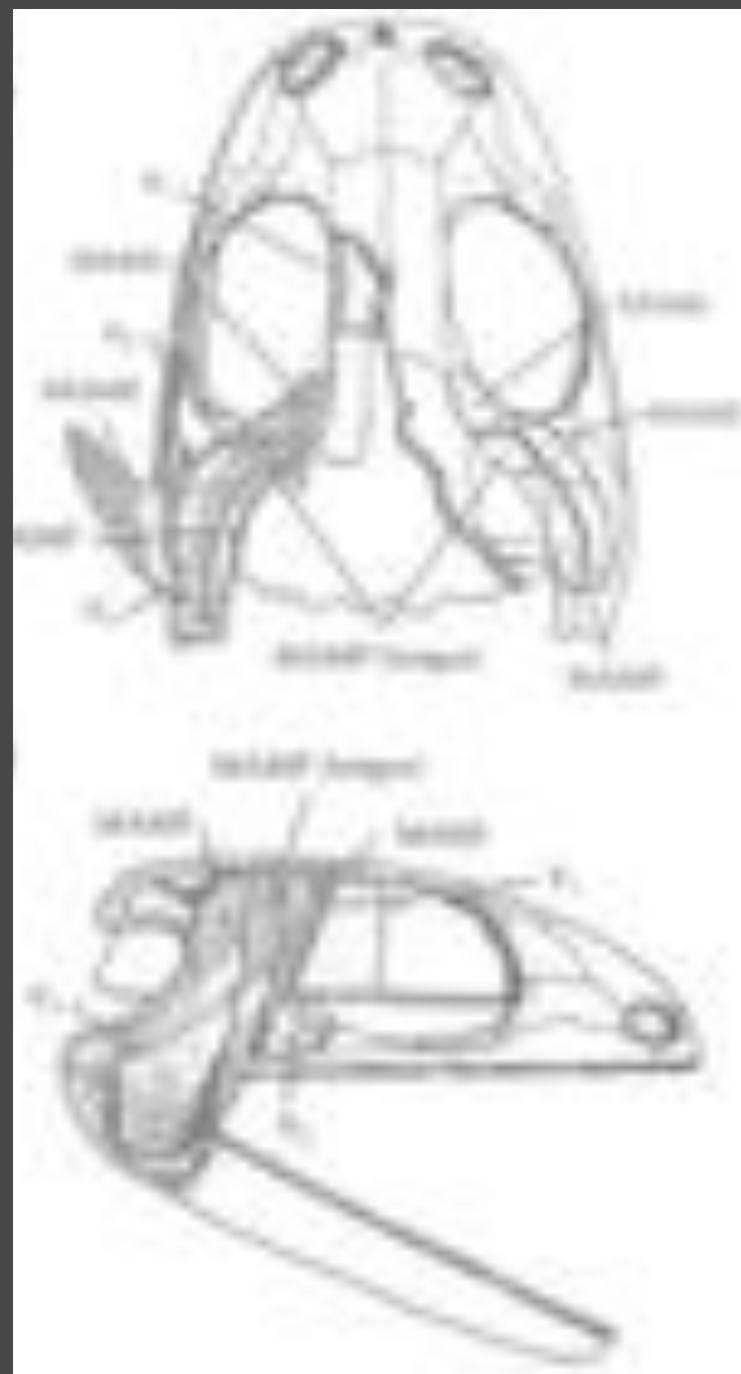


Abb. 9.39: Muster der Kiefermuskulationen. a: *Anolis*, ein rezentarisches Salamander und b: *Aesculus*, ein primitivem Frosch. Abkürzungen:  $V_1$ ,  $V_2$ ,  $V_3$  – Äste des 3. Hinterwurfs, Dm – M. depressor mandibulae, MAME – M. adductor mandibularis extimus (er ist bei den meisten Salamandern groß, fehlt aber bei den meisten Fröschen), MAMI – M. adductor mandibularis internus, MAMI (pro) – Prolatordkopf des MAME, MAMI (pr) – Protygoiderkopf des MAME, MAMI (sup) – Superficialiskopf des MAMI (er ist bei den Salamandern groß, fehlt aber bei den Fröschen), MAMP – M. adductor mandibularis posterior (er wird bei den Fröschen ausgehoben, nicht aber bei den Salamandern), MAMP (longus) – Longuskopf des MAMP (aus Carrill & Hobson: EPB).



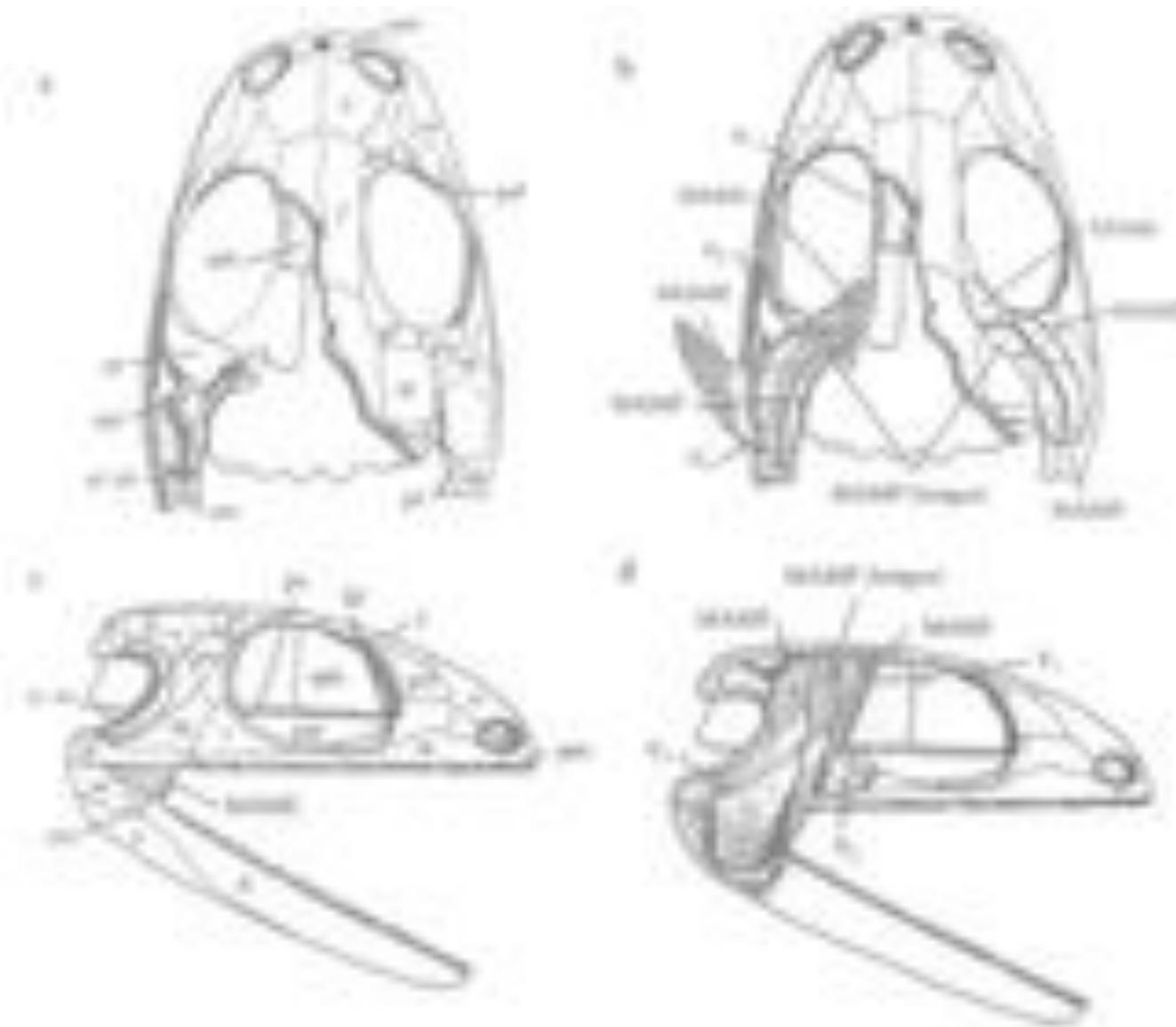


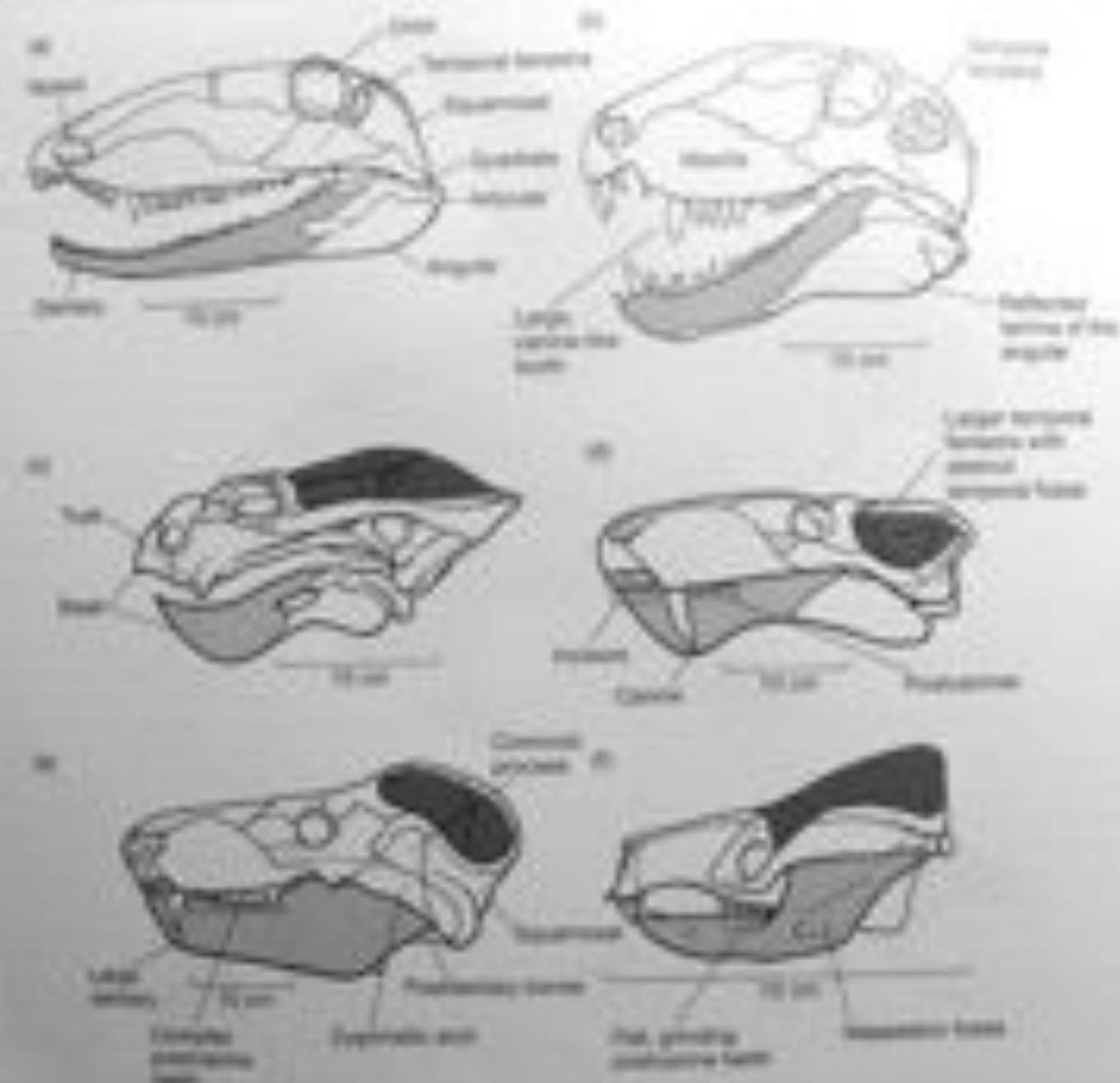
Abb. 9-10: Schematische der anatomischen Strukturen des Menschen.  
a) Lateralansicht, Glottis und subglottische Atemtröhre mit den benannten Schichten.

b) Hintere Anschauung: Glottis und subglottische Atemtröhre mit den benannten Schichten.

c) Vordere Anschauung der Glottis und subglottischen Atemtröhre.

d) Lateralansicht der Glottis.

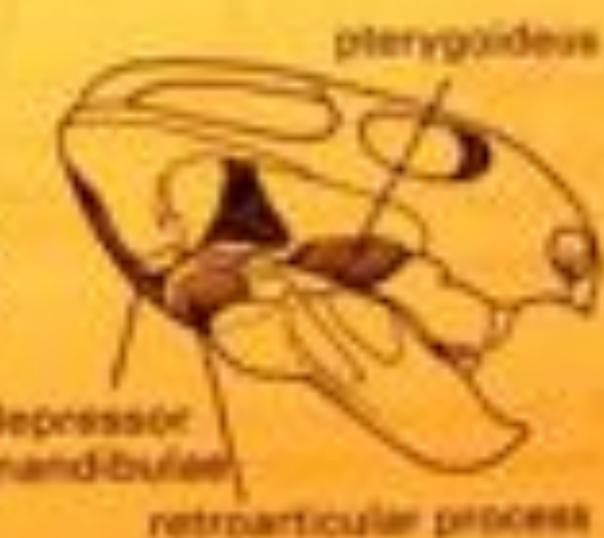
e) Vordere rechteckige Ausschnitt des Schalls, um die Körnungskräfte zu verringern. Abbildungen aus in Abb. 9-3 und 9-10, rekonstruiert. Mit — Tonsurwerk, 47/21 — Umdrehen des Pfeilsgriffs, 56 — Laut der Aufzählgang der Körnungskräfte (aus Grollig, Frerichs (1989)).



▲ Figure 18-4. Shells of ammonoid-like cephalopods. (a) The straight-sided polyconic *Ophyllites*; (b) The straight-sided



(a-d) A profile showing series of *Plesiosaurus* (as in (a)) lowers its jaw and moves it back, (b) moves it forward, (c) up for the bite, (d) and backwards to how the head (e-g) restoration of the jaw muscles of *Plesiosaurus* drawn out at progressively deeper levels, shown on figure (After Crompton and Wilson, 1967.)

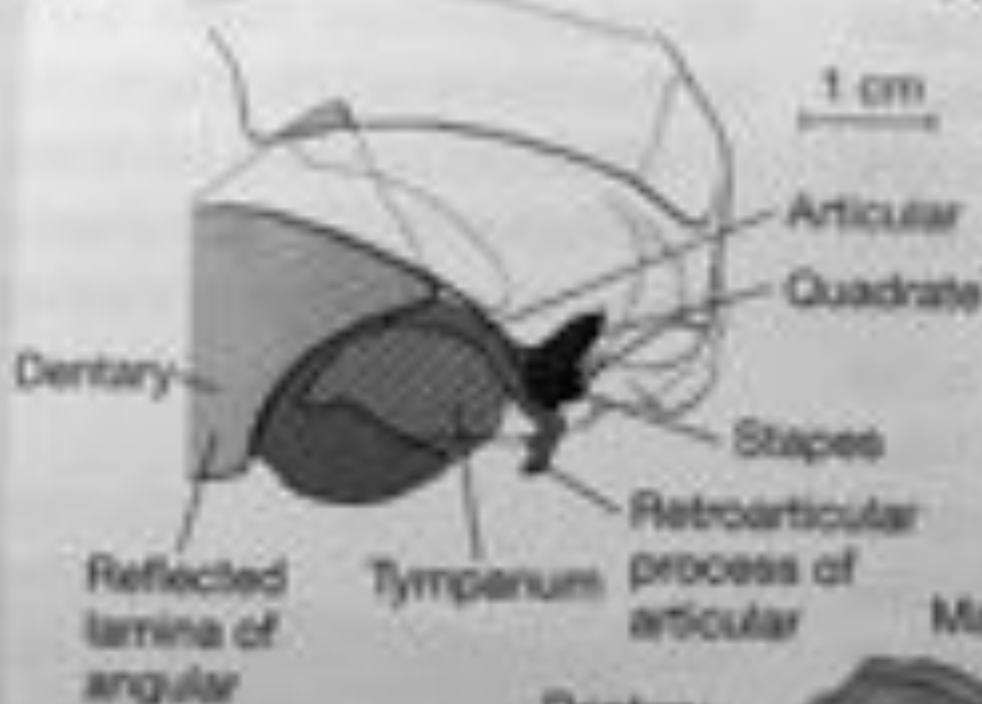


(g)

pterygoideus

retroparticular process

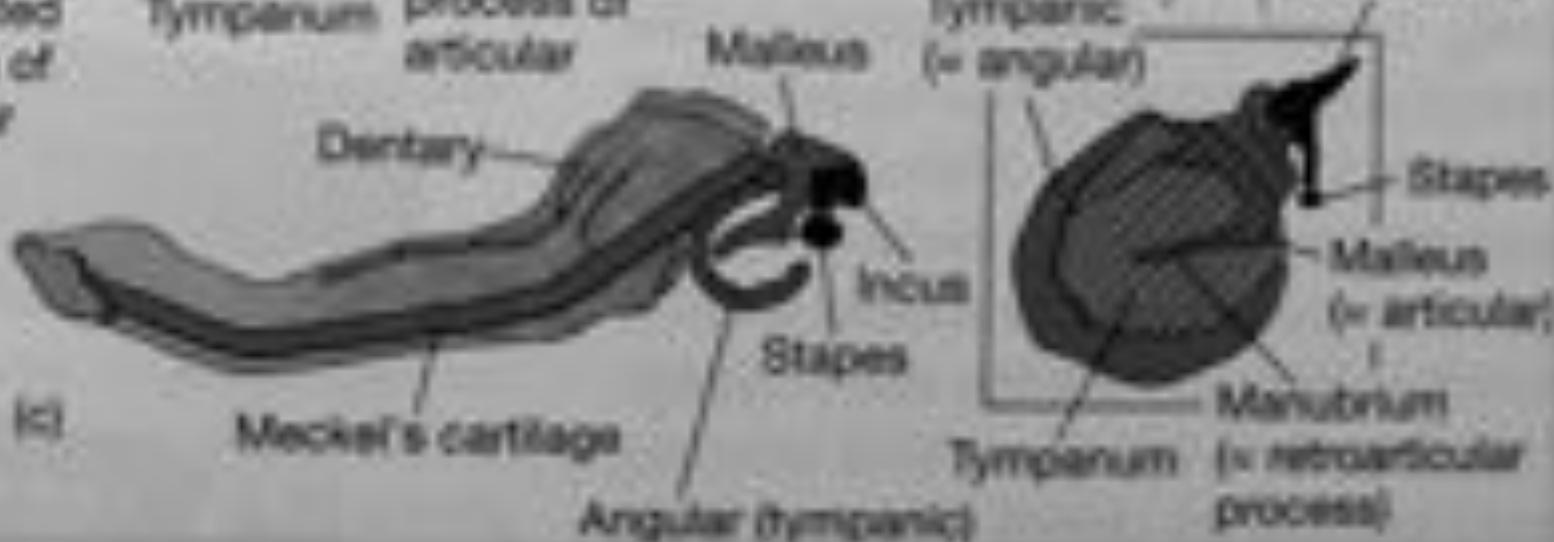
(a)



(b)



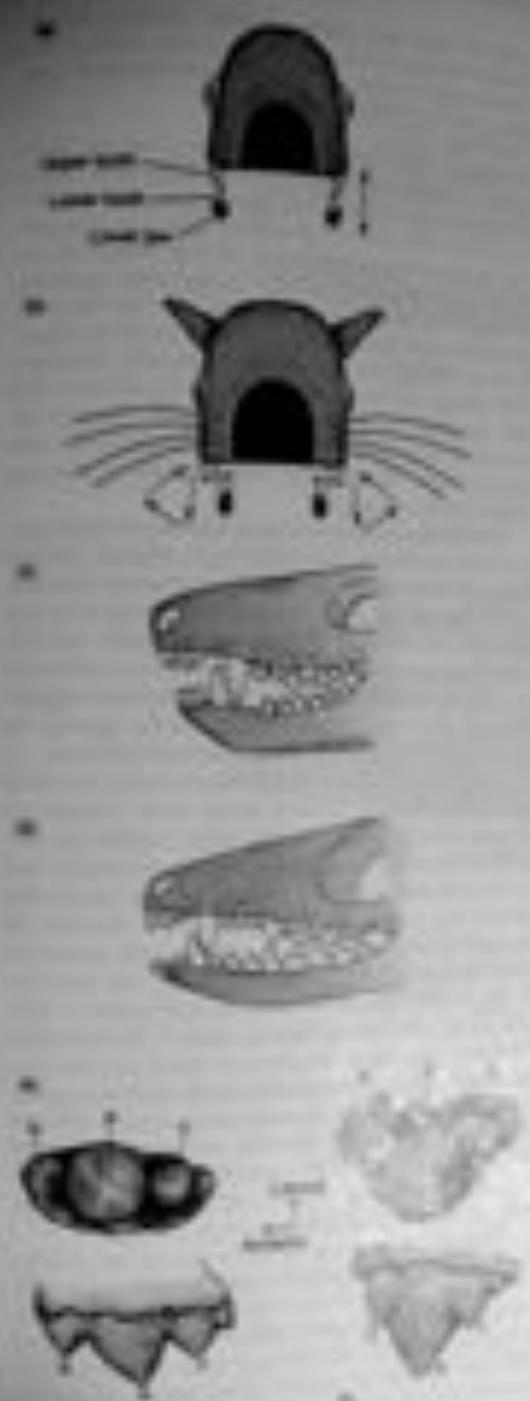
(c)



Anatomy of the back of the skull and the middle ear bones of synapsids. (a) Thylacine, a Tasmanian opossum. (c) Embryonic mammal.

The Evolution of Latching and Snapping  
Snapping has been more speculative than the evolution of the latching mechanism. Studies of the early and branching forms, which did not possess the latching teeth, were not promising. It is possible that one function of the latching teeth is to maintain the biting force after both teeth and the masticatory muscles have fatigued and the mouth is closed.

**Latching.** Cawthon Reed (1971) has argued that precise occlusion and displacement indicate the role of latching in early mammals. She points out that precise occlusion requires a mesh with the appropriate dimensions in mammals. Because only a fully developed tooth occlusion provides such a mesh, it is the chief test of this view. This could be especially true for the half-primary teeth through upper molars (Figures 18-121), because a small process or enlargement could break the teeth. Precise disengagement of occlusion is less important in mammals with blunt teeth, such as hominids. Hominid hominines, however, did independently evolve a form of occlusion, but this was with the teeth that did not require precise alignment for their function.



• **Figure 18-17:** Occlusion and range axes in mammals and early mammals. (A) has occlusion tests through the mouth of a placental. Lower teeth and upper teeth are in the same direction with respect to each other. Disengagement is complete. (B) shows teeth with a narrow anterior overlap. Disengagement of the anterior teeth does not damage the incisor. A horizontal furrow with one down suggests that either a primary M1 or a primary upper canine is present. (C) shows a wide anterior overlap of the upper and lower teeth. The vertical axis of the upper teeth is to the right of the lower teeth. (D) shows a narrow anterior overlap of the upper and lower teeth. The vertical axis of the upper teeth is to the left of the lower teeth. (E) shows a wide anterior overlap of the upper and lower teeth. The vertical axis of the upper teeth is to the left of the lower teeth.

# Gnathologie a biomechanické souvislosti dentálních adaptací savců

- kinetika čelistního aparátu
- strukturní design
- funkční koreláty

# Čelistní svaly

- CR-Md:
  - **masseter (addukce md)**
  - **temporalis (addukce, retrakce)**
  - **pterygoideus medialis (addukce, mediopulse)**
  - **pterygoideus lateralis (protrakce, lateropulse)**
  - **digastricus, mylohyoideus, geniohyoideus (abdukce)**
- svaly jazyka
  - genioglossus, hyoglossus, styloglossus, transversus linguae, longitudinalis, vericalis linguae ...
- vestibulum oris a svaly ústní štěrbiny (Theria)
  - buccinator, orbicularis oris

# Pohyb čelisti

- habituální poloha + kinematický řetězec změn
- vertikální (**deprese-elevace / abdukce-addukce**)
- sagitální (**protruse-extruse / protrakce-retrakce**)
- transversální (laterální exkurze / latero-mediopulse)
- \* souborná charakteristika mobility čelistního pohybu:  
*Posseltův kužel* - prostor vymezený extrémními polohami symfysálního bodu
- Biomechanické aspekty pohybu: závěsový vs. pákový model, kinematický prostor

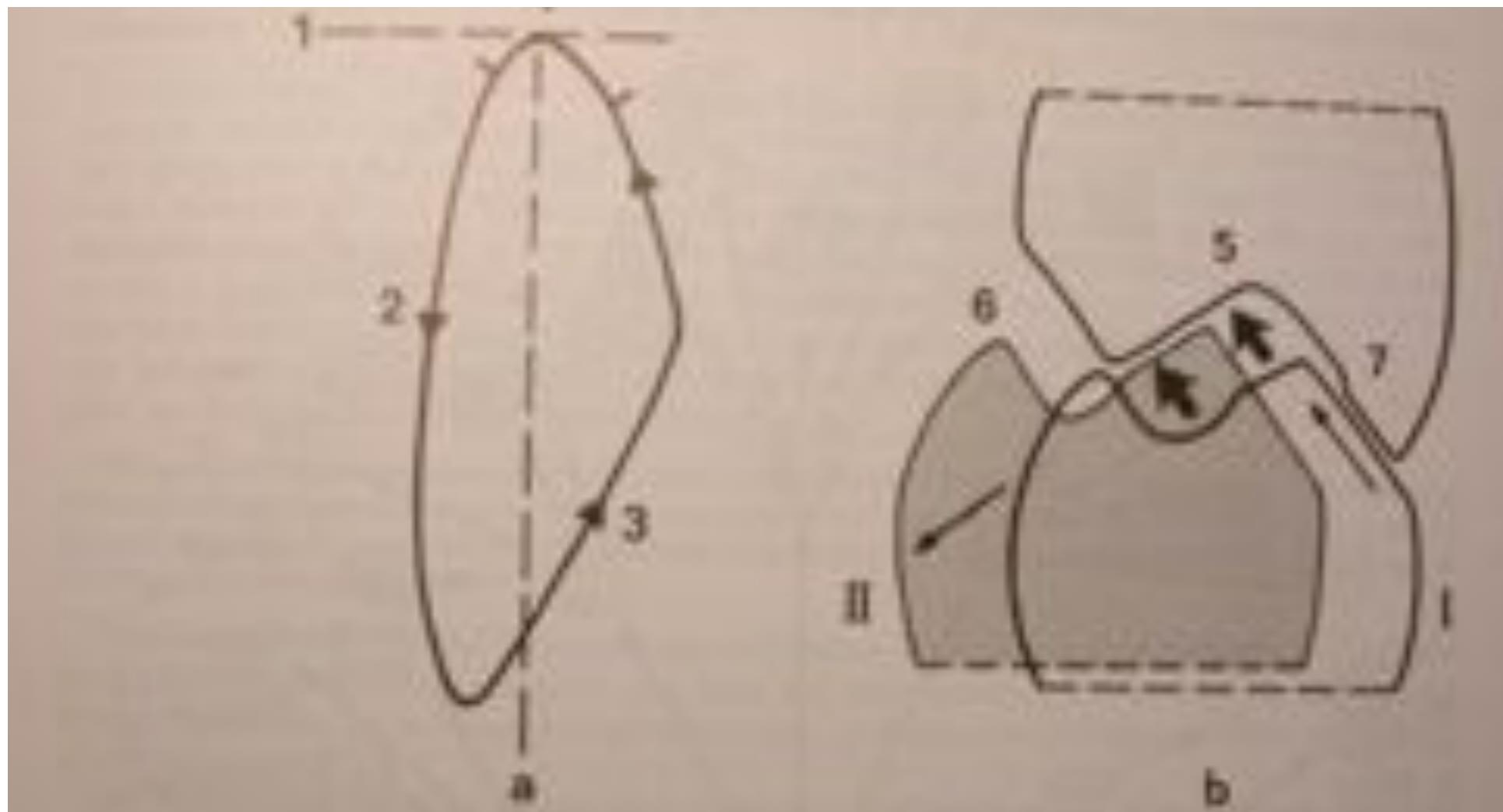


Abb. 1098. Abduktionsbewegungen. a) Verlaufsrichtung einer Bewegung bei transversalem Rollenroll. Die beiden Markierungsstücke im oberen Bild sind g. heutige Form der knorpeligen Kontaktfläche bei Zusammenspiel der Schenkeln und flüchten zweier antagonistischer Muskeln. Zeitpunkt der Kontaktfl. im eine vertikale Druck- und in eine flächigspannende Schwellung umgesetzt.  
 I. Diskusknorpelstück; 2. Öffnen; 3. Schließen; 4. Artikulationspunkt; 5. Kompression; 6. Subluxation; 7. Rollen; I, II. Erste und zweite Phase. Nach W. Menn 1966.

# Tvar a pohyby čelistního kloubu

válcový-rotace (axiální cirkumdukce) - karnivoridní design

-translace (posun) - herbivoridní design

specializovaný kloubní design (Carnivora, Ruminantia, Rodentia) - bez discus articularis

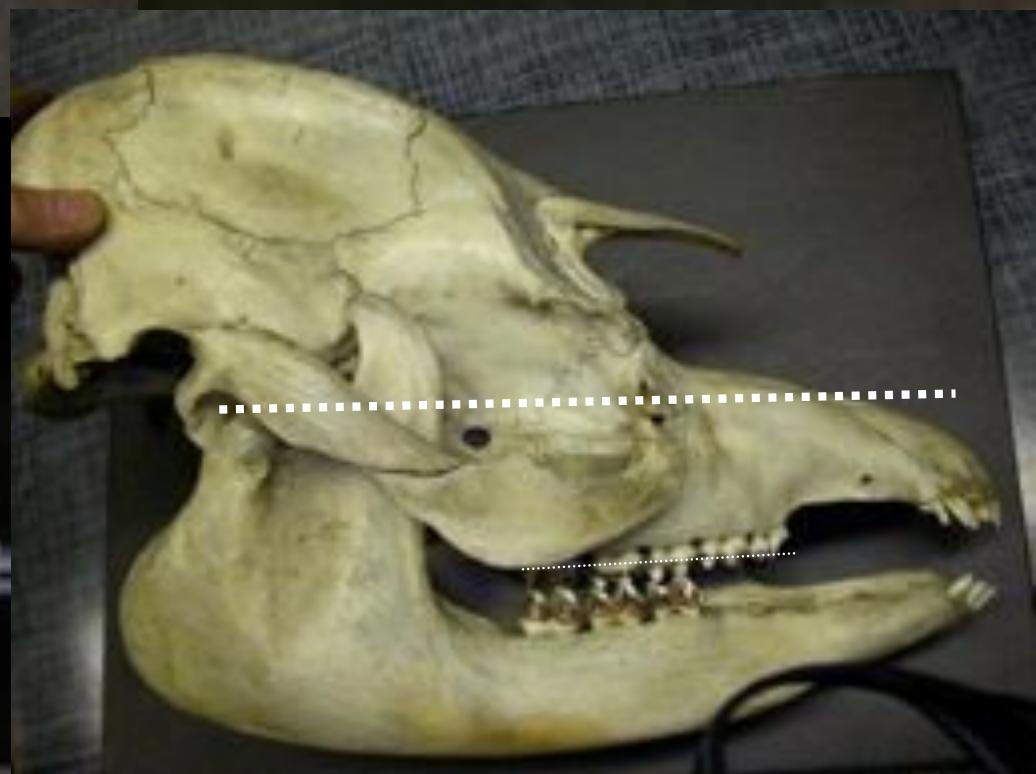
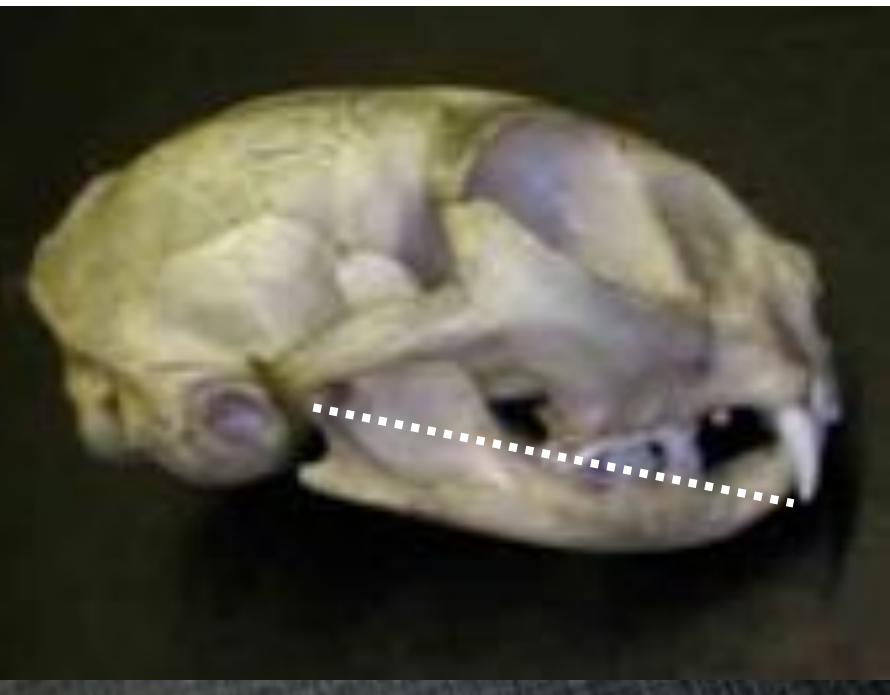
discus articularis - u primátů (versatilita kloubního pohybu)

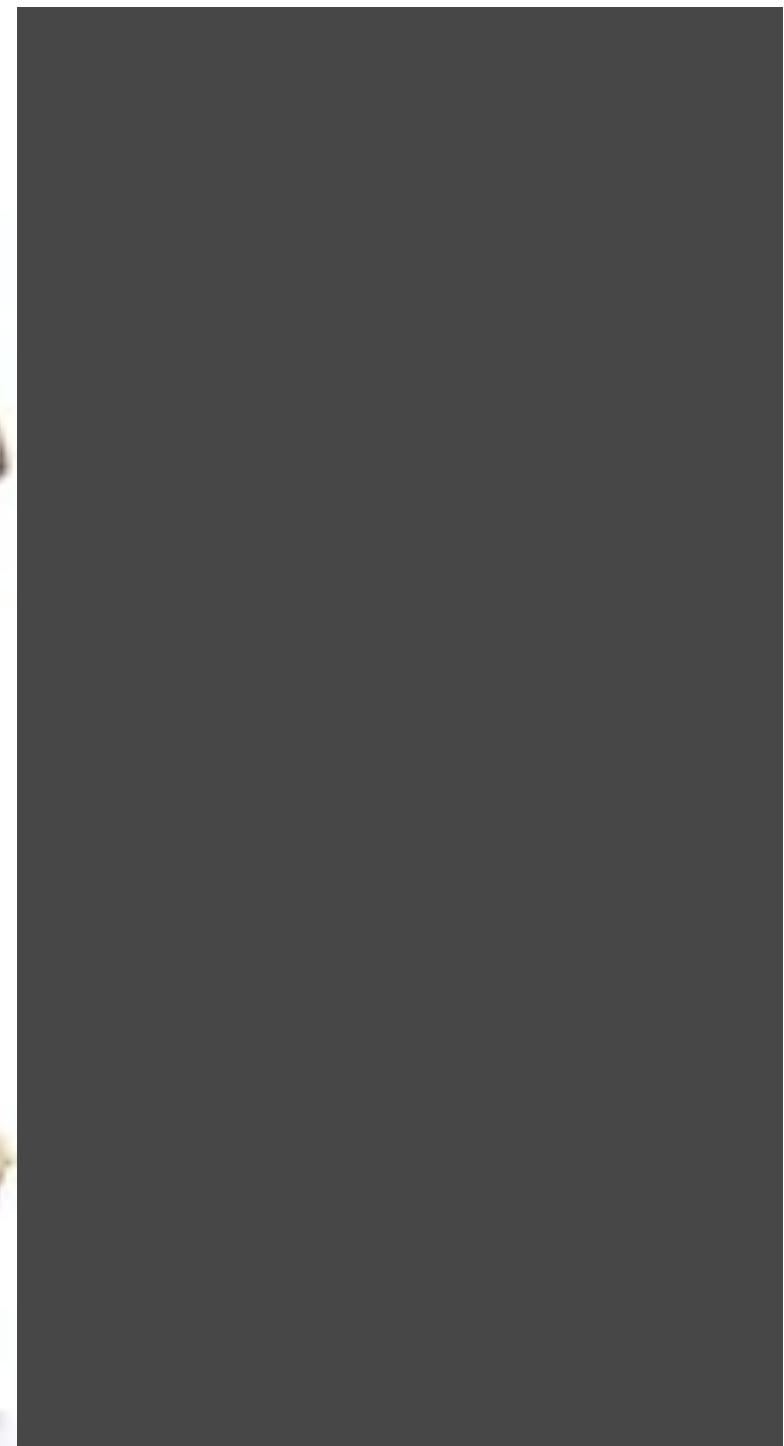
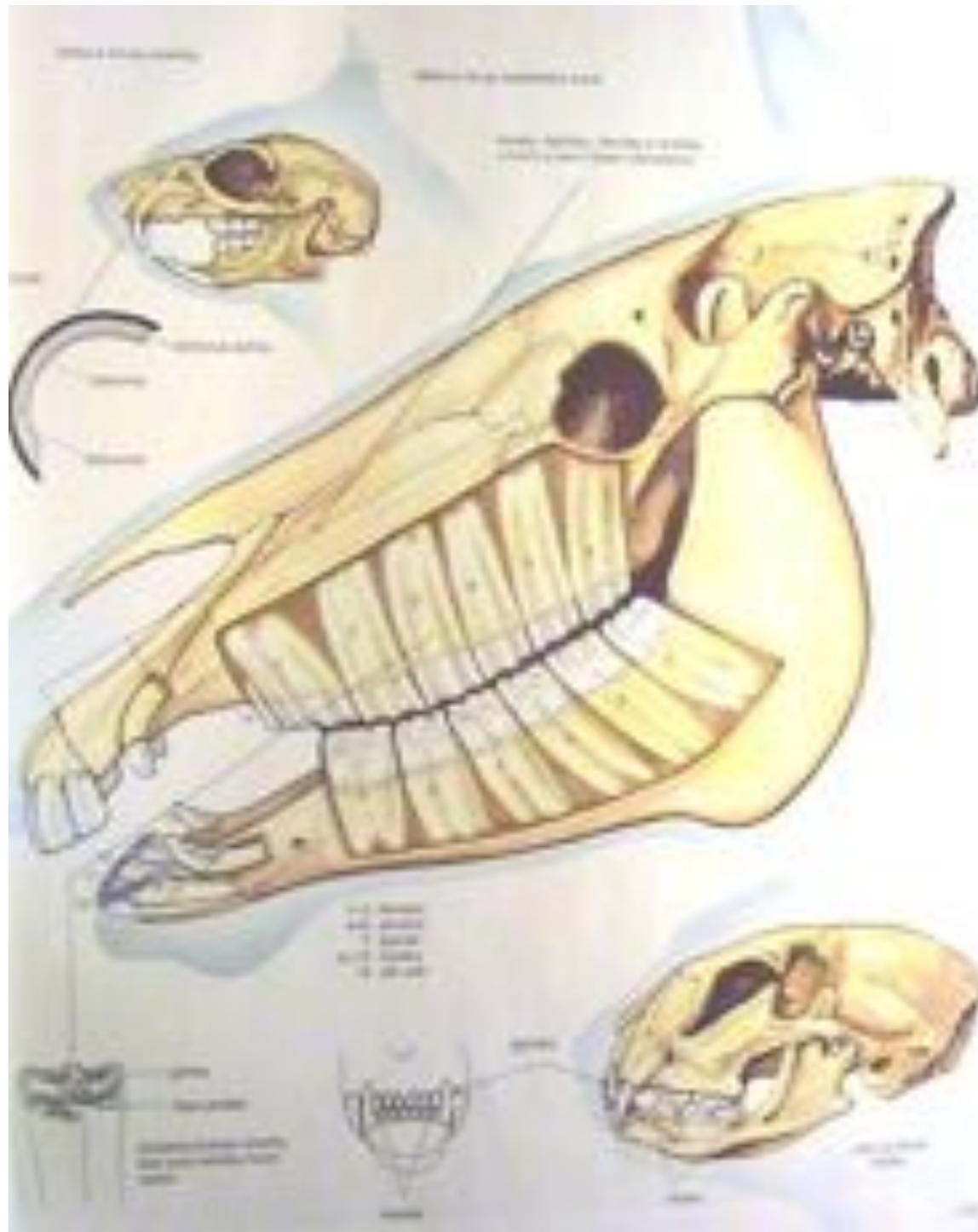




# Posice čelistního kloubu

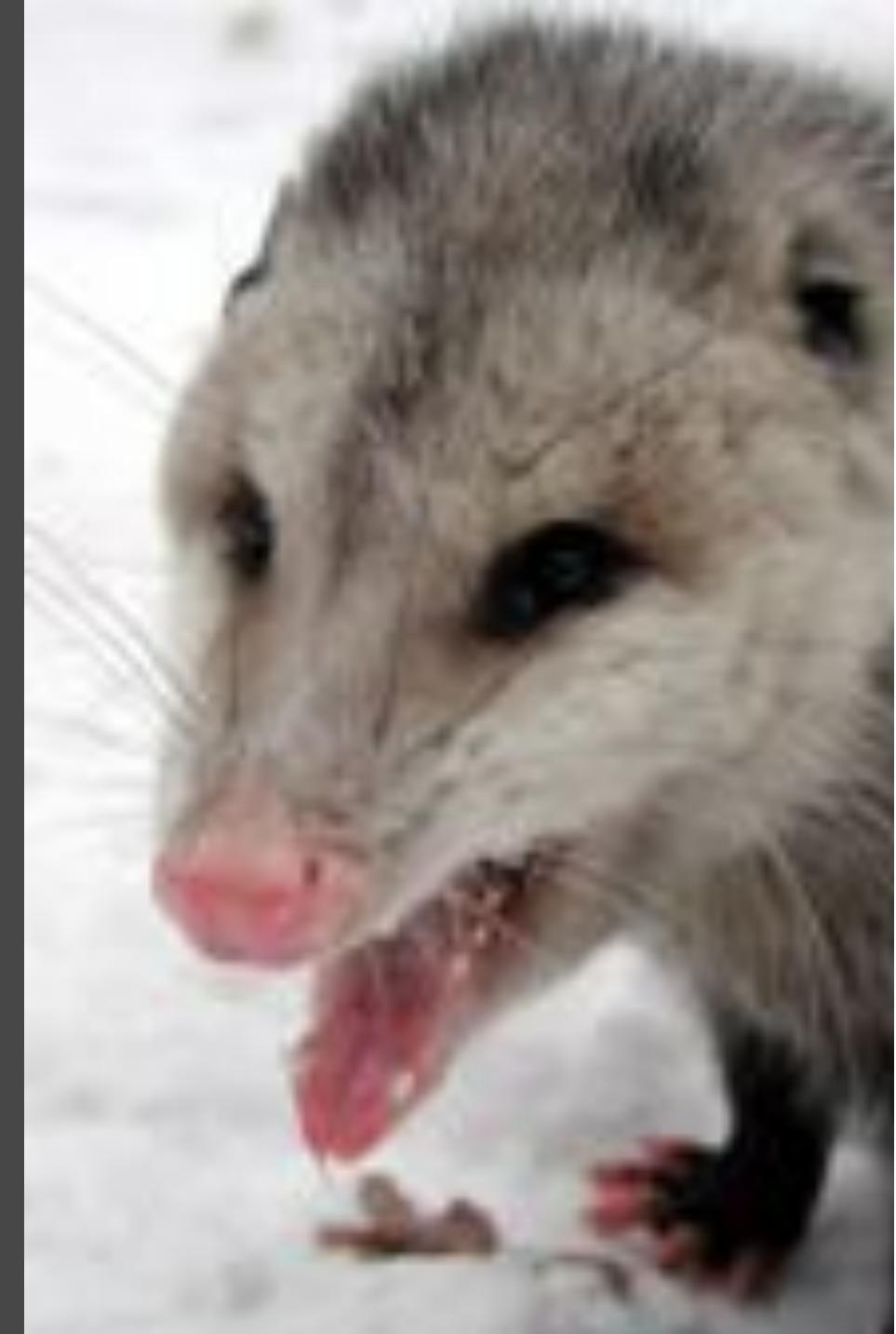
- dolní: v ose okluse: největší efekt pákového pohybu (m.temporalis) - přenos síly do přední části dentice, zkracování horizont.ramena páky / prodlužiování vert. (proc.coronoideus)
- horní: nad osou okluse: maximisace efektu závěsového pohybu (m.masseter) - účinnosti silové addukce v molariformní oklusního prostoru

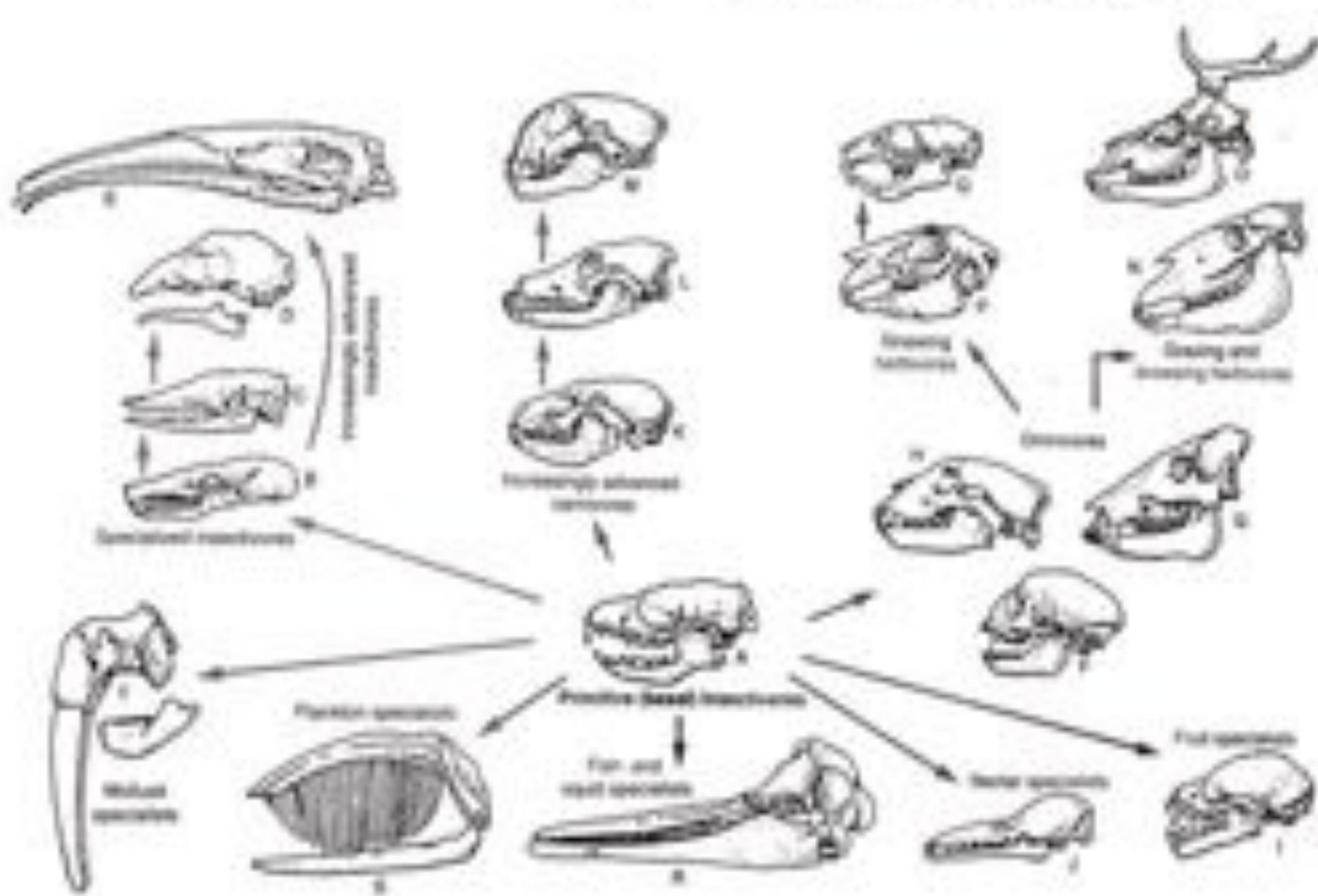




# Potravní adaptace:

Výchozí stav:  
širokospetrá faunivorie  
(zejm. insectivorie) +  
frugivorie ,  
oportunistická predace





**Figure 6.1** Skull and dentition specialization. Hunting specializations in the dentition and skulls of mammals relate to their dietary habits. (A) Insectivore; (B) meat; (C) omnivore; (D) grazers; (E) giant carnivore; (F) mammal; (G) grazing; (H) deer; (I) koala; (J) grazing herbivore eating leaf.

Zákl. paradigma  
srovnávací odontologie  
savců

1: všechny typy  
savčích stoliček  
vznikly vývojovou  
diferenciací  
*tribosfénické*  
stoličky

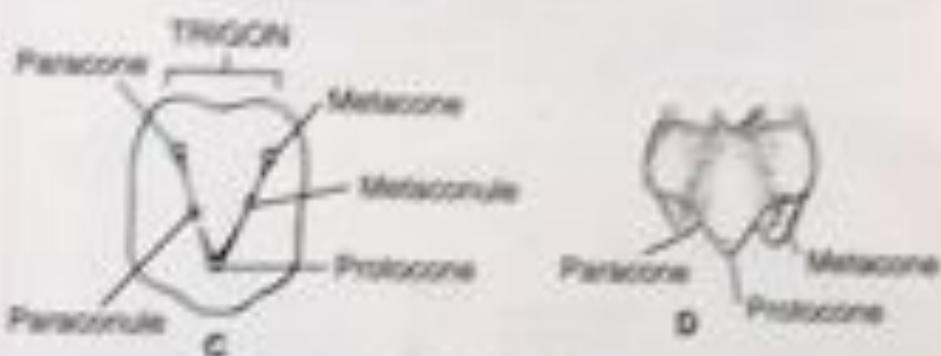
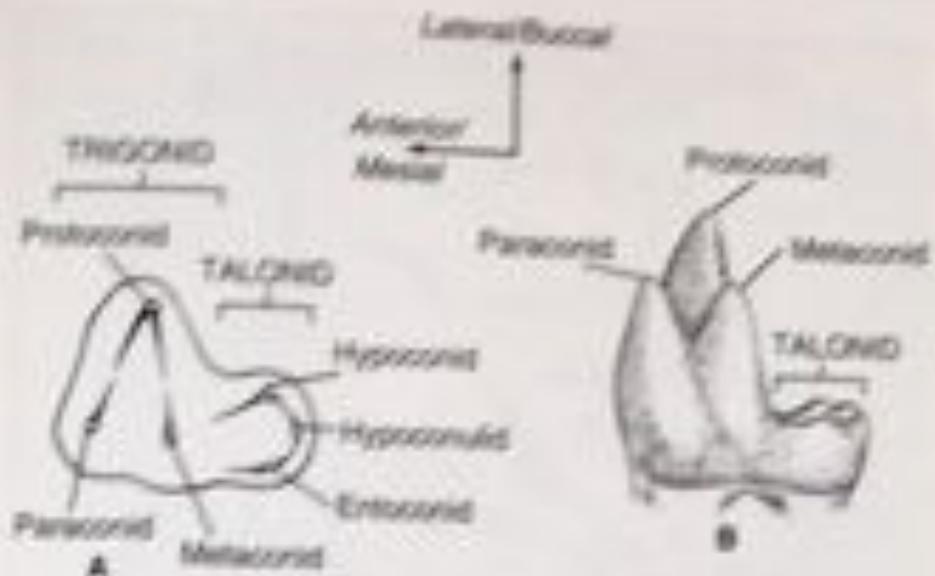


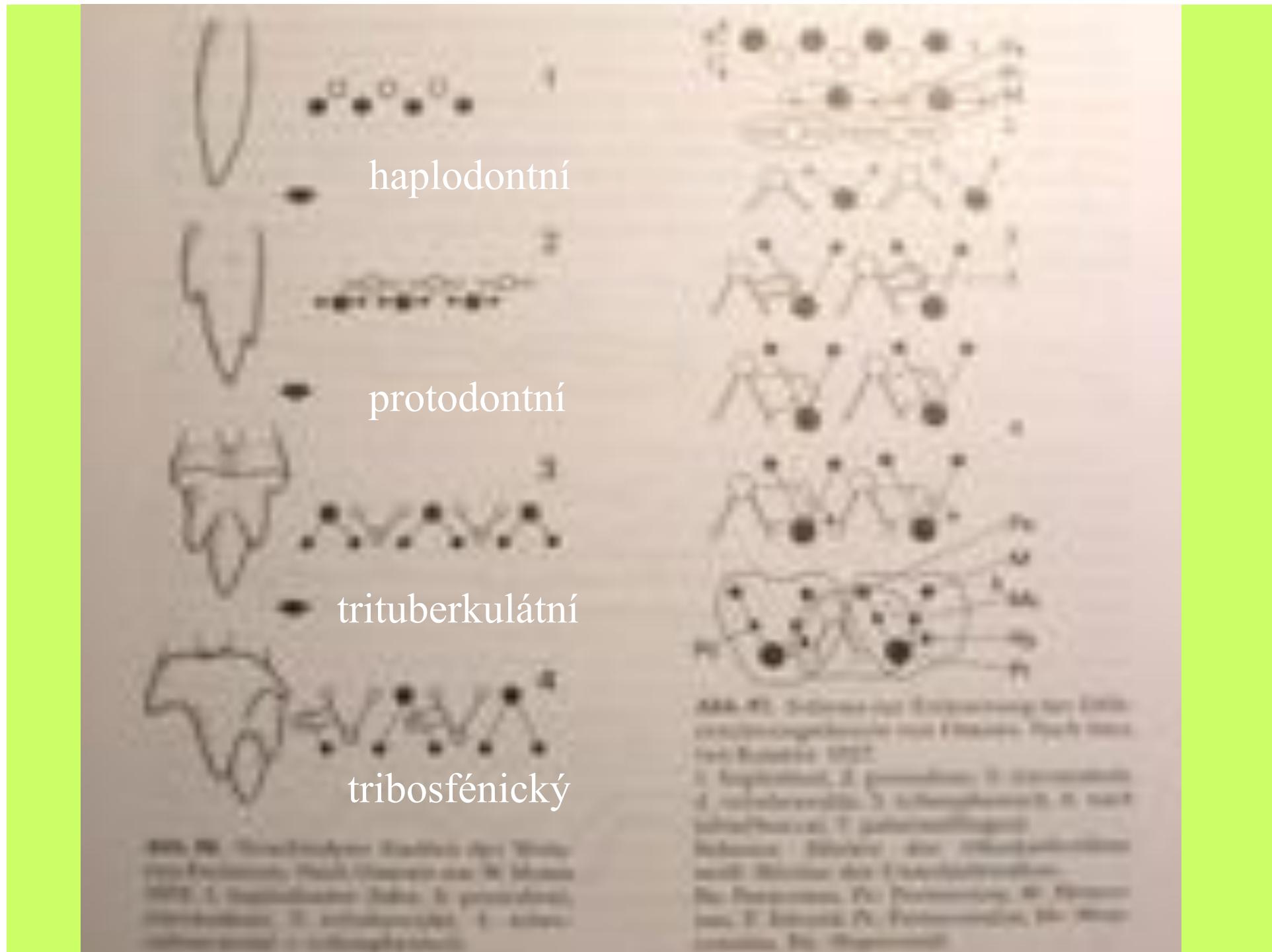
# Cope-Osbornův model dentální evoluce

- E.D.Cope 1883: výchozí typ u všech skupin savců - trituberkulátní molár
- H.F.Osborn 1907: evoluce savčí dentice diferenciací trituberkulátního (tuberkulo-sektoriálního) typu (=tribosfenický molár sensu Simpson), veškeré zuby savčí dentice lze s tímto typem homologisovat
- jednotlivé zuby i jejich strukturní elementy jsou vzájemně homologní (zákl. předpoklad srovnávací analysy)
- existuje zde homologie historická, seriální i iterativní

|                   | Bryozoa<br>dolomica | Schalen-<br>kraut | Ran-<br>mydoe | Multiku-<br>berulosa | Mycetina<br>strobilosa | Ectone-<br>donta | Symme-<br>tridae | Dissi-<br>clonia | Ponta-<br>tharia | Thysia-<br>cidae | Meso-<br>rhiza | Sulcatae |
|-------------------|---------------------|-------------------|---------------|----------------------|------------------------|------------------|------------------|------------------|------------------|------------------|----------------|----------|
| Ostero-<br>Kreide |                     |                   |               |                      |                        |                  |                  |                  |                  |                  |                |          |
| Jahor-<br>Kreide  |                     |                   |               |                      |                        |                  |                  |                  |                  |                  |                |          |
| Oster-<br>Dolce   |                     |                   |               |                      |                        |                  |                  |                  |                  |                  |                |          |
| Unter-<br>Dolce   |                     |                   |               |                      |                        |                  |                  |                  |                  |                  |                |          |
| Unter-<br>Jura    |                     |                   |               |                      |                        |                  |                  |                  |                  |                  |                |          |

Die Tabelle zeigt die Verteilung von Bryozoenarten auf verschiedene Schichtungen. Für jede Ordnung nach Römerow eignete Trennungslage nur eine, die Absonderung der Zählziffer nicht möglich oder fraglich. — Nach Künne-Schäfer 1977.

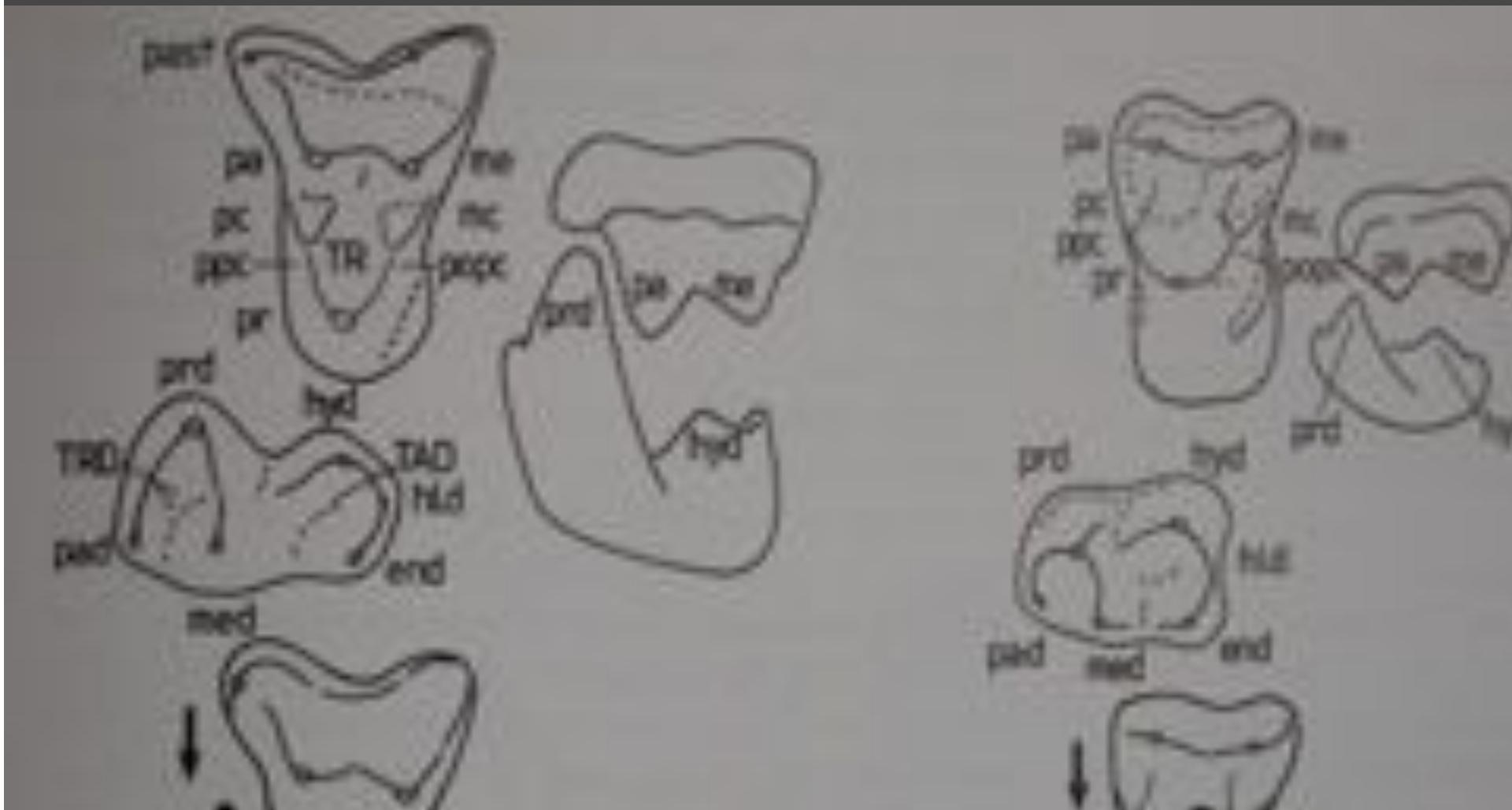




# Cope-Osbornova teorie dentální homologie

- (1) trituberkulátní zub ancestrální všem savcům
- (2) vzniká z *jediného* kuželového zuba plazů přidáním postranních tuberkulů
- (3) nové hrbolky vznikají *diferenciací* nikoliv konkresencí
- (4) u md.zubů je pův.hrbolek na vnější straně, u max na vnitřní
- (5) Z (2-4) plyne, že všechny jednotlivé zuby dentice a všechny jejich struktury (cingula, styly, cristy) jsou vzájemně *homologní*
- existuje zde homologie *historická, seriální iterativní*

# Cope-Osbornova terminologie a homologisace



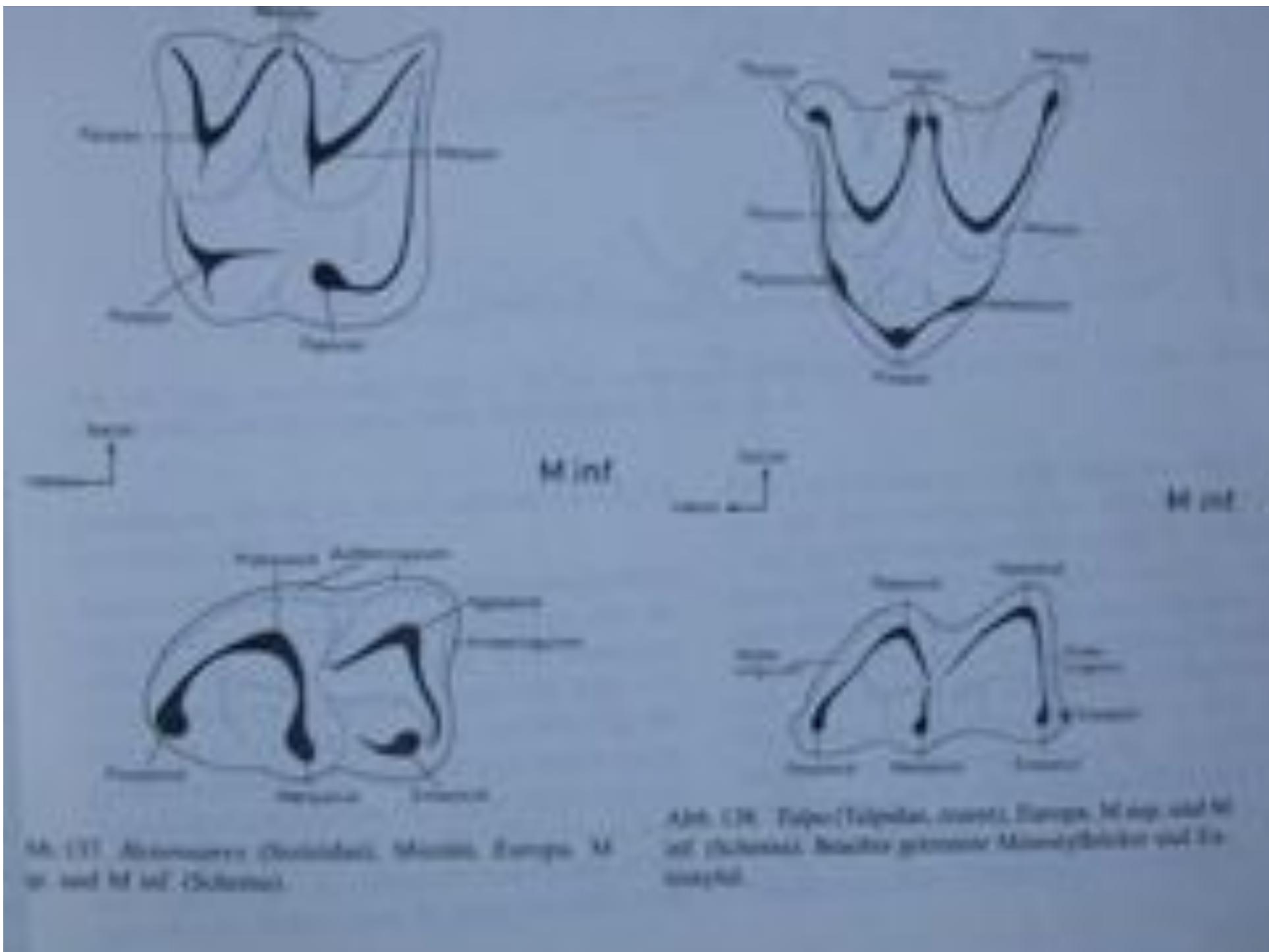


Abb. 138. *Maxillärer (oben) und mandibularer (unten) Europa-M1 und M2 inf.* (Schemat.)

Abb. 138. Folger (Teilgebaut, anatom. Europa, M1 und M2 und M1 inf. Schemat.). Rechte gekennzeichnet Maxillärer und links mandibularer.

# *Nomenklatorický výraz Cope-Osbornovy homologisace*

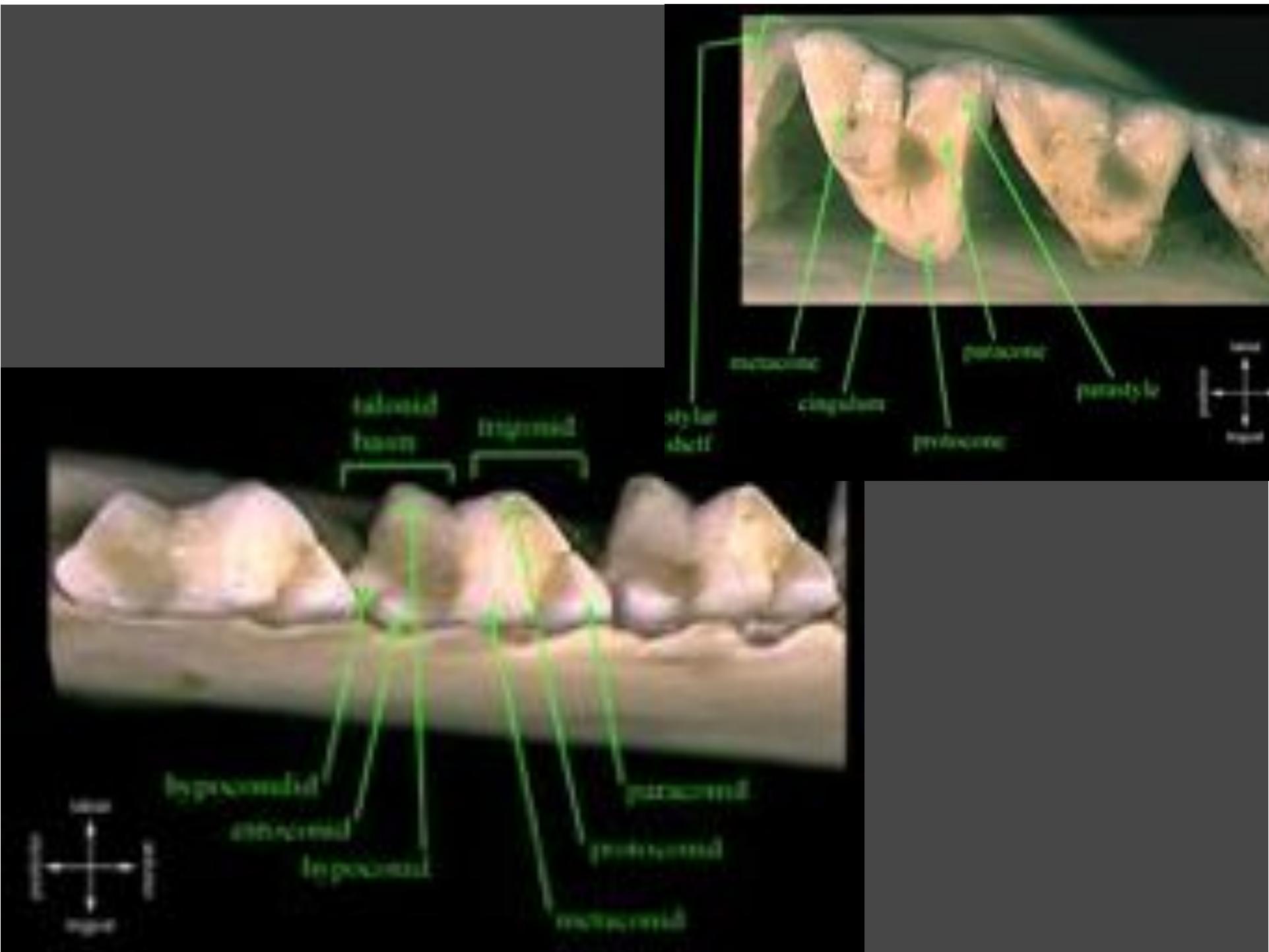
- *Maxilární*
- 1 protoconus
- 2 paraconus
- 3 metaconus
- 4 hypoconus
- 5 dist.cingulum
- Talon
- Trigon 1-2-3

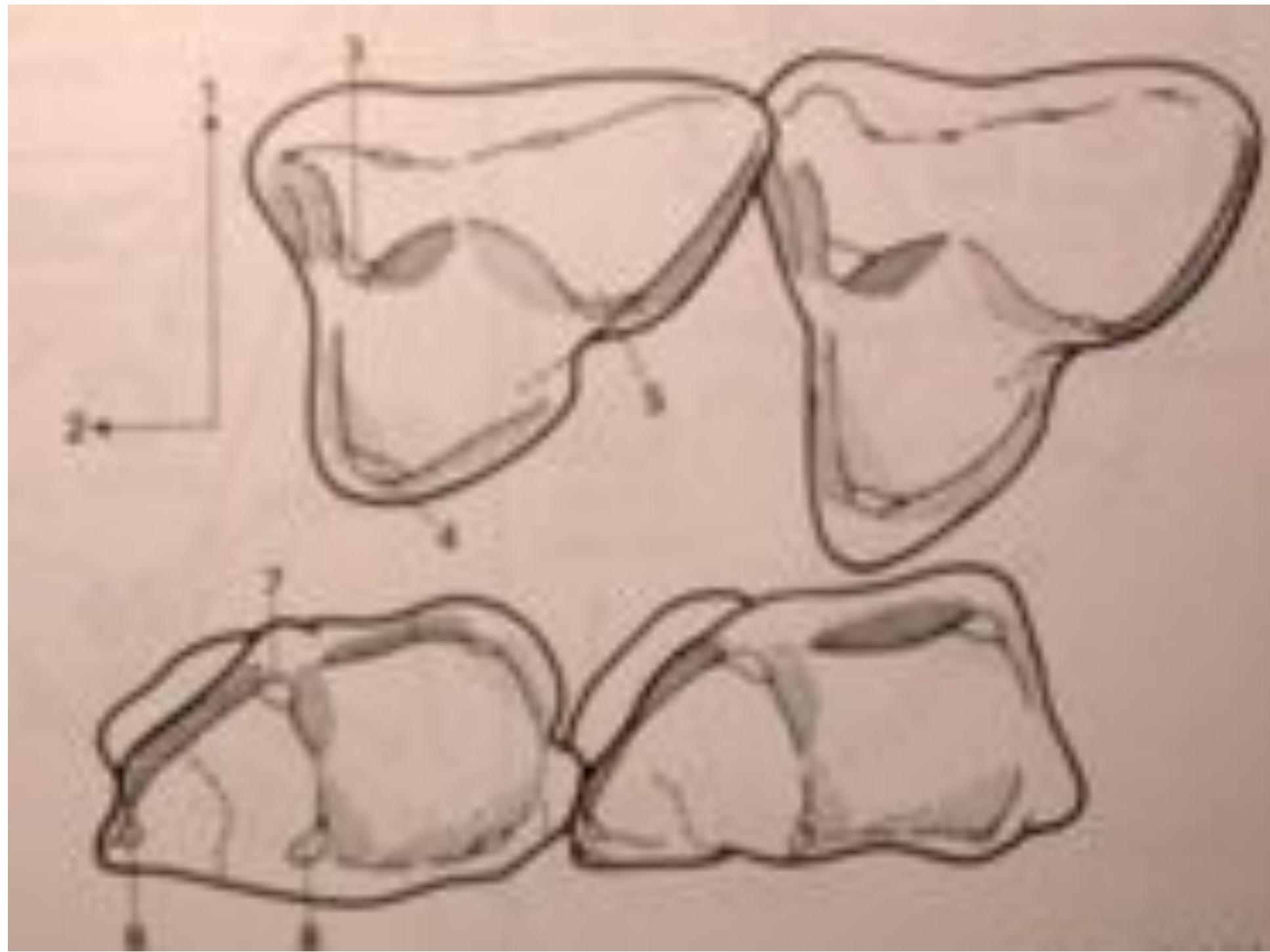


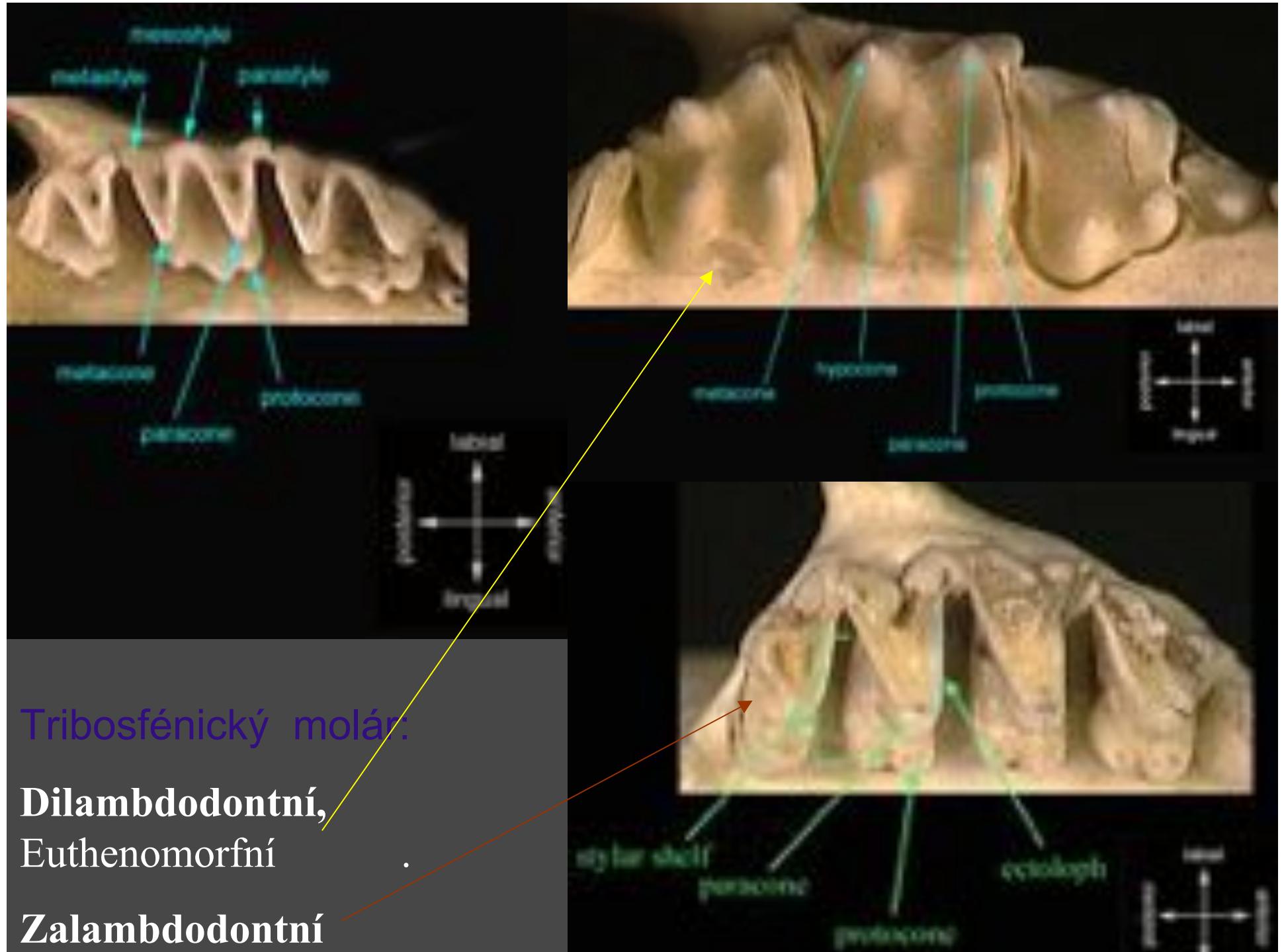
- *Mandibulární*
- 1 protoconid
- 2 paraconid
- 3 metaconid
- 4 hypoconid
- 5 entoconid
- Talonid
- Trigonid 1-2-3

...ale ...

- 
- vzájemně neokludují a jejich velikost nekoreluje
- ve fylogenesi se objevují v jiném pořadí než predikuje teorie
- atd

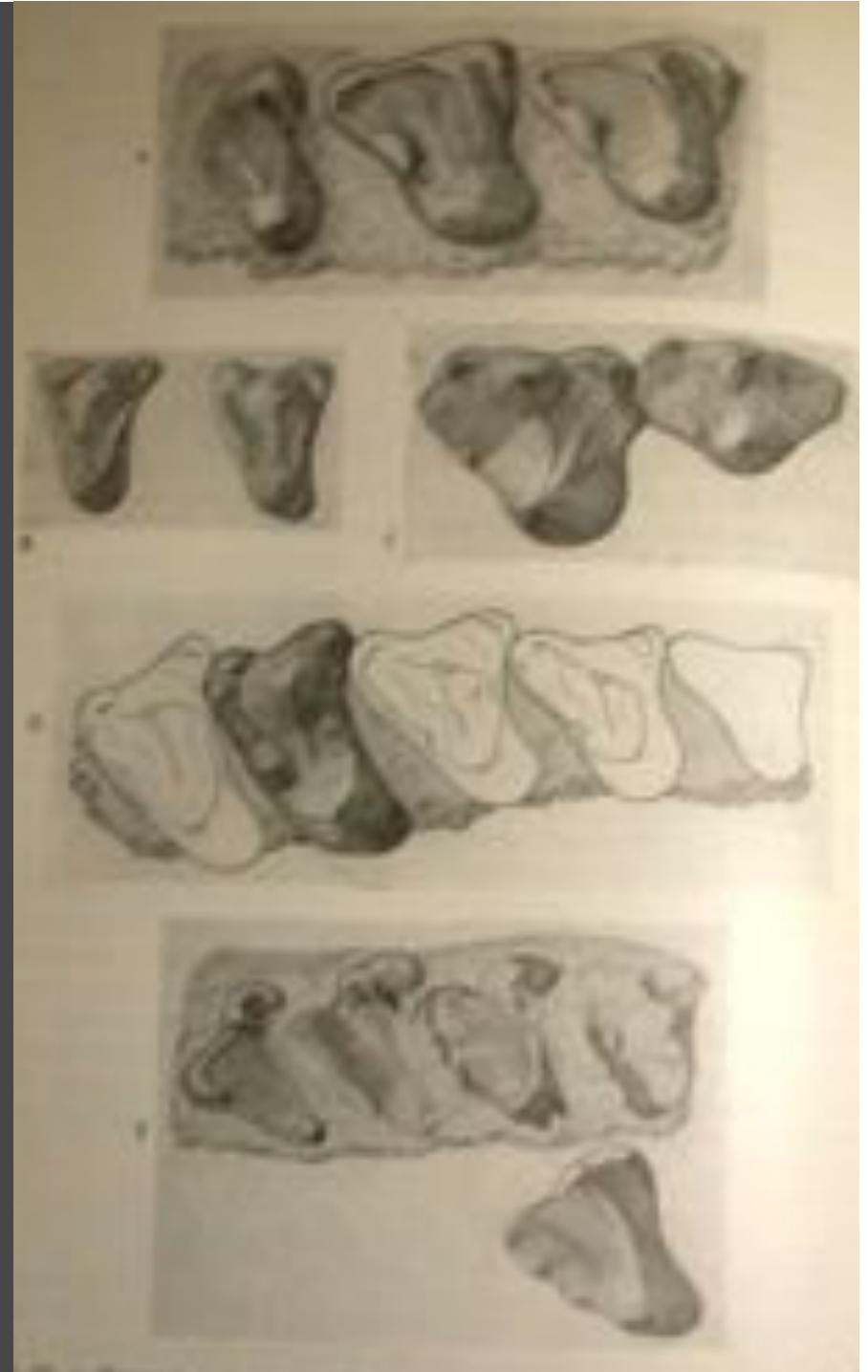






## Eupantotheria

- Dryolestidae - drobní omnivoři J-Cr
- Peramuridae  
– Cr





Figures illustrating the mouth parts of the *Homoptera*, with their anatomical names, drawn by J. G. Koenigsmann, and reduced from his original drawings by Dr. F. W. H. Melsheimer, and published by the author. The figures are arranged in three rows: the top row has four drawings, the middle row has five, and the bottom row has six. The drawings are numbered 1 through 14. The labels include: 1. Mandible; 2. Maxilla; 3. Maxillary palp; 4. Labrum; 5. Lip; 6. Labium; 7. Maxillary palp; 8. Maxilla; 9. Mandible; 10. Maxilla; 11. Maxillary palp; 12. Labrum; 13. Lip; 14. Labium.

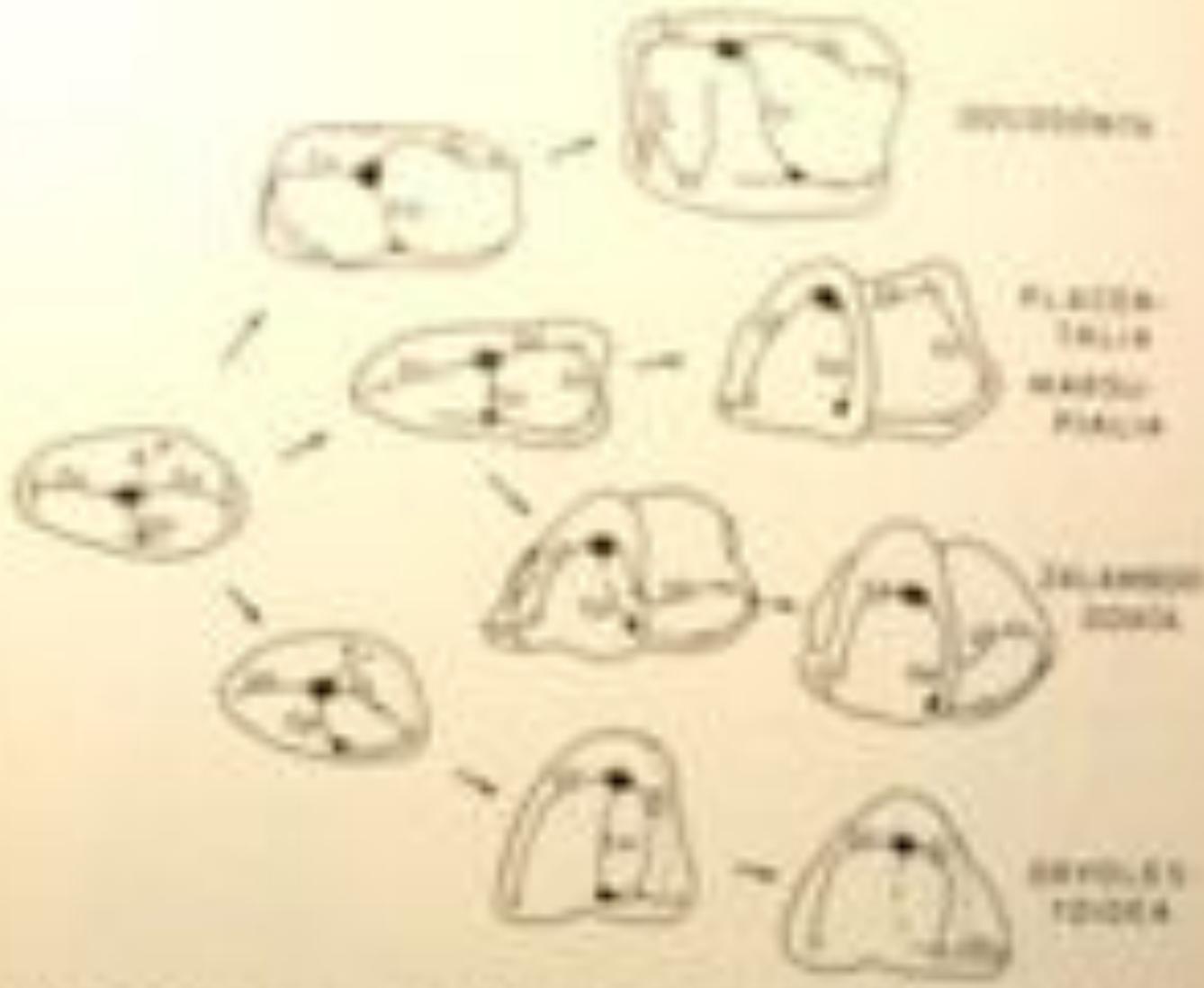
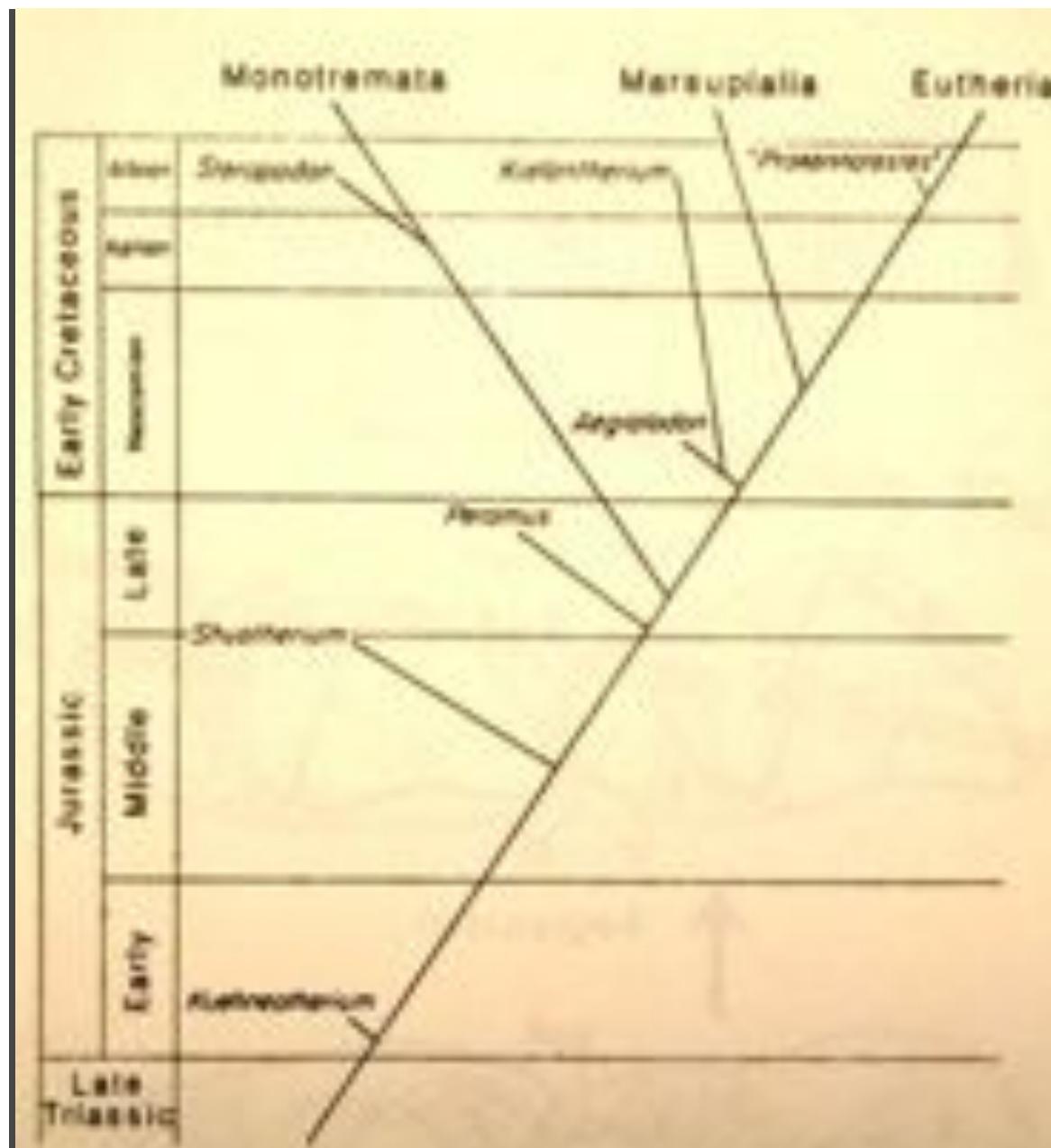
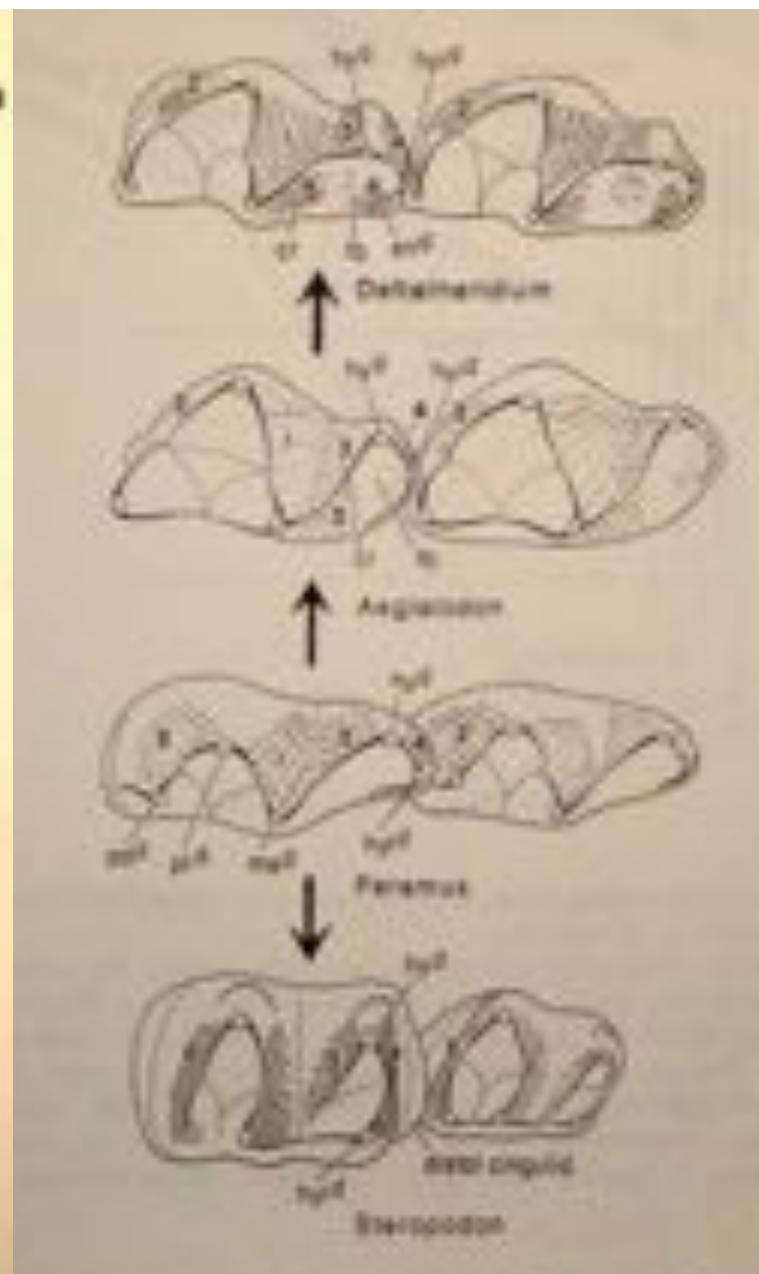


Figure 10. Diagram showing (a) and (b) showing progressive development of the four different types of plant cells and (c) indicating the division and maturing stages of the meristematic cell.

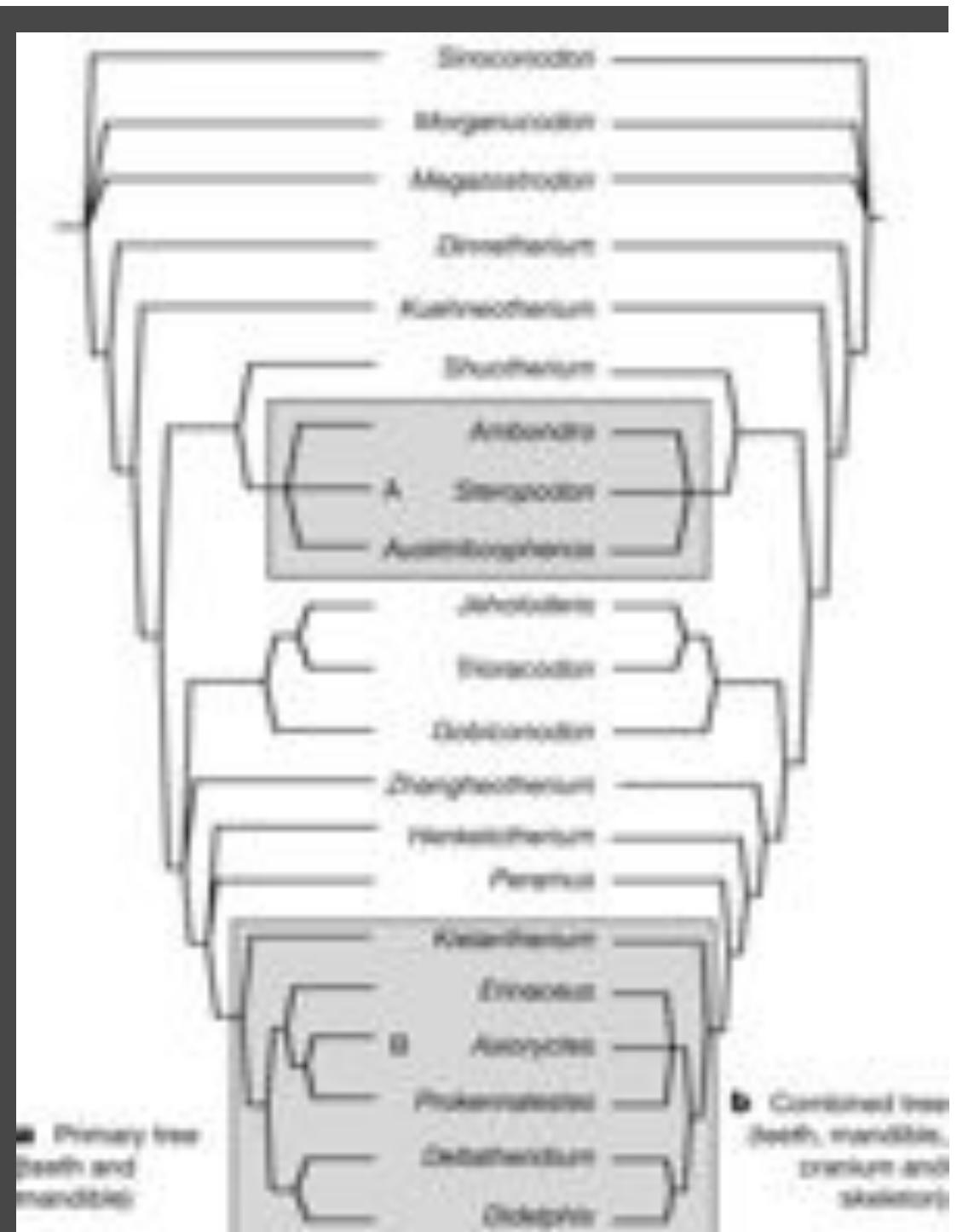
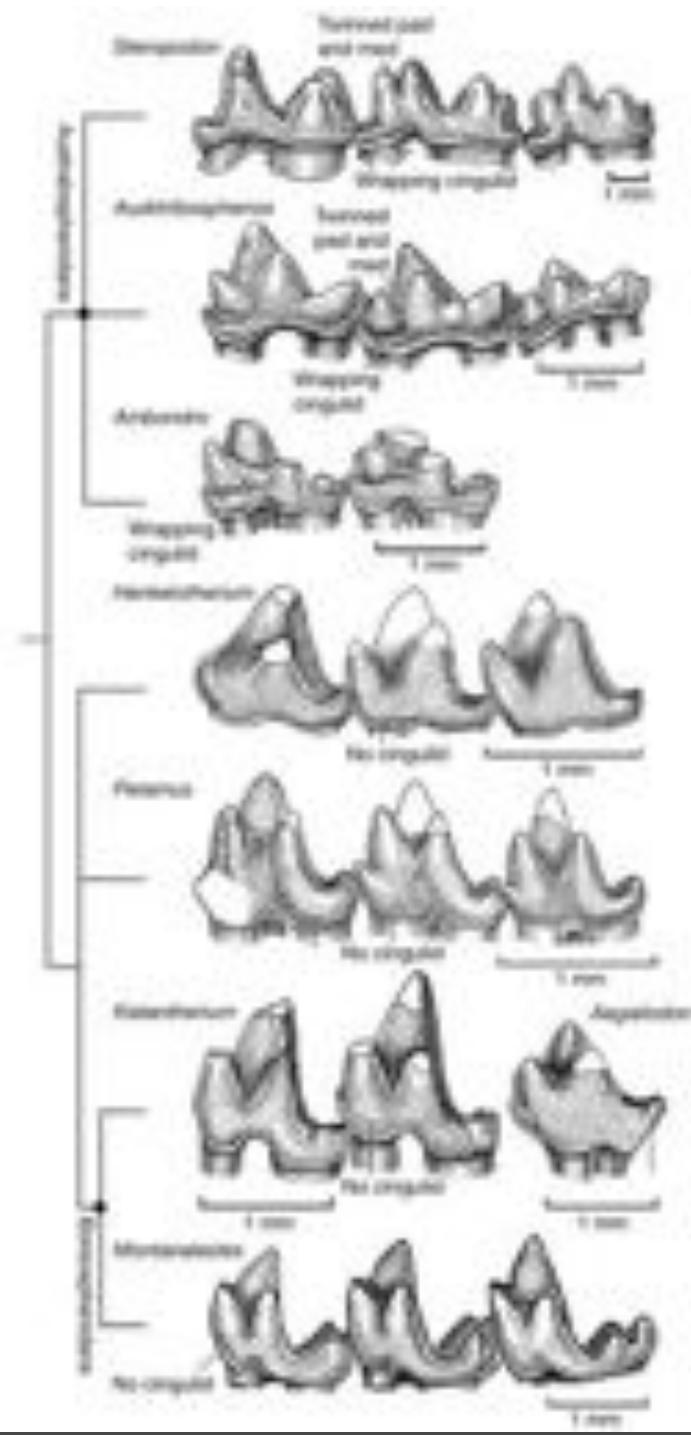
(a) = Apical meristem (b) = Tissue differentiation and division (c) = Division  
Fig. 10. Diagram showing (a) and (b) showing progressive development of the four different types of plant cells and (c) indicating the division and maturing stages of the meristematic cell.



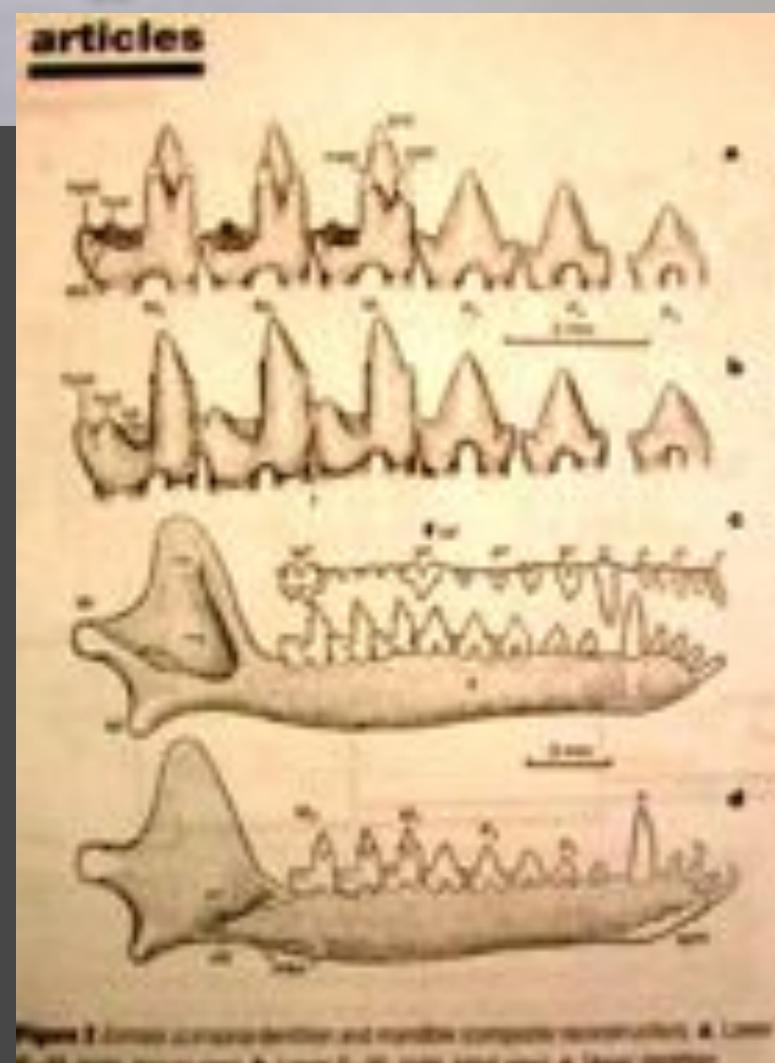
**Fig. 2 Relations of *Steropodon*.**



**Fig. 3 Comparison of pre-tribosphenic (*Ptenomys*), tribosphenic (*Angulatitan* and *Deltatherium*) and *Steropodon* lower molar in occlusal view. Homologous shearing surfaces (1-4) numbered according to the scheme of Crompton et al. (1972). 'hypf' associated with 'hypoflex' and 'mglf' associated with 'metaglyphe'.**



- Nejstarší doklad EUTHERIA:
- *Eomaia scansoria* Ji et al., 2002  
Crl Čína 125 My ago (tj. 50 My před jinými Euth.)



# Potravní specialisace - dentální adaptace

- primární situace - širokospektrá mikrofaunivorie
- makrofaunivorie a odvozené typy (ichtyofagie apod.)
- mikrofaunivorní specialisace
- herbivorie (frugivorie, nektarivorie, palynovorie, foliovorie, graminivorie)

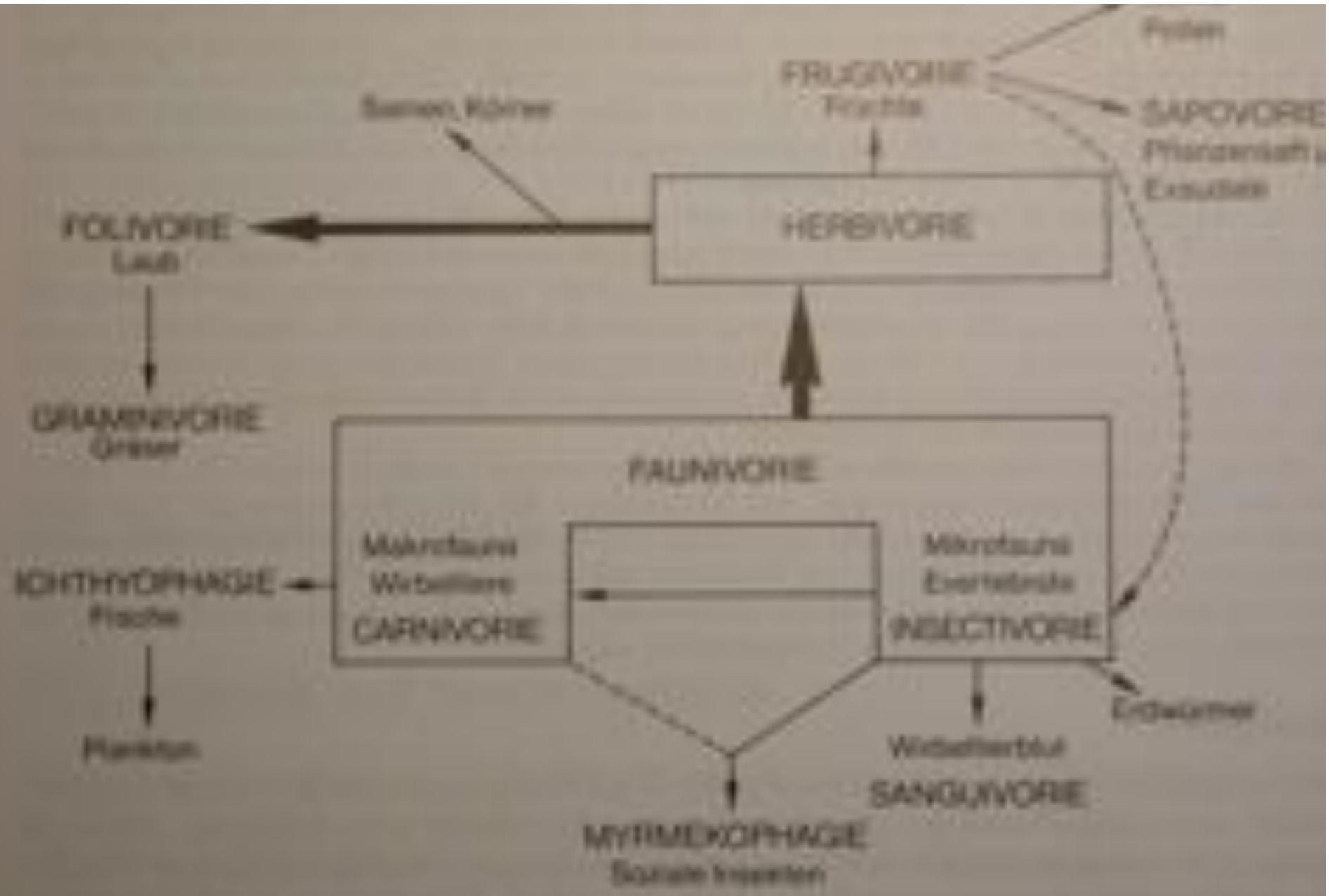


Abb. 81: Übersicht über die verschiedenen Ernährungstypen bei Säugetieren und deren physische Überprüfung

# Komponenty dentálních adaptací

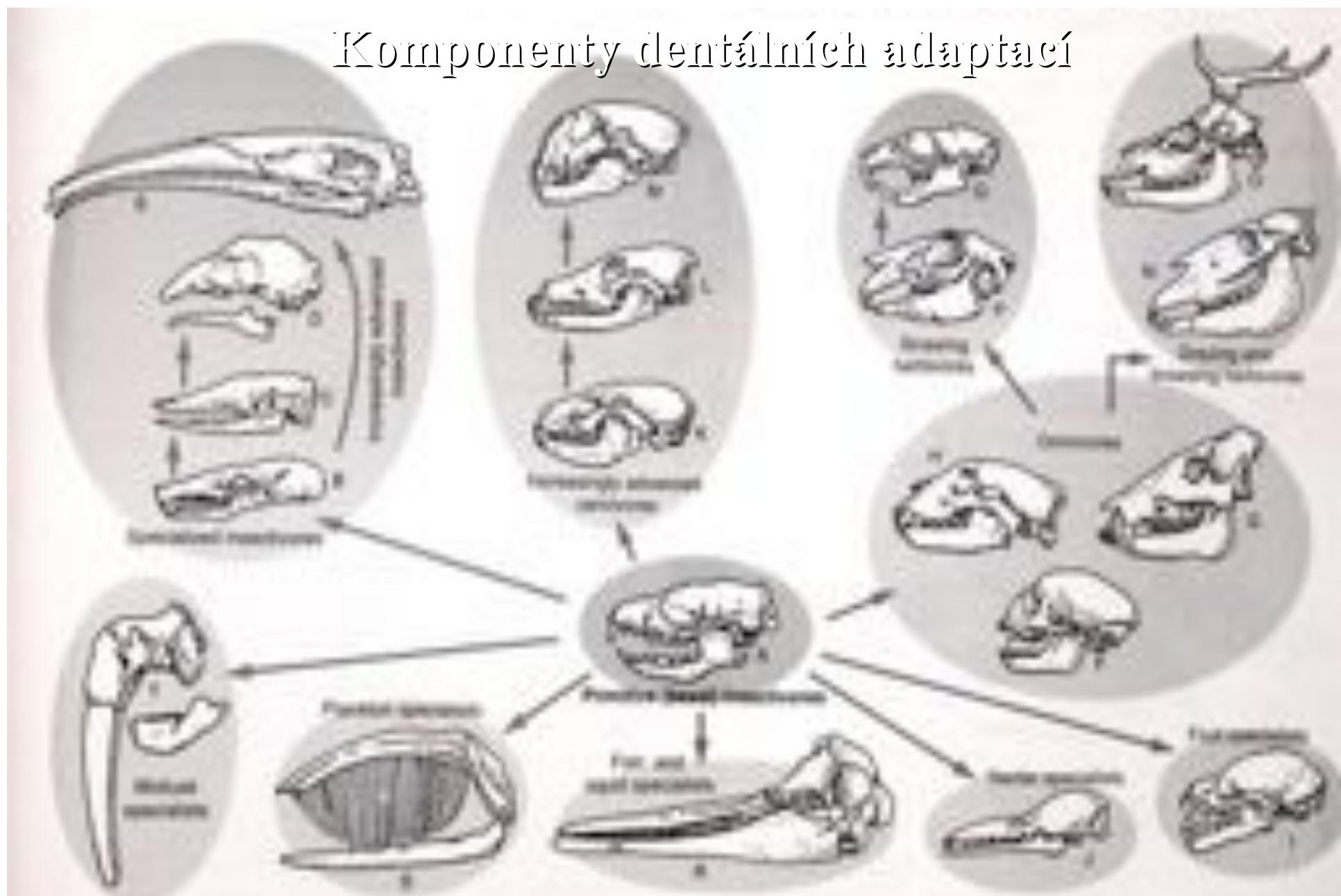
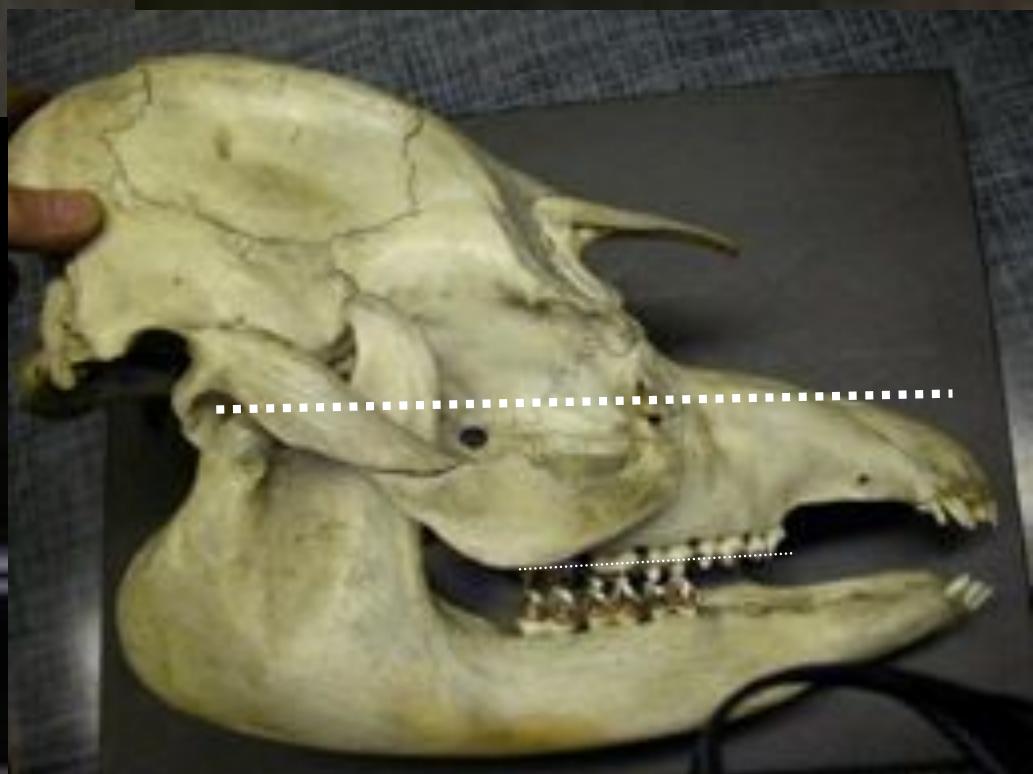
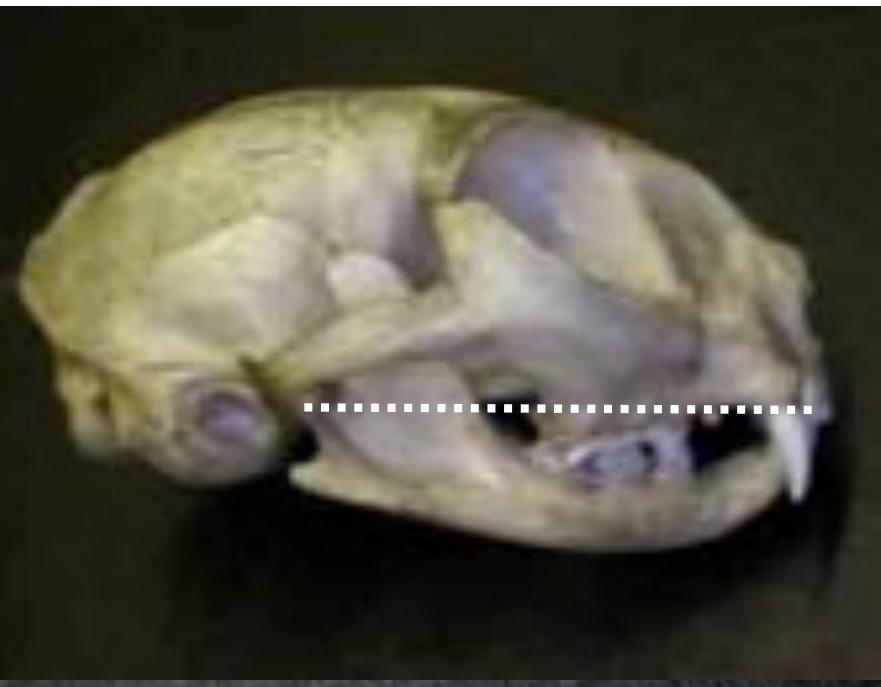
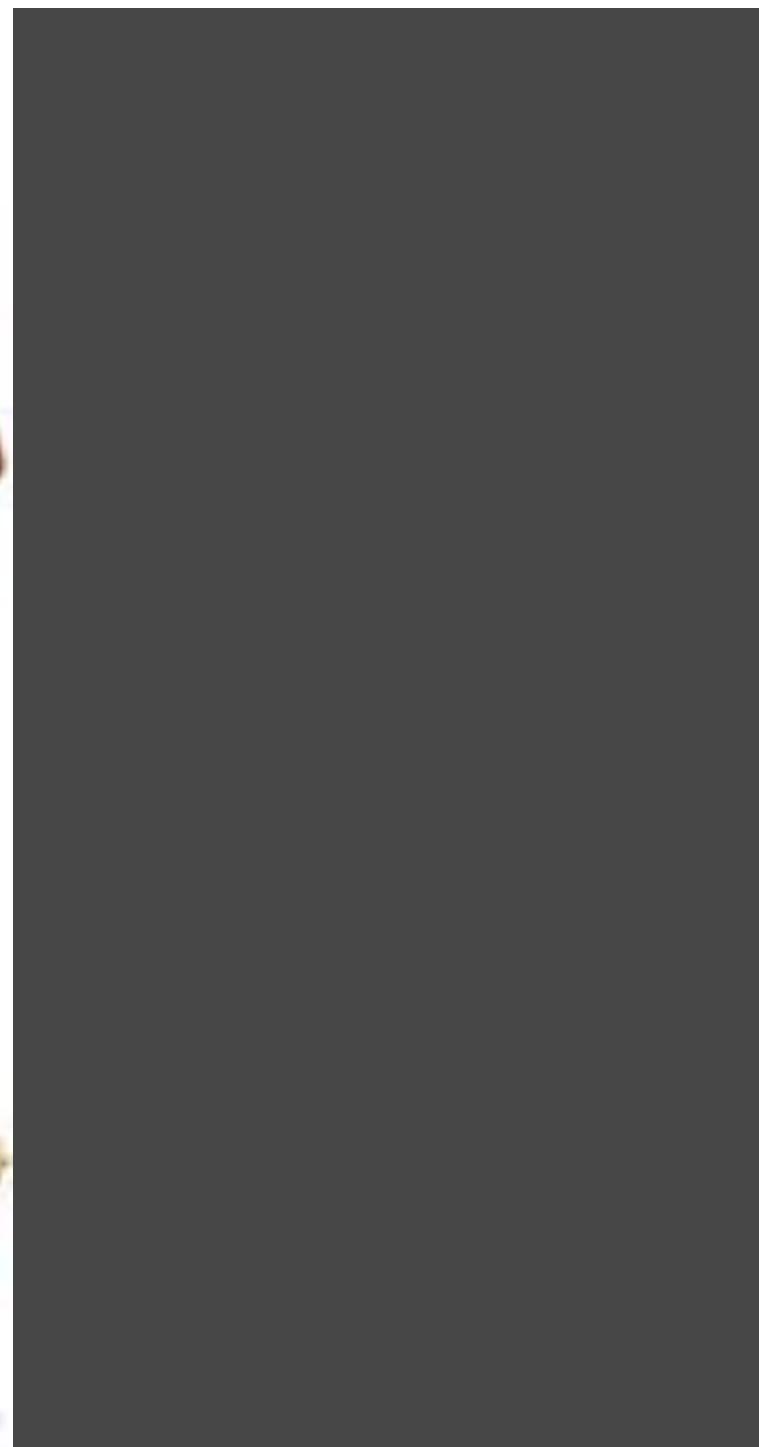
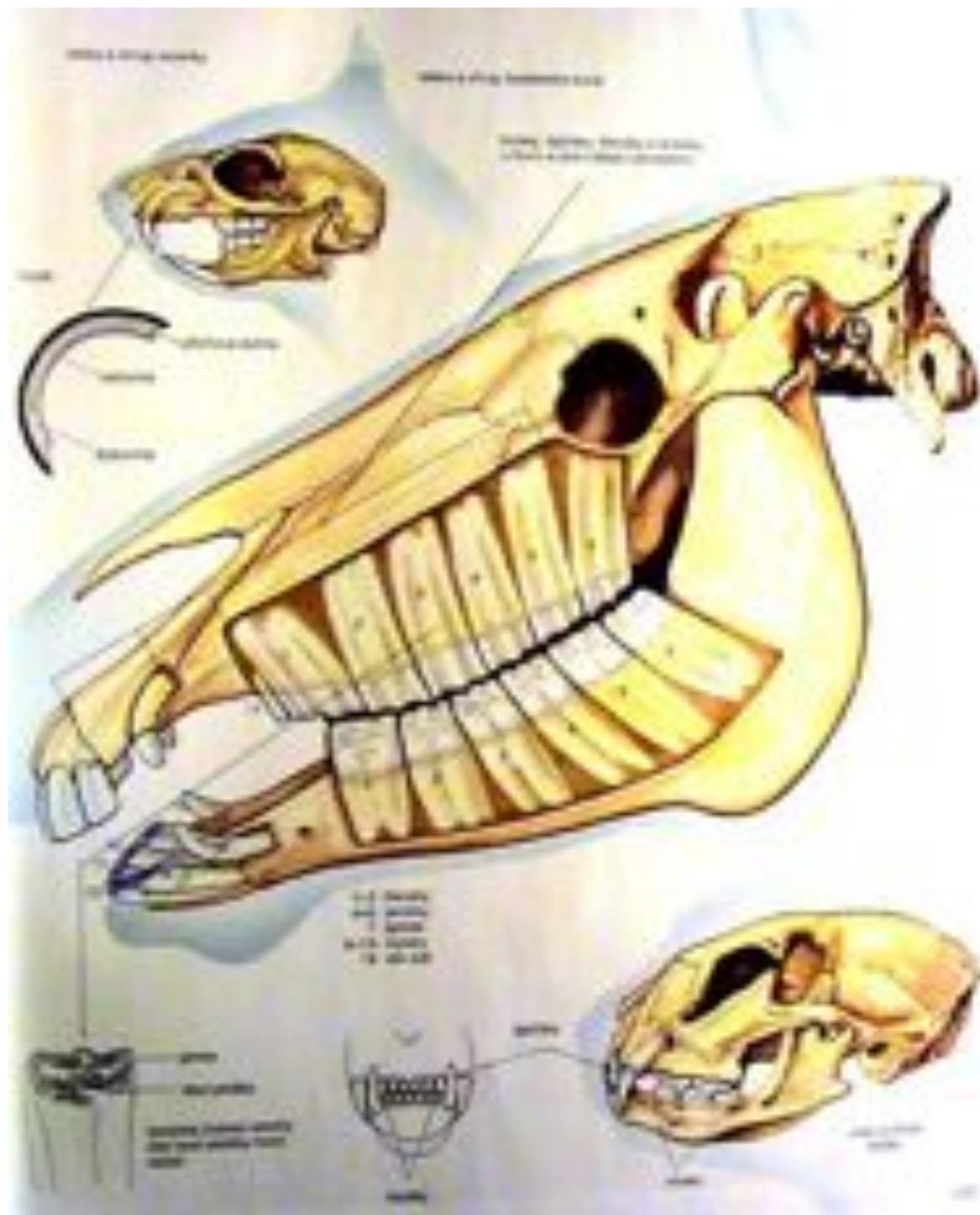


Figure 6.1. Skull and dentition specializations. Planting generalizations in the dentition and skulls of mammals range to other dietary niches. (1) Insectivore; (2) herbivore; (3) omnivore; (4) carnivore; (5) fruit and seed specialist; (6) frugivore; (7) leaf-eating herbivore; (8) leaf-eating herbivore feeding tool.

## (i) Posice čelistního kloubu

- dolní: v ose okluse: největší efekt pákového pohybu (m.temporalis) - přenos síly do přední části dentice, zkracování horizont.ramena páky / prodlužování vert. (proc.coronoideus)
- horní: nad osou okluse: maximisace efektu závěsového pohybu (m.masseter) - účinnosti silové addukce v molariformní oklusního prostoru





## (ii) Přestavby dentice, tvaru zubů (zejm. stoliček) a skloviny



Figure 6.2 Skalička and dentition specifications. - Figuring variations in the dental morphology of mammals, ranging from simple teeth to complex, all-predatory (shovel-shaped molars, etc.) teeth. (Source: Skalička and Dentition, 2006, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 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# Adaptivní strategie vs. diferenciační potenciál dentice a jednotlivých zubů

- *generalismus ? nebo*
- *potravní specialisace ?*
- výtěžnost potravy vs.  
náročnost potřebných  
přestaveb
- dostupnost potravy a  
spolehlivost strategie,
- *efektivita vs riziko adaptace*
- generalisovaný stav + reversibilní  
modulace (uvolnění constraints)
- redukce premolárové řady,  
relativní změny prostoru  
jednotlivých částí dentice
- přesun caninisace (do I-řady)
- přestavby molářů
- komplexní dentální apomorfie

# Typické adaptivní přestavby dentice

sběr drobné kořisti (ze substrátů) - caninisace incisivů

imobilisace velké kořisti - špičáky

trhání potravy - trháky

komsumace fragmentované potravy bez tlakového zpracovávání -  
redukce molariformní řady

transport objemné či tekuté potravy - prodloužení premolárového  
sektoru dentice (často s redukcí zubů - diastema)

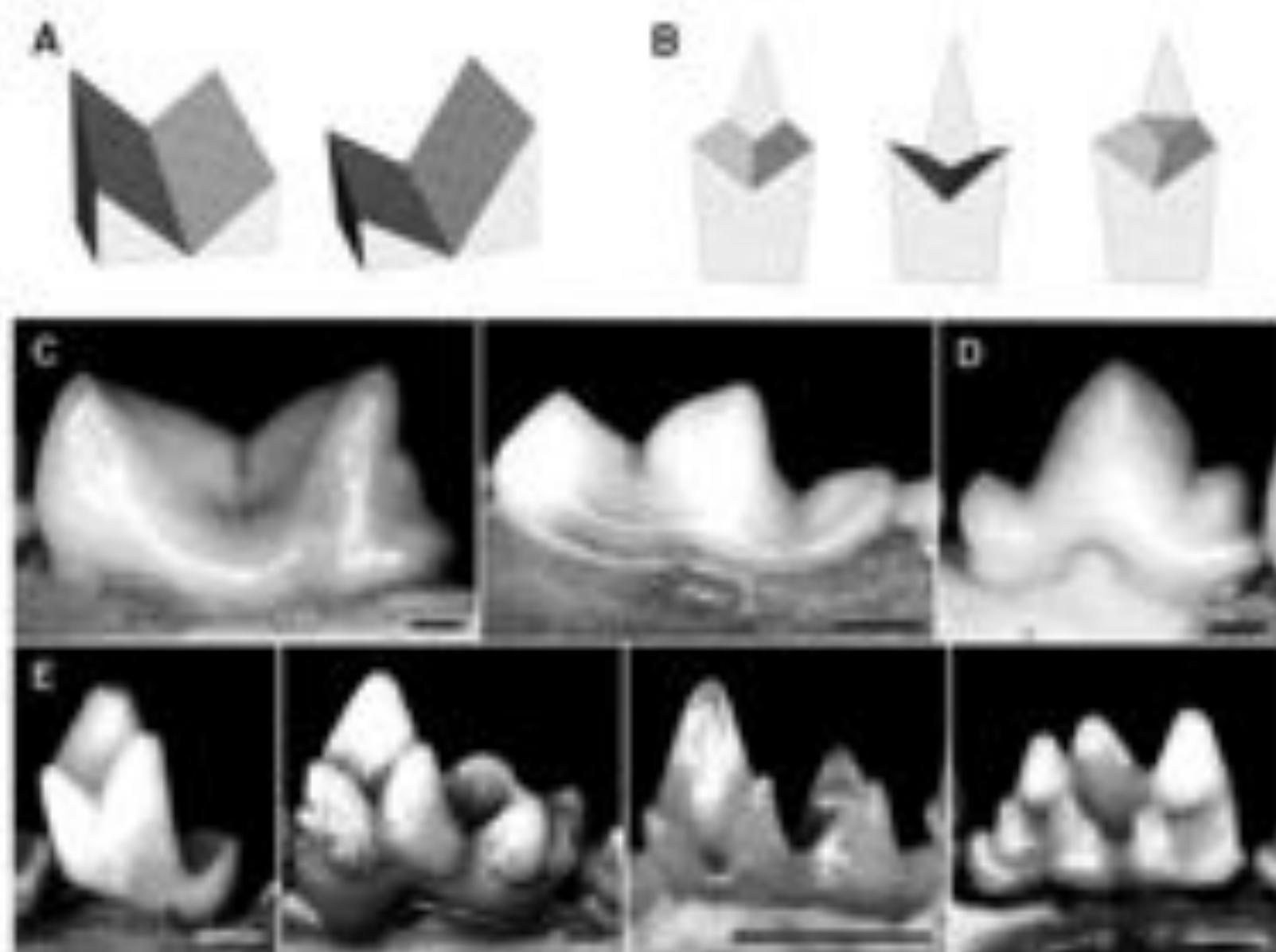
tlakové zpracování objemné potravy - zvětšení plochy molariformní  
řady (\*okluzní plochy zubů, počtu zubů - molarisace premolárů) -  
+ variantní specialisace

# Typické adaptivní přestavby moláru

- rozšíření tribosfénického rozvrhu - euthenomorfisace (dopl. o hypoconus etc.) - čtyřúhelníková plochy (pokroč.: včetně vyhrocení cingulárních cuspidů etc.)
- sekodontní typ - zesílení střížné efektivity - zvýšení a prodloužení hřebnů
- bunodontní typ - redukce hřebenů, plošné zesílení skloviny
- lofodontní typ - spojení hrubolků do příčných korunkových lišt

# Typické adaptivní přestavby molářů

- hypsodontie - zvýšení korunky (až hypselodontie - neukončený růst)
- plagiodontní /loxodontní typ - zmnožení lišt v rámci jednoho zuba (většinou v kombinaci s hypsodontií)
- selenodontní zub - kompartmentisace oklusní plochy, zvýšení hřebenů
- plagiolofodontní etc.

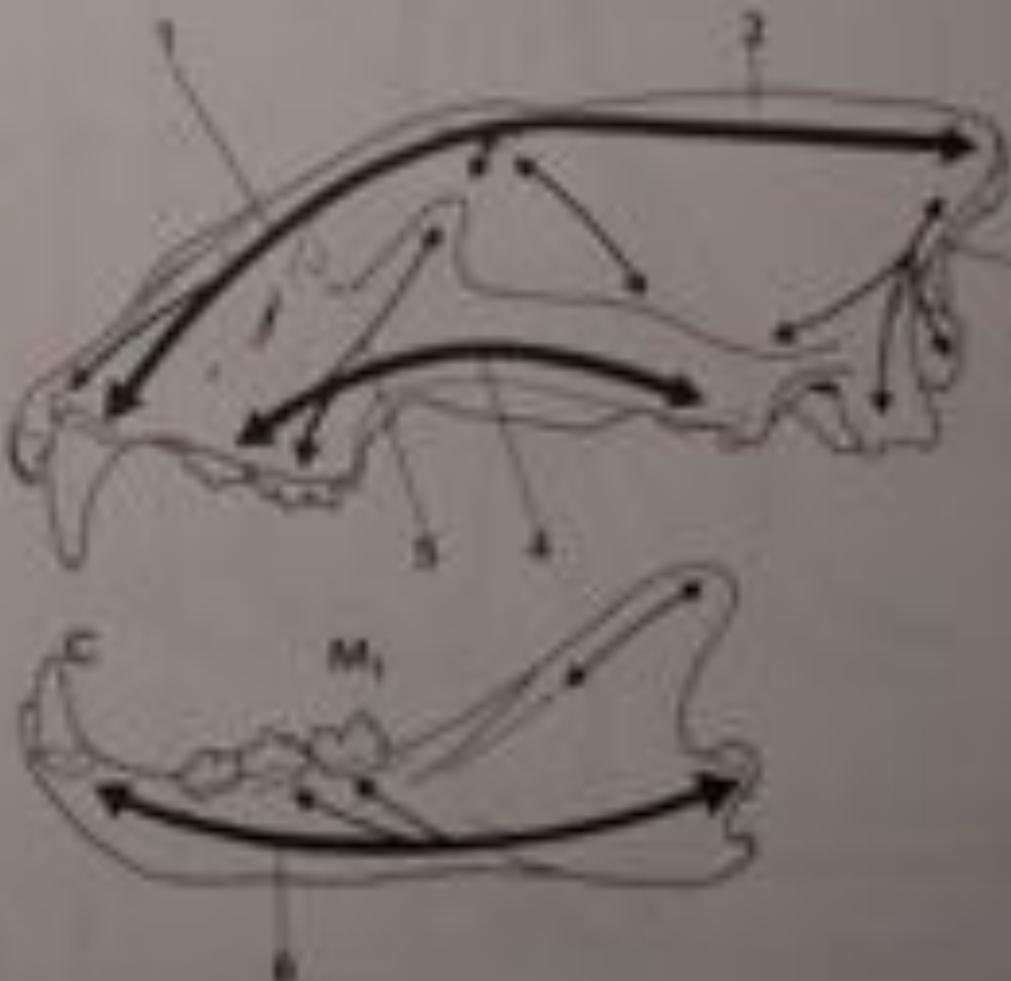


**Figure 5.** Comparative larvae of stink and reef mantispid path fauna. (A–B) Molted moults; (C) single-bladed teeth; symmetrical (C) and asymmetrical (D); (E) double-bladed teeth (G, H, I), day 40. Mantid larvae: (C) lower instars of *Petaurus aculeatus*; Follicular and Ricinus from *C. venusta*; Blattidae; (D) granular of *P. aculeata*; (E) lower instars of *Bruceia maculata* (Blattidae); Immature; Distinctive irregular; Distiphlepsophilus; Distiphlepsis; and Chalcophila granulata (Hymenoptera: Encyrtidae); and upper instar of *Bentornis nocturna* (Hymenoptera: Encyrtidae); Scale bar = 1 mm.

- maximisace aktu immobilisace velké kořisti - caninisace, extense m.temporalis (a odpovídající kraniální přestavby), redukce postcaninové dentice

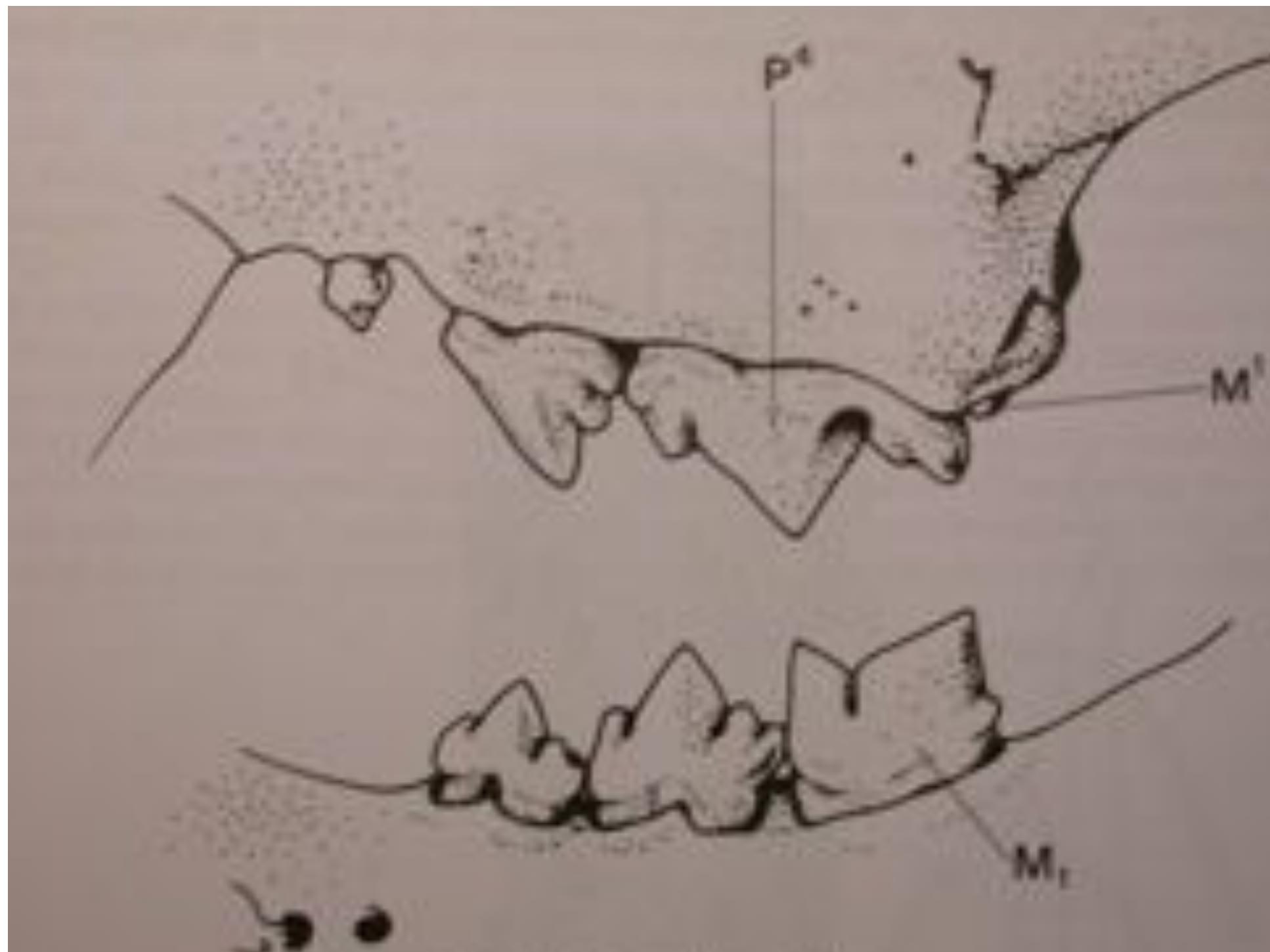
Abb. 38. Panthera leo. Löwe. Schädel. Darstellung der festen Knochenverbindungen im Suttermassiv. Nach Sprauz 1967.

1. Gelenk-mandibulo-frontaler Balken,
2. Crista supraorbitalis, 3. Crista maxillaris,
4. Jugulus Balken, 5. Frontaler Mahlzähnchenbalken, 6. Basalbogen im Unterkiefer,
7. Caninus, M<sub>1</sub> erster Molar im Unterkiefer.



Sekodontní





*Canis lupus*  
*carnassialis*

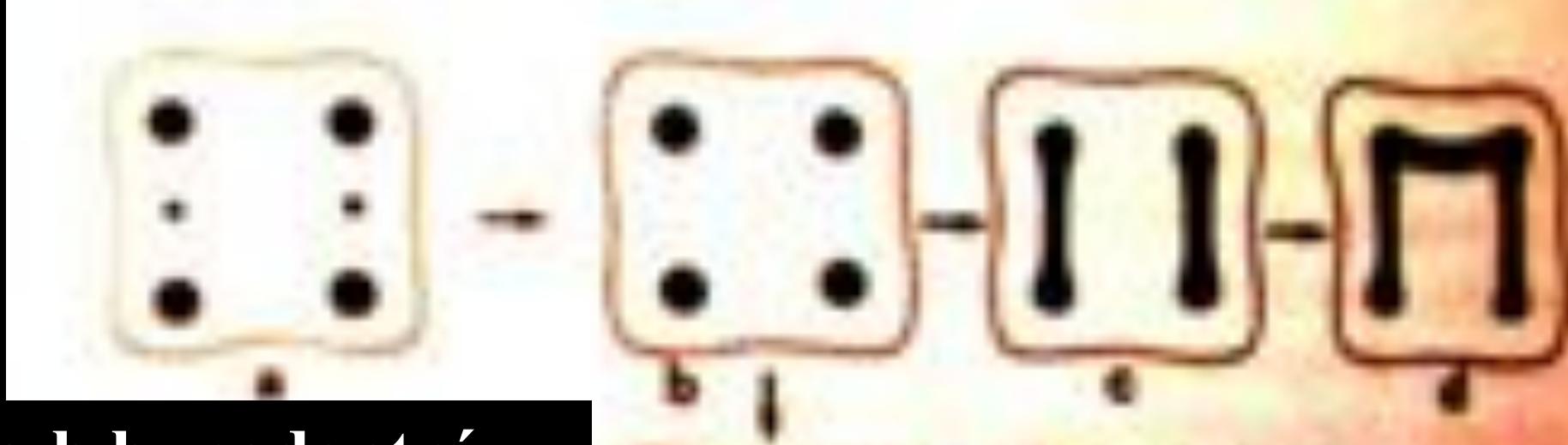
(Trháky) P4/, M/1

view from  
side



upper P4





a-b bunodontní

c- bilofodontní

d- trilofodontní

e- selenodotní

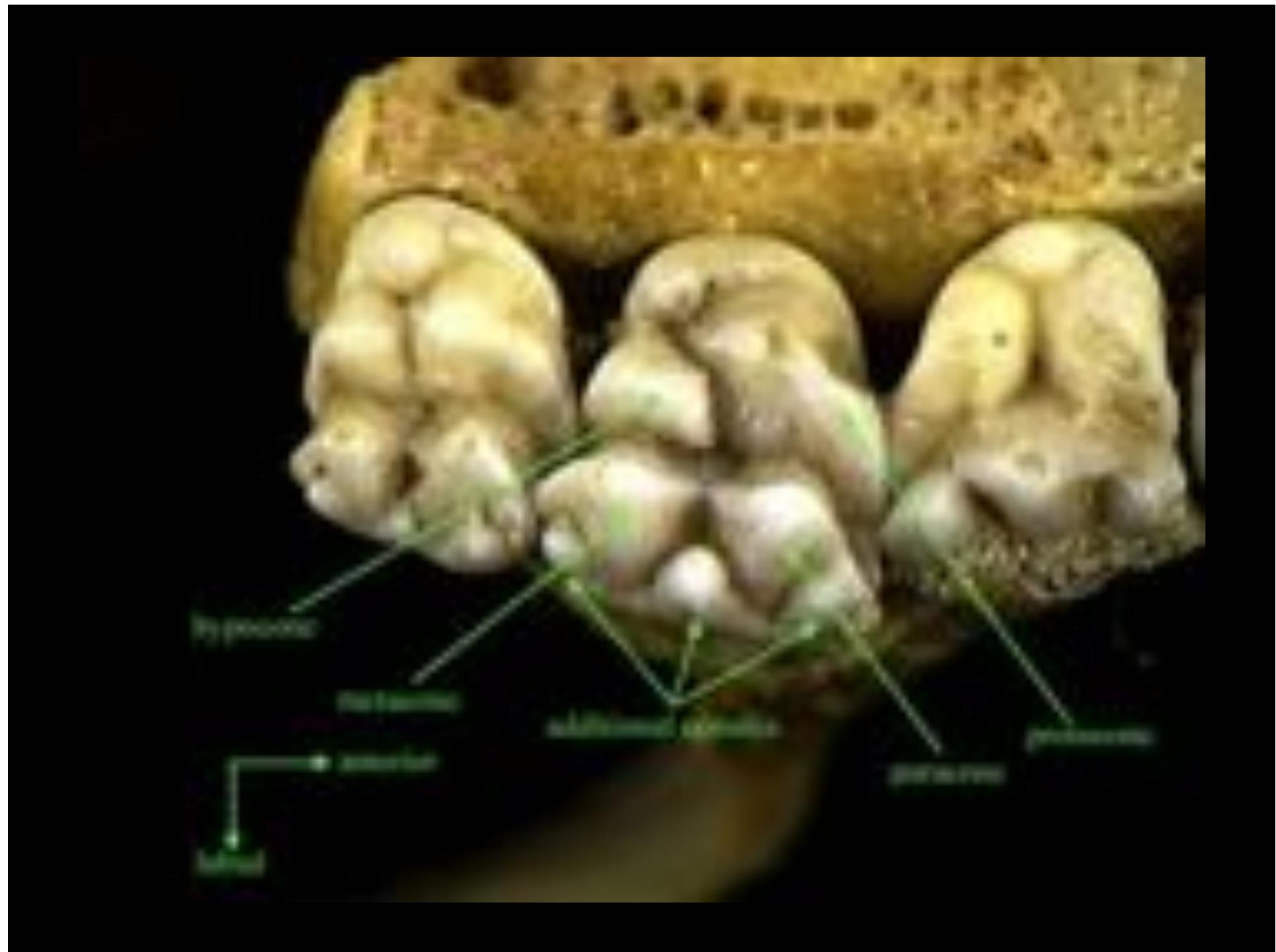
f - g seleno-  
lofodontní

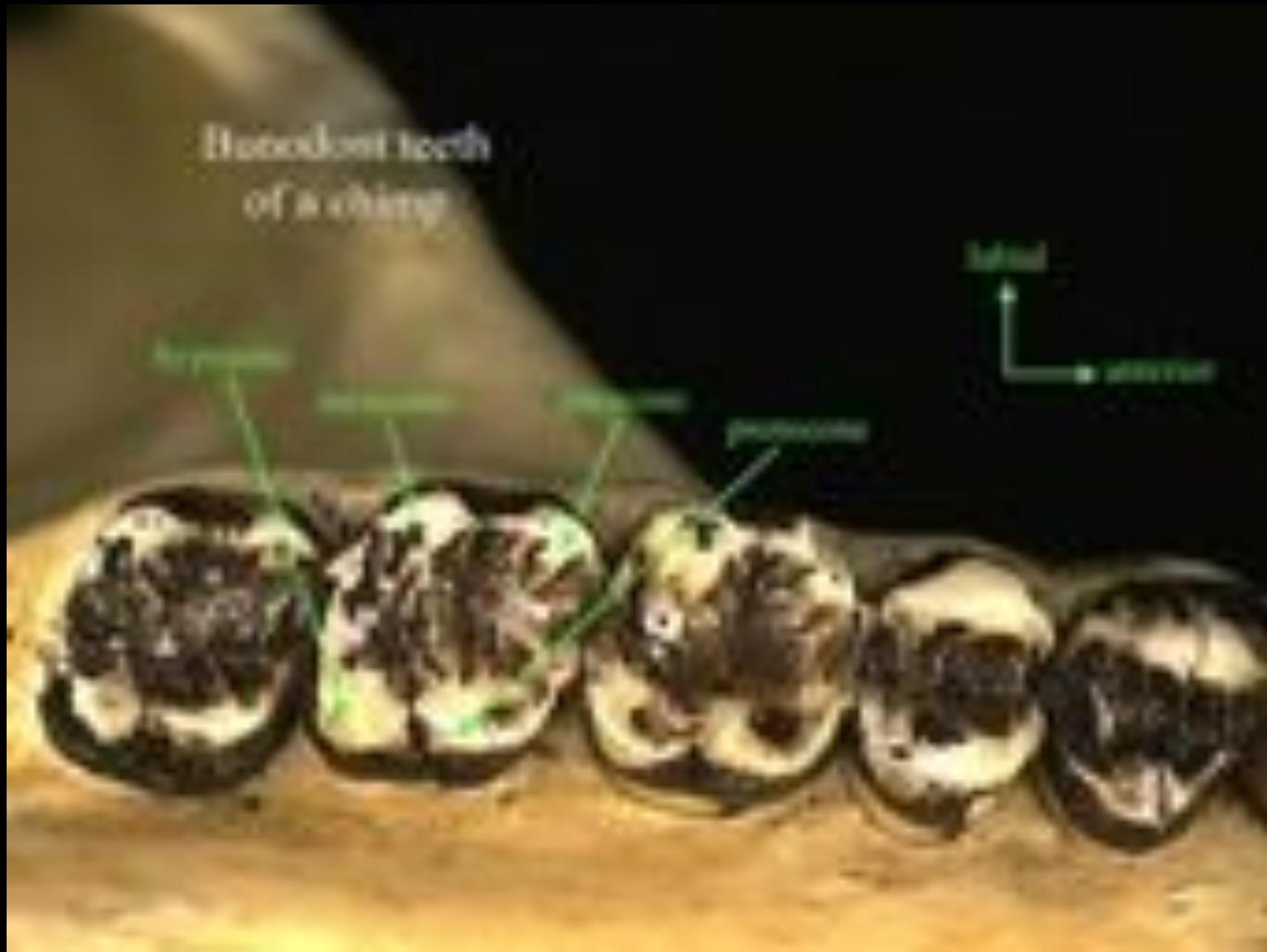
# Rodentia: komplex apomorfií





Figure 21.3. Specialized human Schreger bands (HGB) with corporotubularly oriented intergranular membranes (IGMs). The prints (P) of adjacent layers 8 + 9 are columnar, and the IGM lies in the third dimension. Figure 21.3 is a slightly etched negative section of the interior of the adult *Keratinocystis* dentin.





bifurcated cheek teeth of a baboon





## Lophodont teeth

Trepost  
(Therapsida)



Diprotodon  
(Ornithodonta)



Pholidoscelis  
(Therapsida)



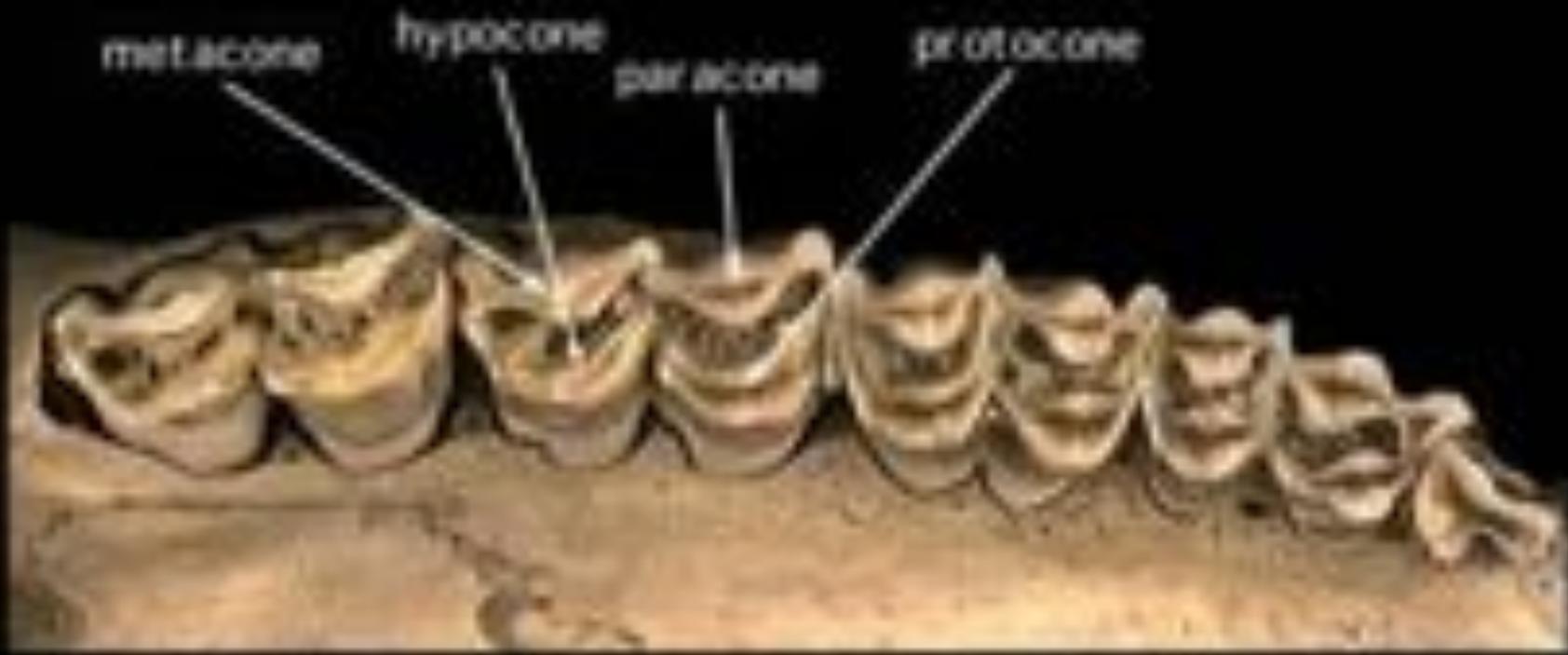
Rhynchosaurus  
(Parareptilia)

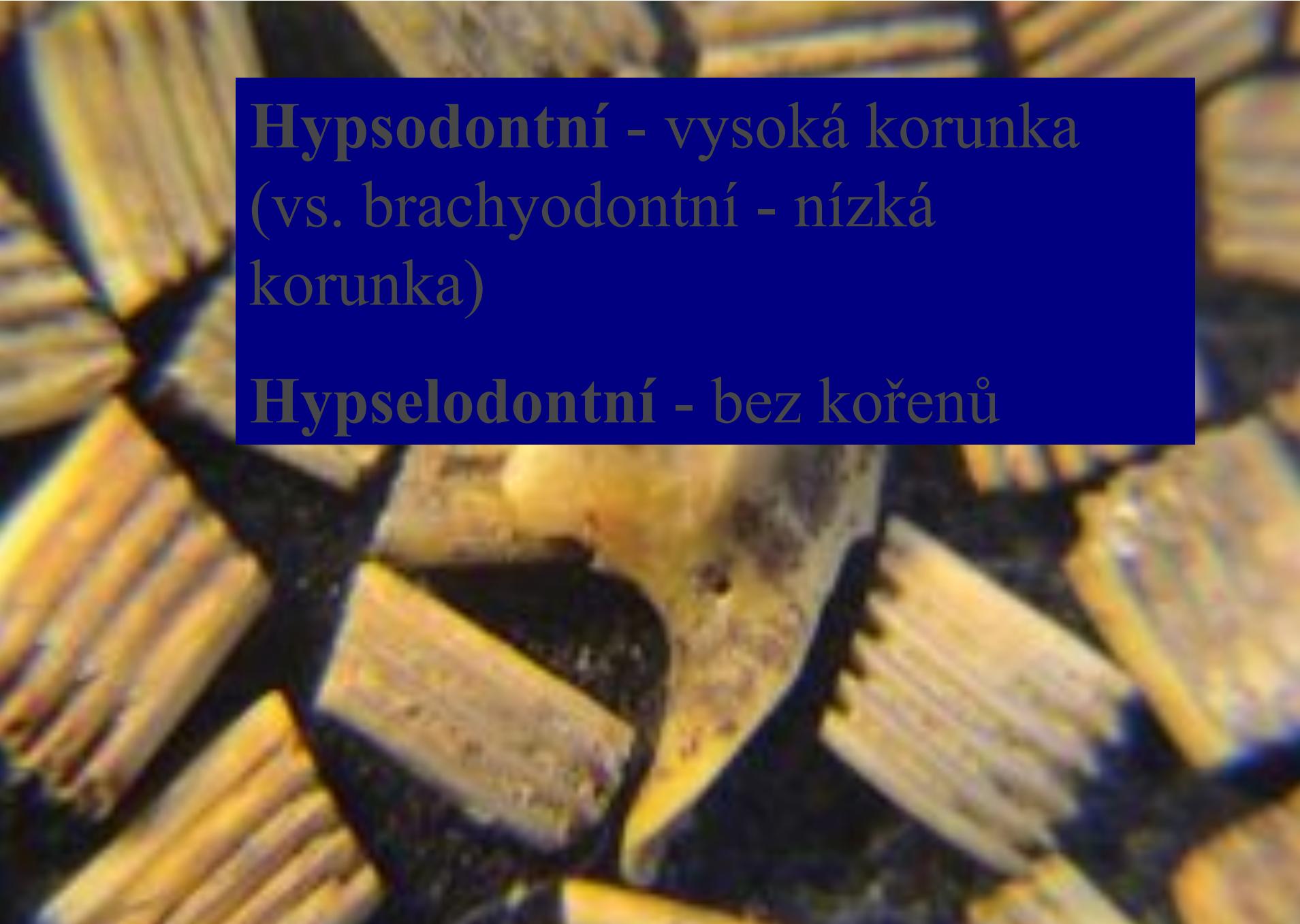


## Loxodont teeth in rodents



## Selenodont teeth of a gazelle



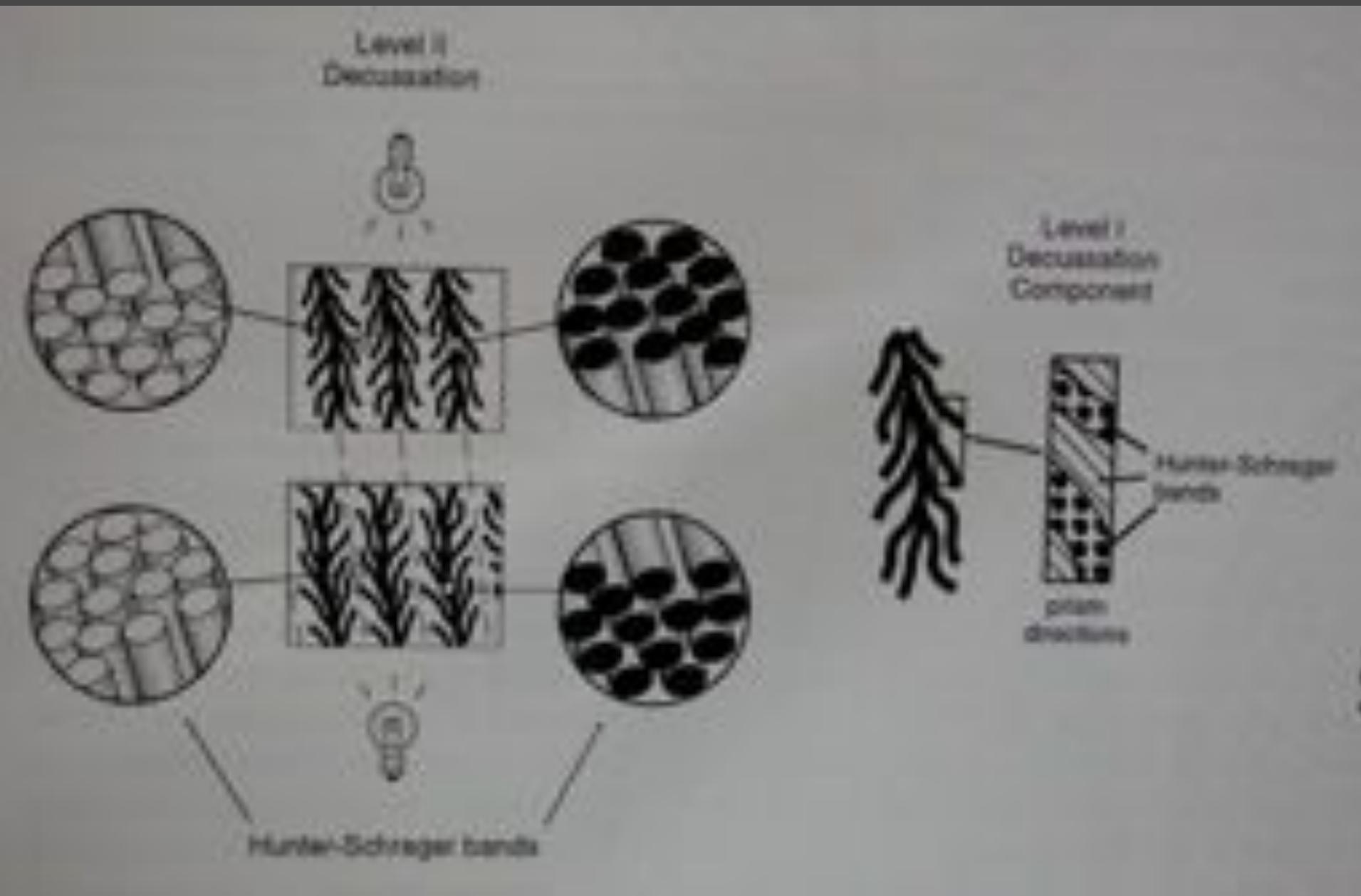


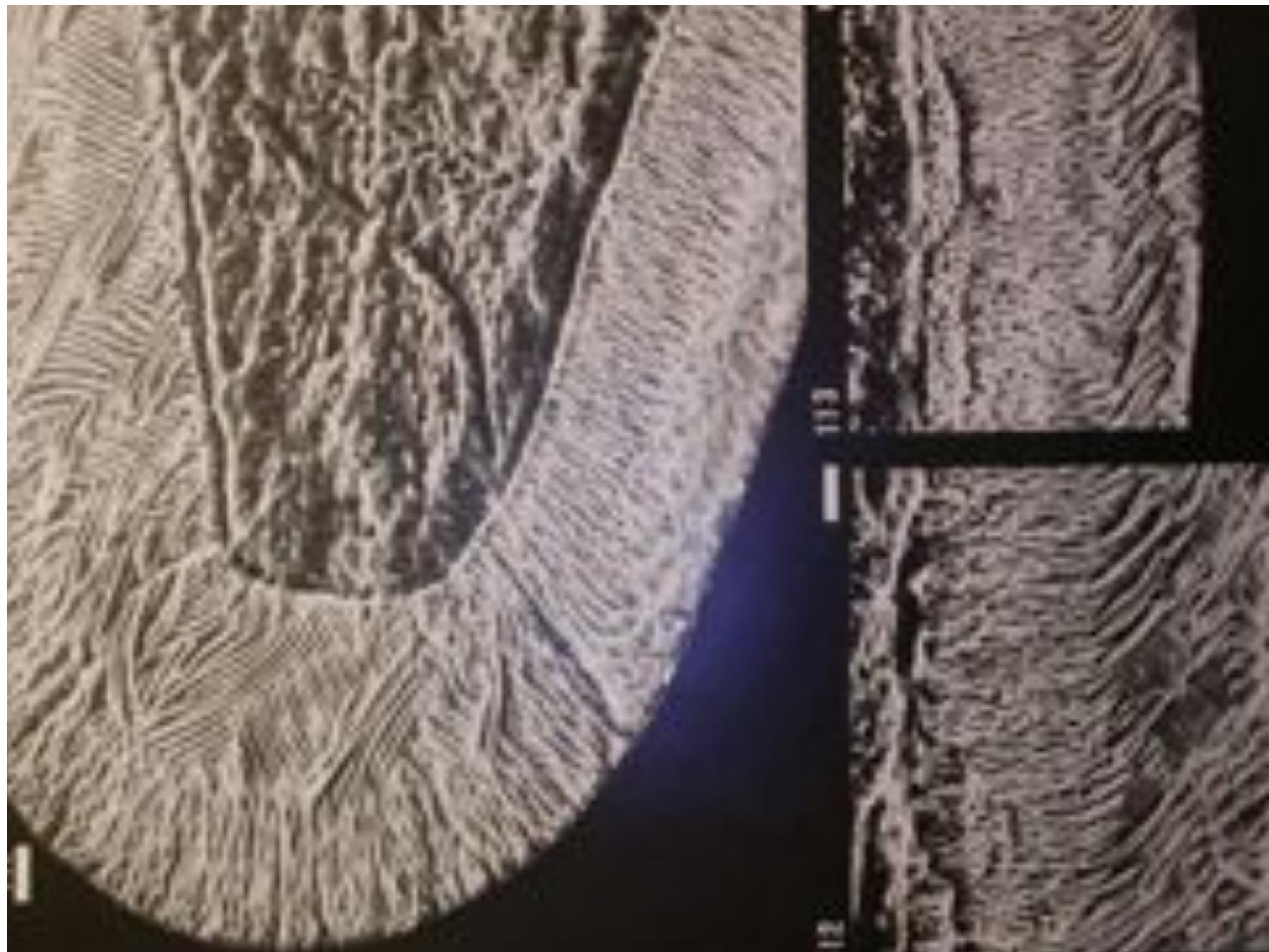
Hypsodontní - vysoká korunka  
(vs. brachyodontní - nízká  
korunka)

Hypselodontní - bez kořenů



## Specialisace skloviny: dekusace (X), Hunter-Schregerovy proužky





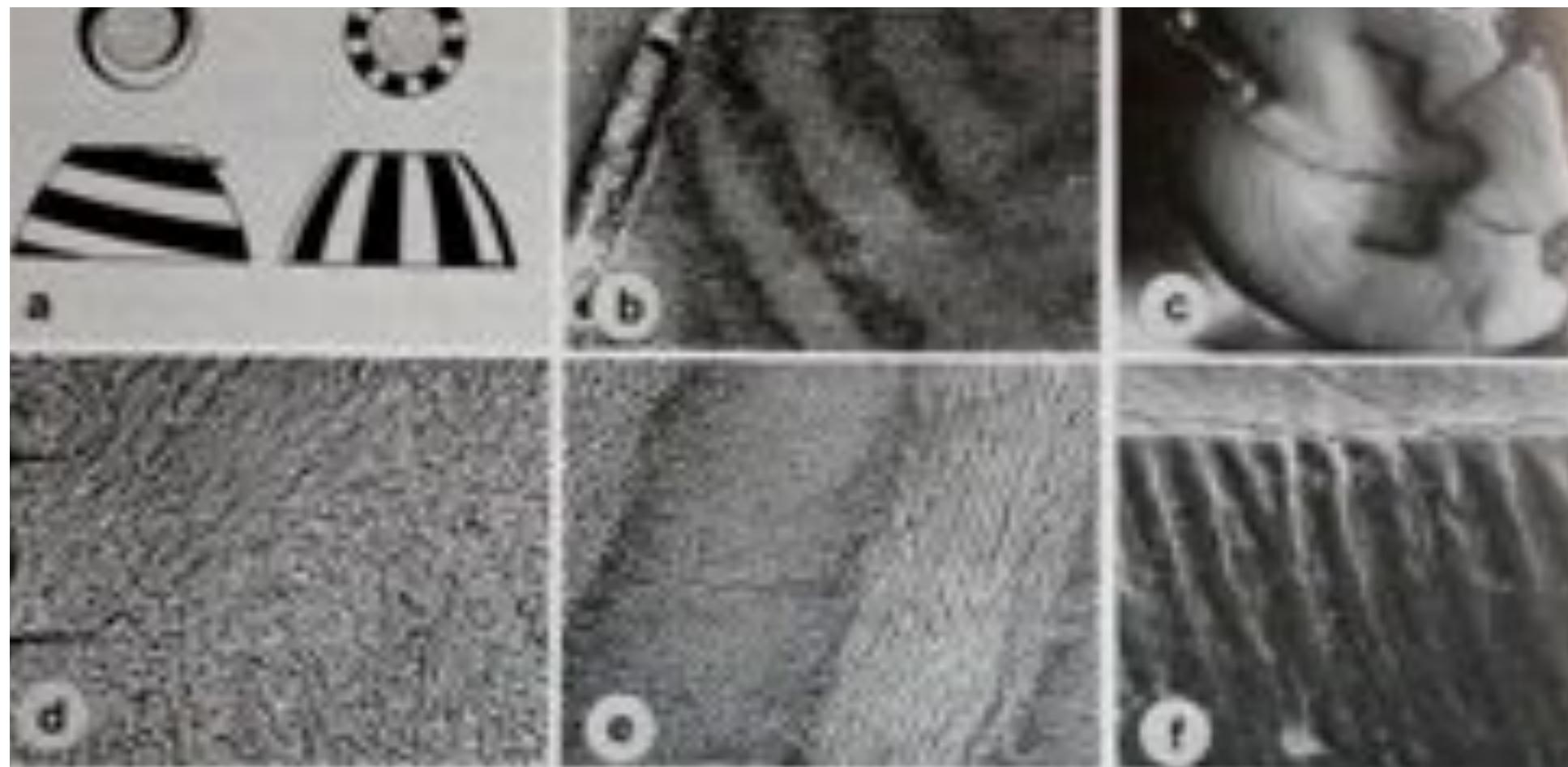


fig. 1a. Schematic tooth cusps showing arrangement of MI bands.  
 horizontal decussation left, vertical decussation right.  
 fig. 1b. *Mecochippus bairdii* (Equidae, Perissodactyla). Buccal edge  
 upper molar, transverse vertical section. Note spiral. SEM-  
 page, field width 340 microns. British Museum (Natural History),  
 registered fragment.  
 fig. 1c. *Potamotherium pyrenaicum* (Suidae, Artiodactyla). Lower molar,  
 occlusal view of naturally worn entoconid. Note concentric

Adaptivní přestavby čelistí,  
dentice a zubů (včetně jejich  
strukturních elementů)

- základní faktor evoluce savců

# MAMMALS

Extreme amount of apomorphies



The mammalian apomorphies are mostly related  
to

- prolonged ontogeny

- extreme energetic efficiency

directly controlled by apomorphies

Lips, vestibulum oris,  
enlarged bucal cavity,  
palatum durum, –  
directly related to *lactation*

at oral region:

- Specialized dentition with *large teeth*, resistant to wear due to *prismatic enamel*, and disposed to extensive and diverse adaptive rearrangements



## **Index dental apomorphies of Mammalia:**

- \* large monophyodont  
multicuspidate distal  
teeth: **molars**
  - \* prismatic enamel
- 

A text-book message:

## Cope-Osborn theory:

- ... all mammalian molars are derived of the *tribosphenic* type
- ... all particular structures in derived molars can be homologized to those in the tribosphenic ...



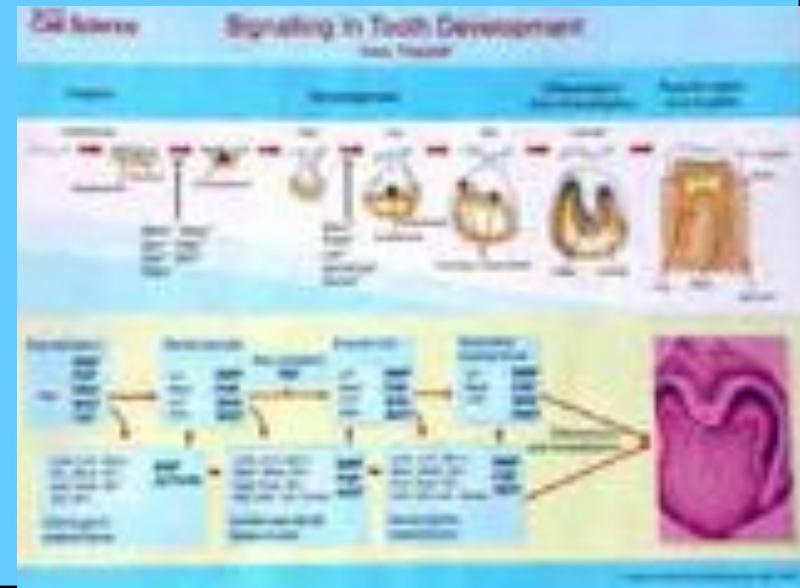
## tribosphenic molar

- - \* presents a *phylotypic stage* of mammalian dental evolution
  - \* all other types evolved obviously via (gradual) rearrangements of the tribosphenic pattern and should be homologized with it

Tribosphenic molar: the most significant apomorphy of Mammalia

# Developmental biology of molar teeth

- subject of a huge number of studies,
- a pilot topics of EVO-DEVO ...



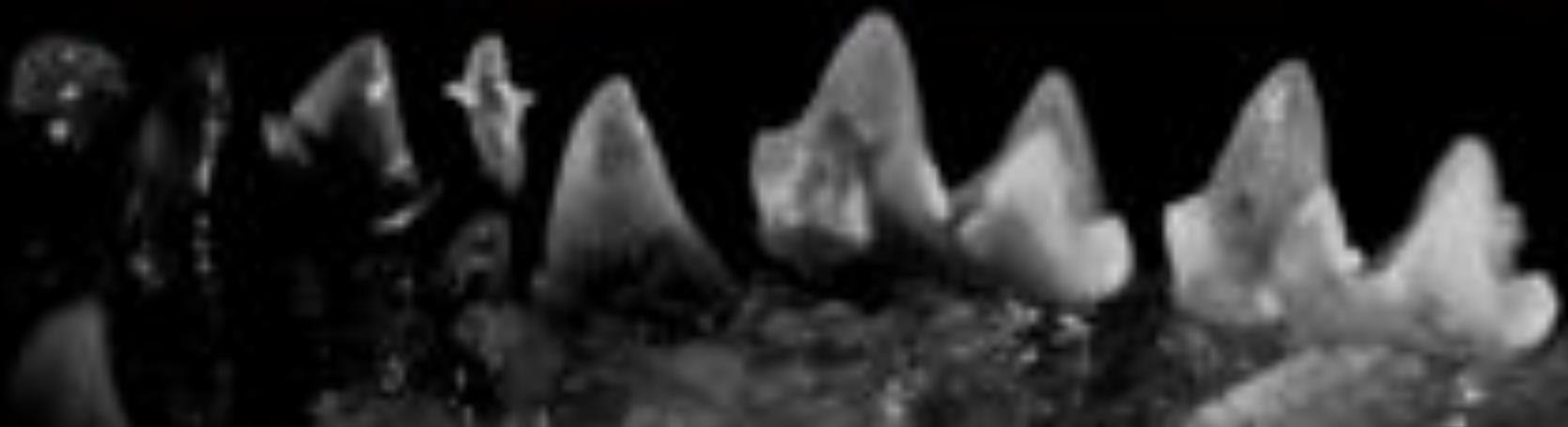
but, in most instances based on model taxa with quite derived dentitions (mouse, human),

**information on tribosphenic surprisingly scarce**



# Why *just* tribosphenic?

What made it so succesfull, universal,  
and so conservative? Why, it remained,  
in contrast to other mammalian  
characters, unchanged over 200 Ma ?





Function!

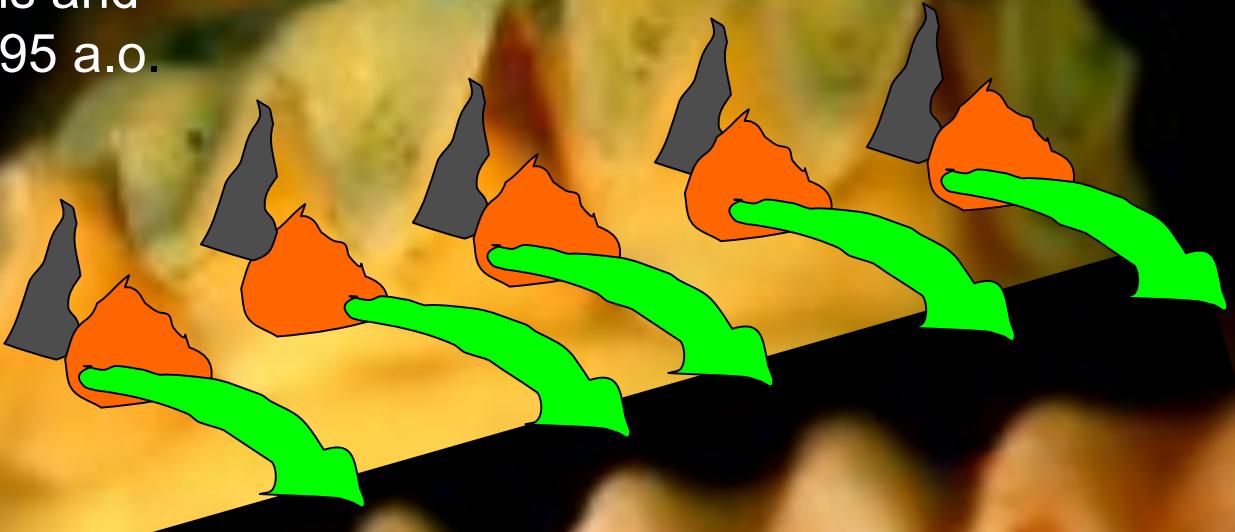
# Teeth of perfection

see e.g Butler 1941, Evans and Sanson 2003, Jernvall 1995 a.o.

compressing-  
transporting

maxillary

mandibular



Simultaneously at one occlusion action  
and multiple !

## insectivory

Insect food : easily digestible, widely available: small but numerous

- (2) Strong selection for efficiency of shearing particularly its quantitative aspect: sharpness and total length of crests
  - The essential character of tribosphenic: the sharp **crests** centered with „cusps“
  - The essential character of tribosphenic: the sharp **crests** centered with „cusps“

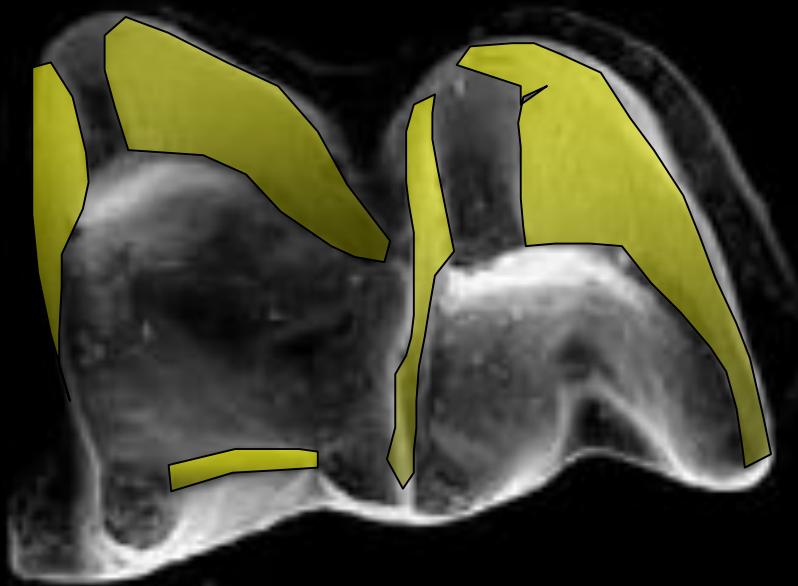


Crests present the major component of tribosphenic molar

Functionally, the molars are mere the sockets for promoting crests

*Hypsugo savii* ad. P4-M3/

M2

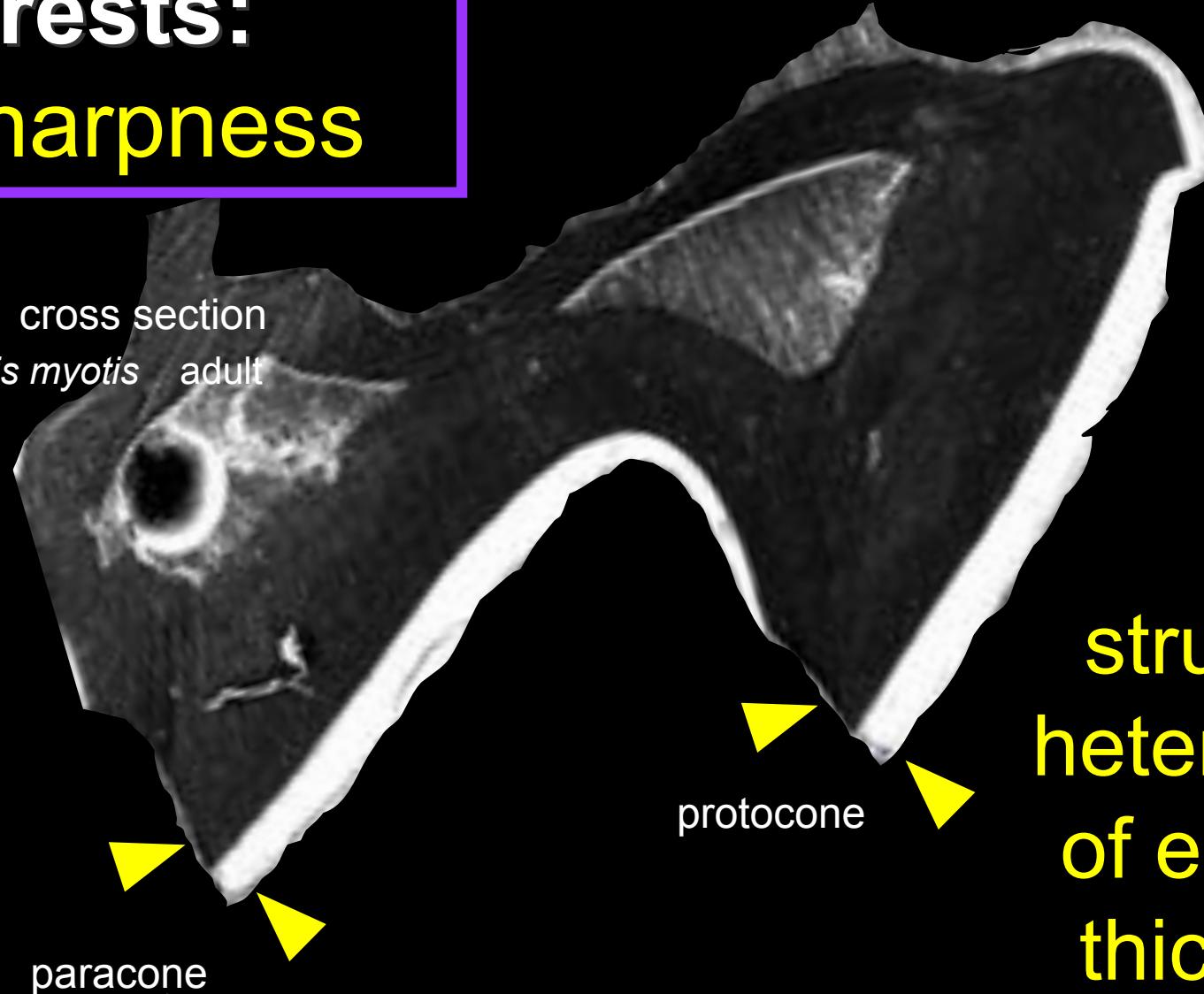


*Fields of attrition lines appear at the occluding crests and their walls only*

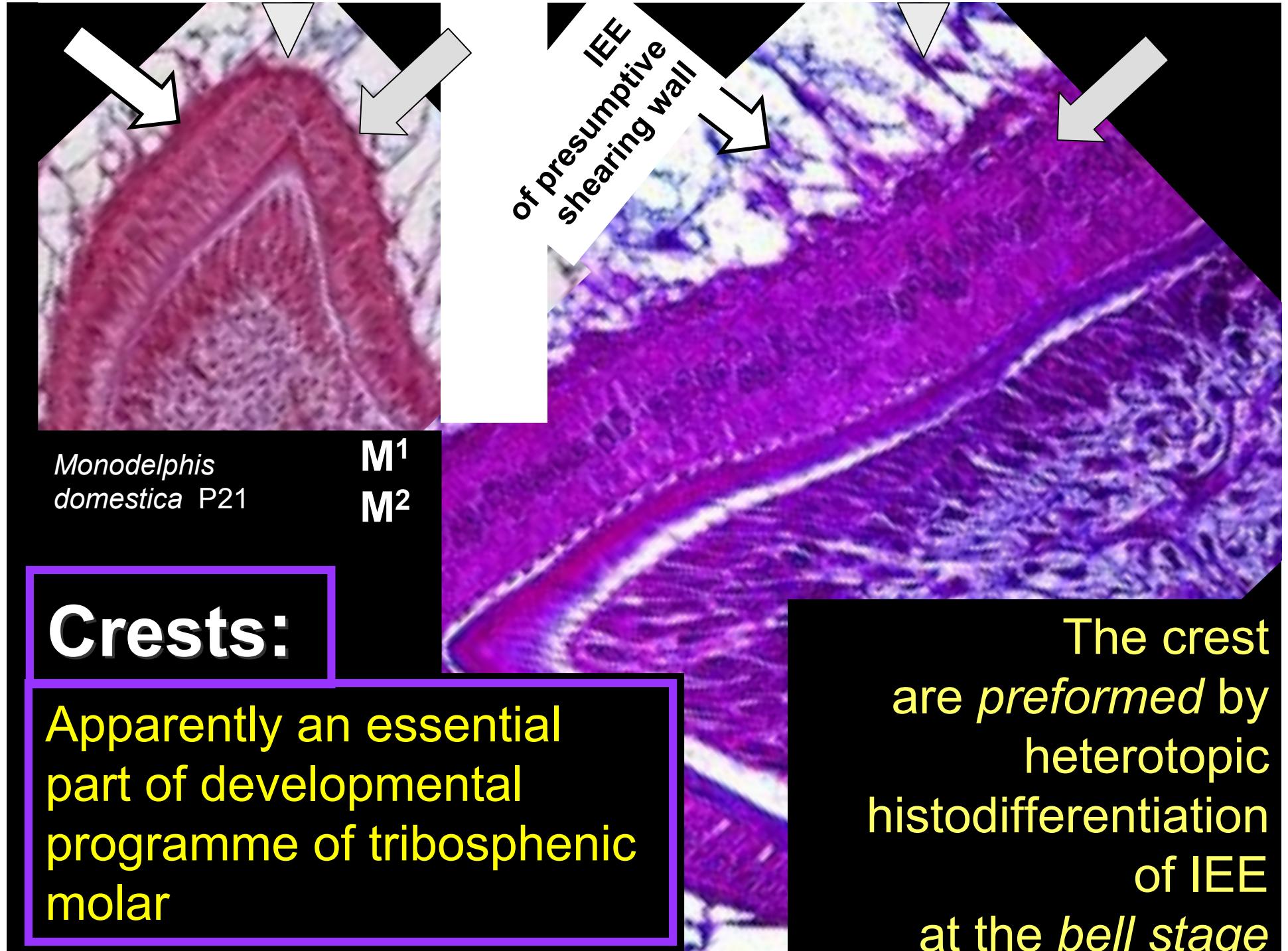
- (2) Strong selection for efficiency of shearing particularly its quantitative aspects: sharpness and total length of crests
  - increases with size of individual molar teeth
  - W-pattern of crests

# Crests: sharpness

**M<sup>1</sup>** cross section  
*Myotis myotis* adult



by  
structural  
heterotopy  
of enamel  
thickness

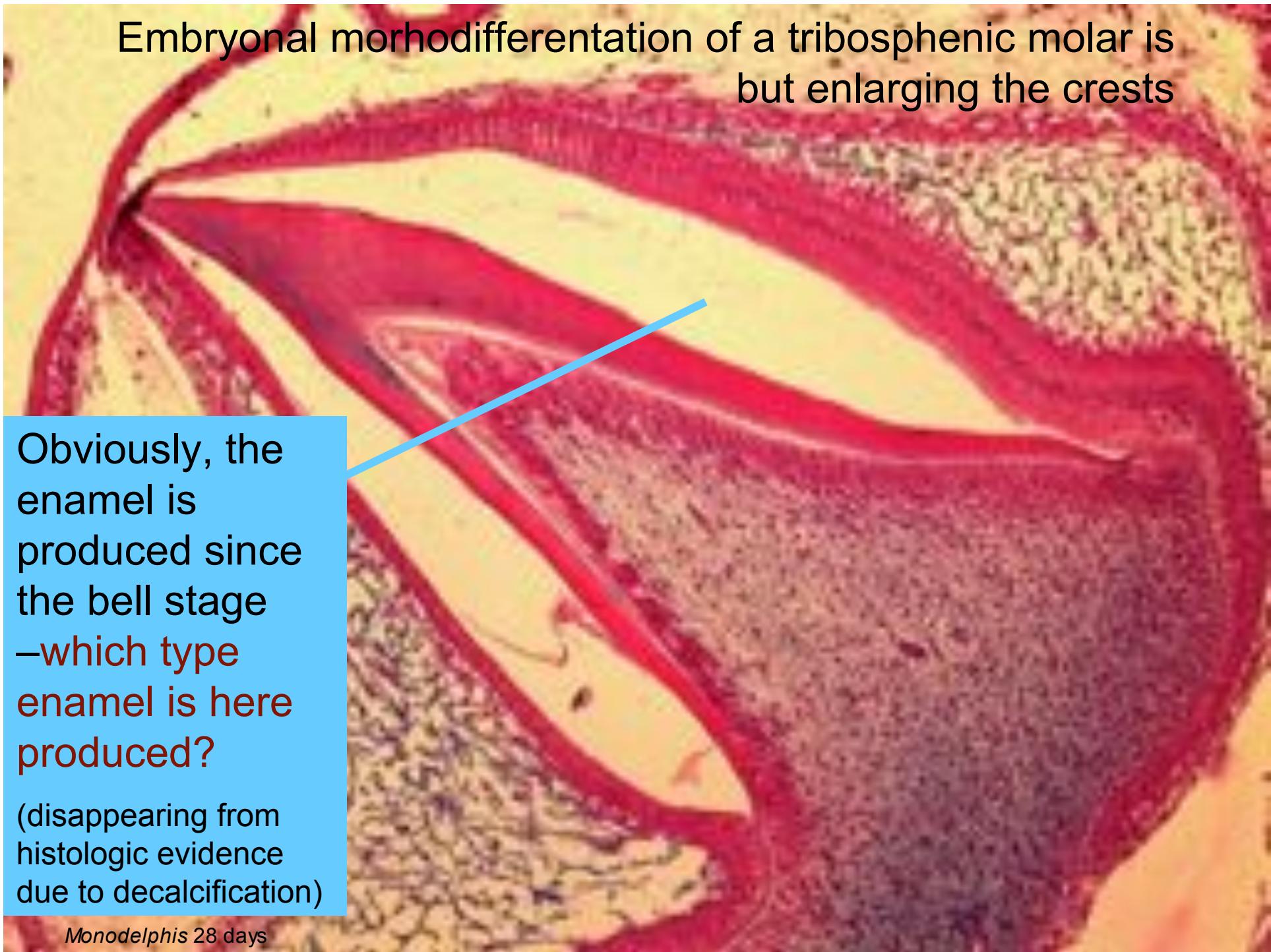


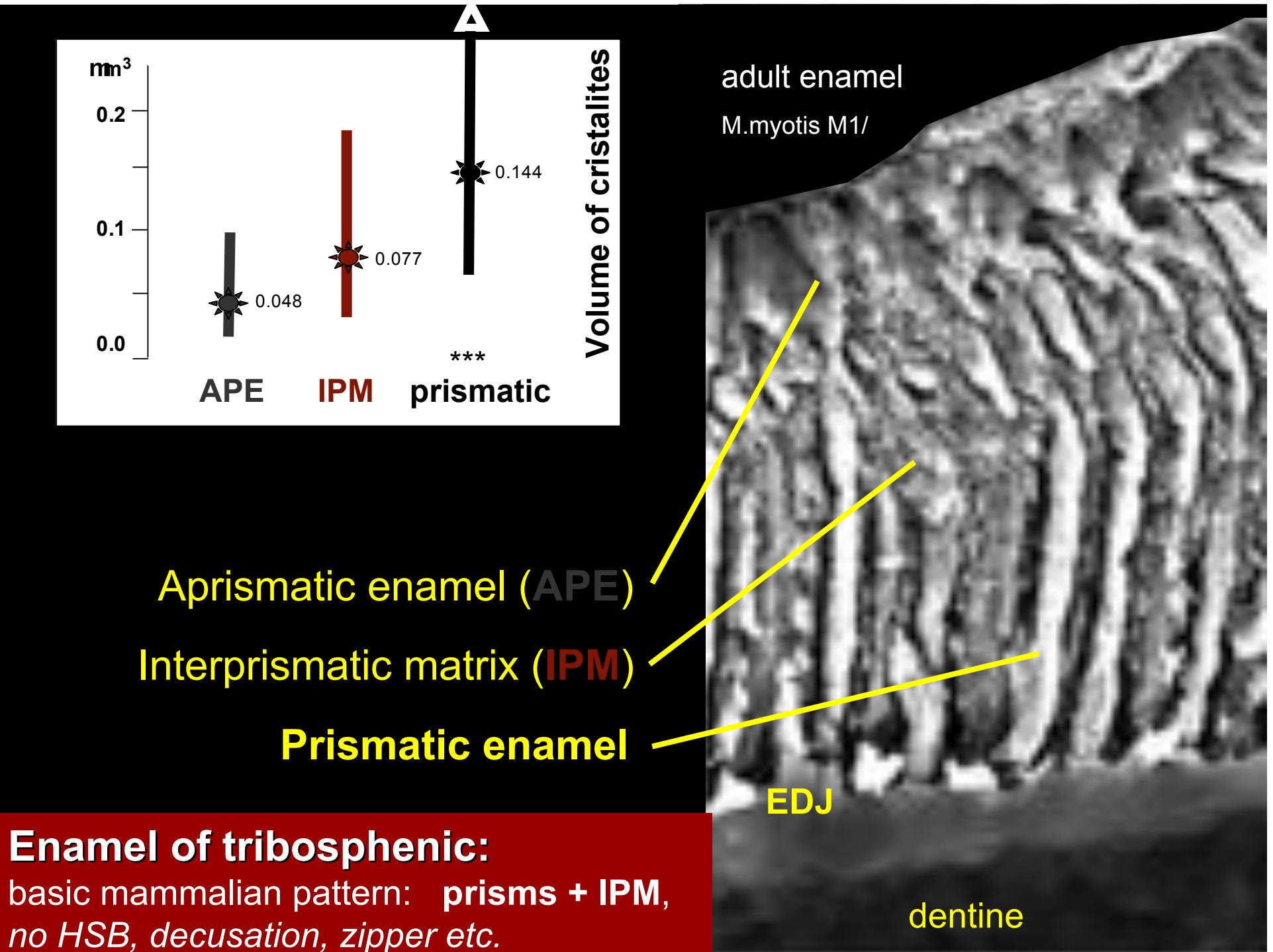
Embryonal morphodifferentiation of a tribosphenic molar is  
but enlarging the crests

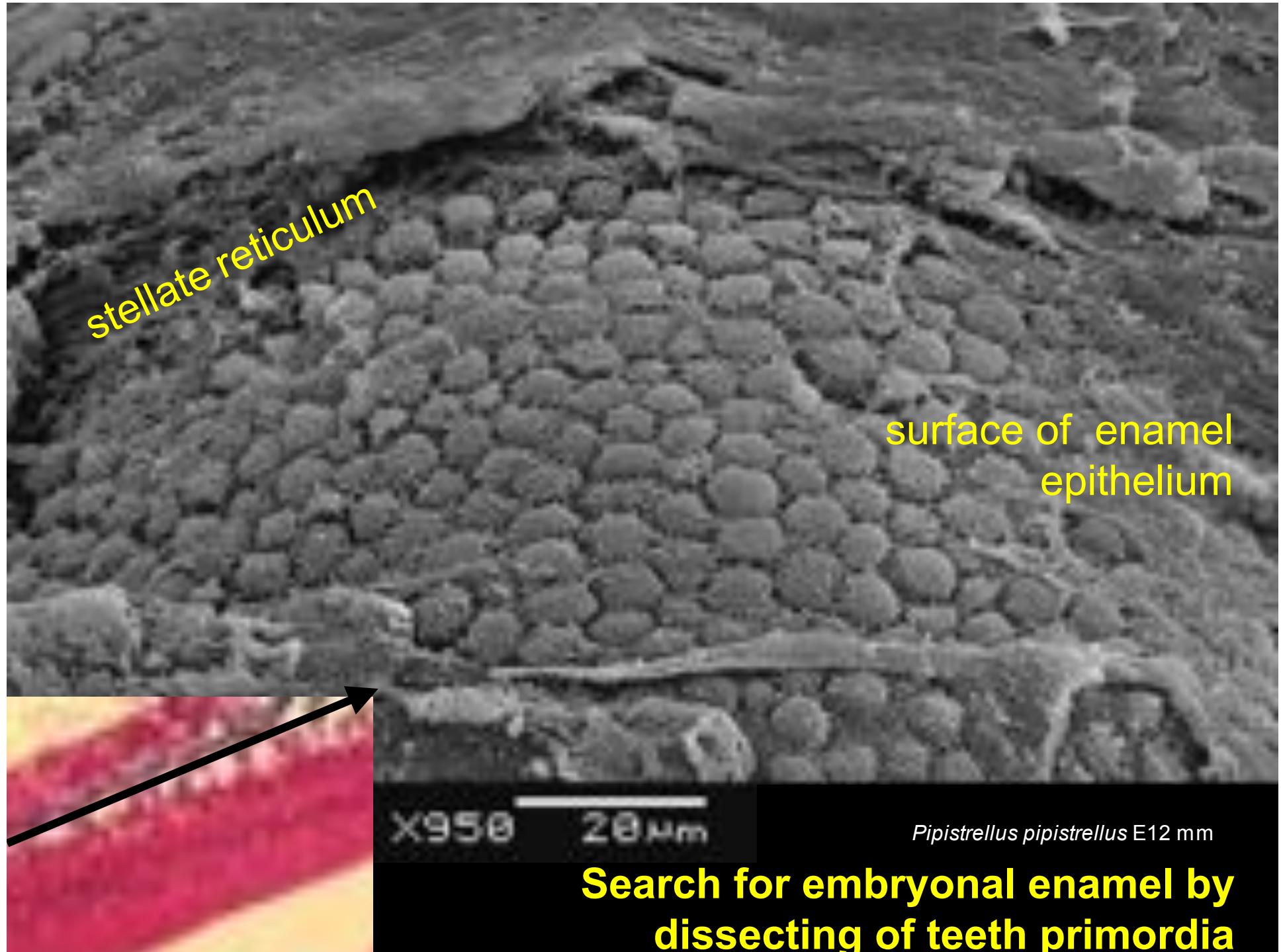
Obviously, the  
enamel is  
produced since  
the bell stage  
**—which type**  
enamel is here  
produced?

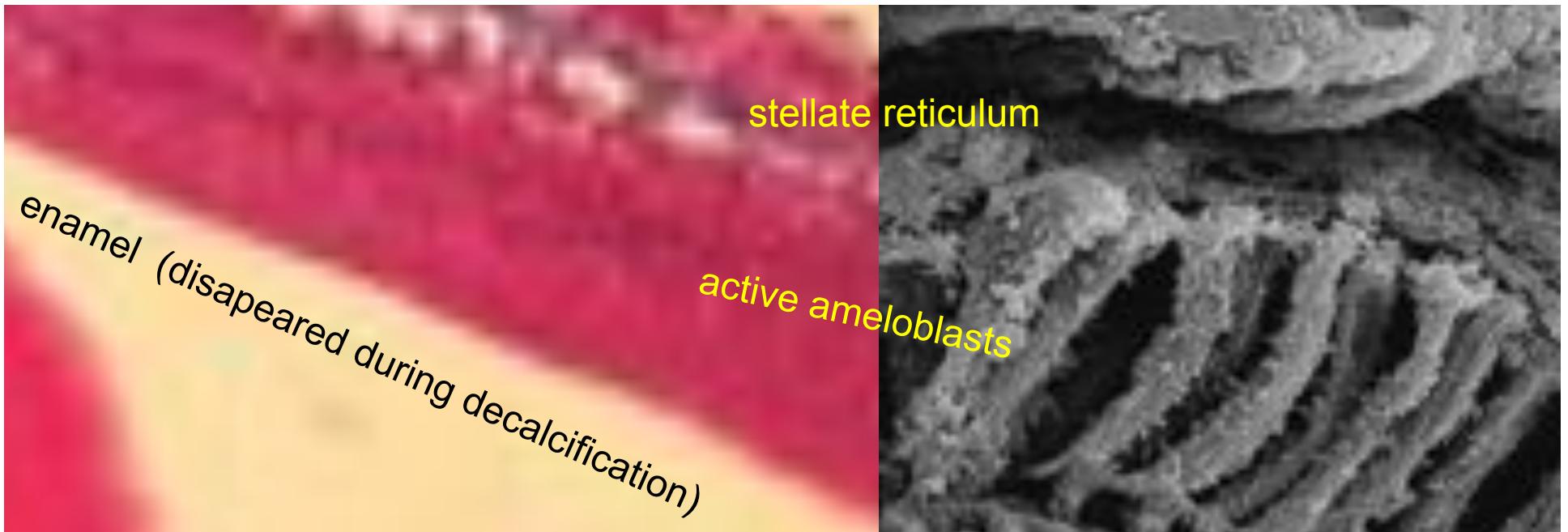
(disappearing from  
histologic evidence  
due to decalcification)

*Monodelphis* 28 days

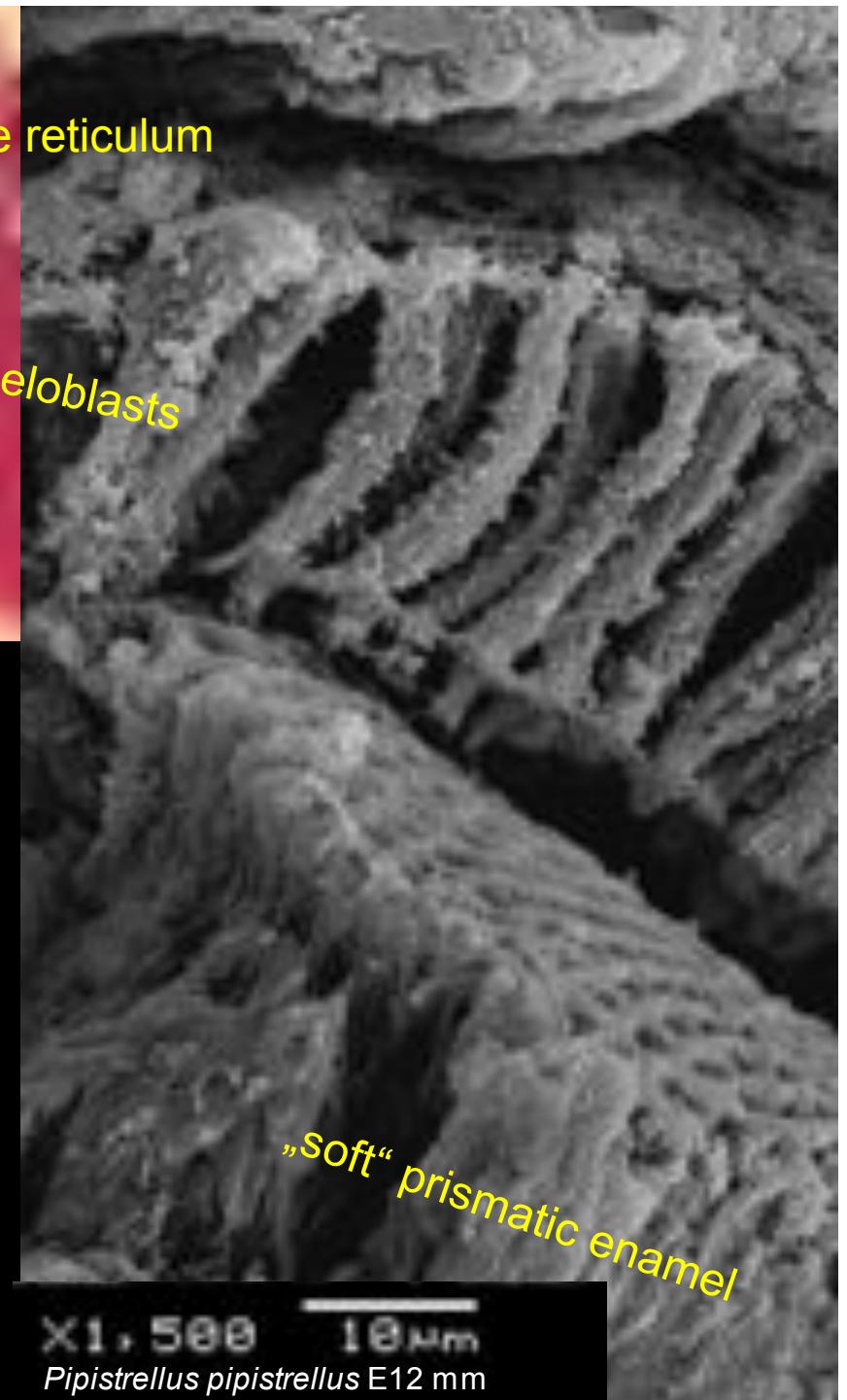


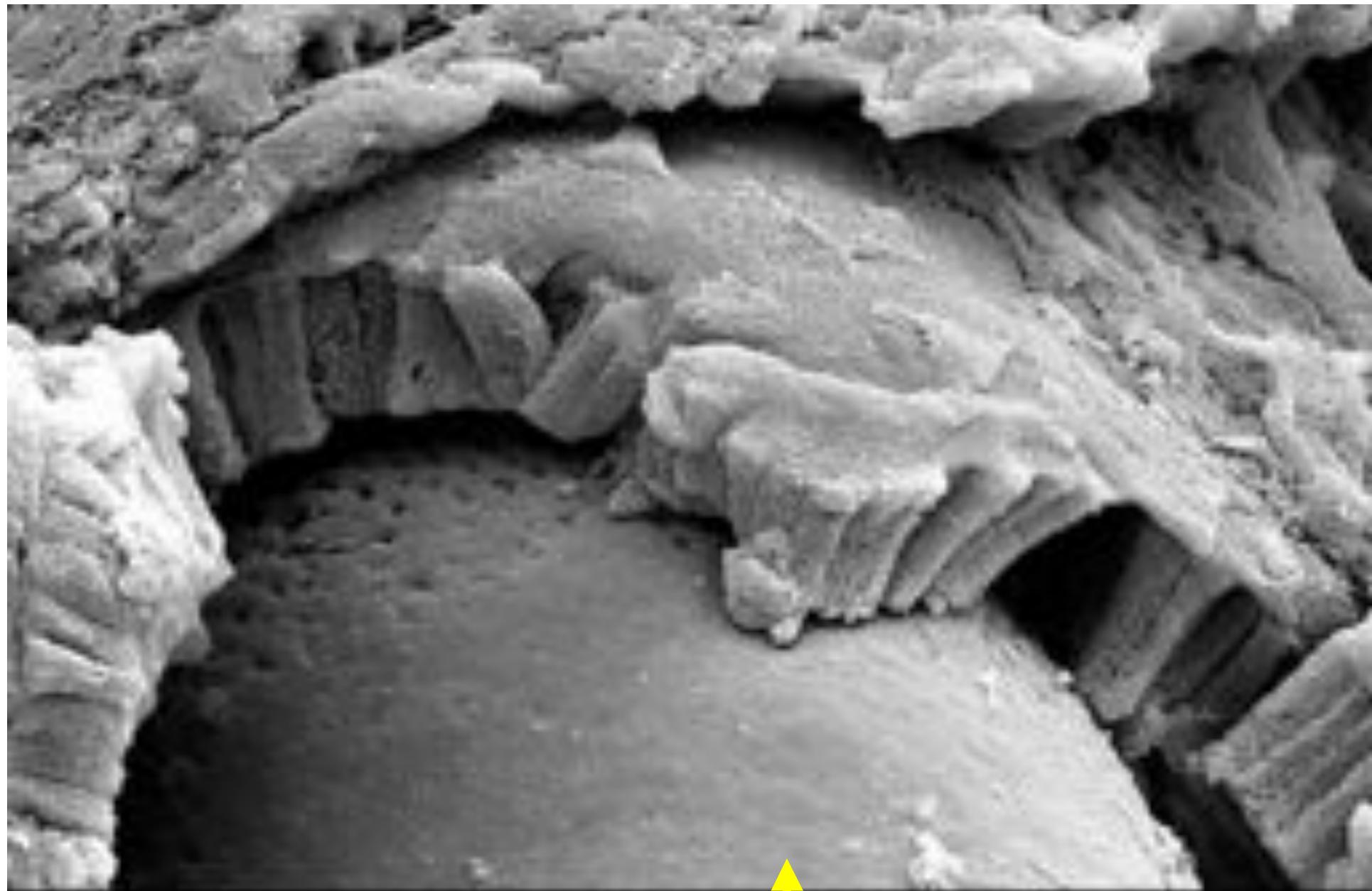






Since beginning of their activity the ameloblast produce the „soft“ but prismatic enamel





*Pipistrellus pipistrellus* E12 mm

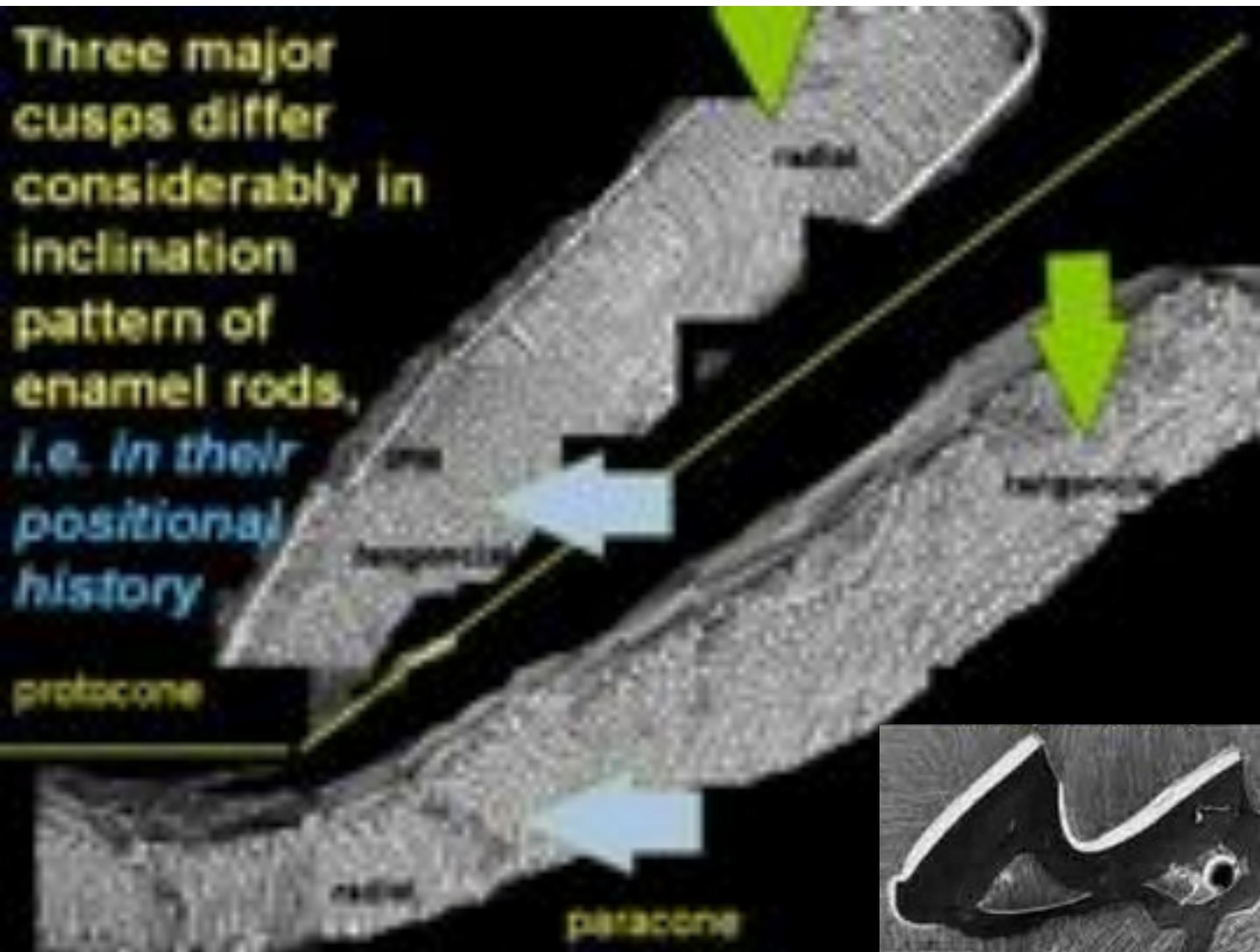
x800 20μm

Terminal stage of amelogenesis:  
production of the surface  
..... aprismatic enamel

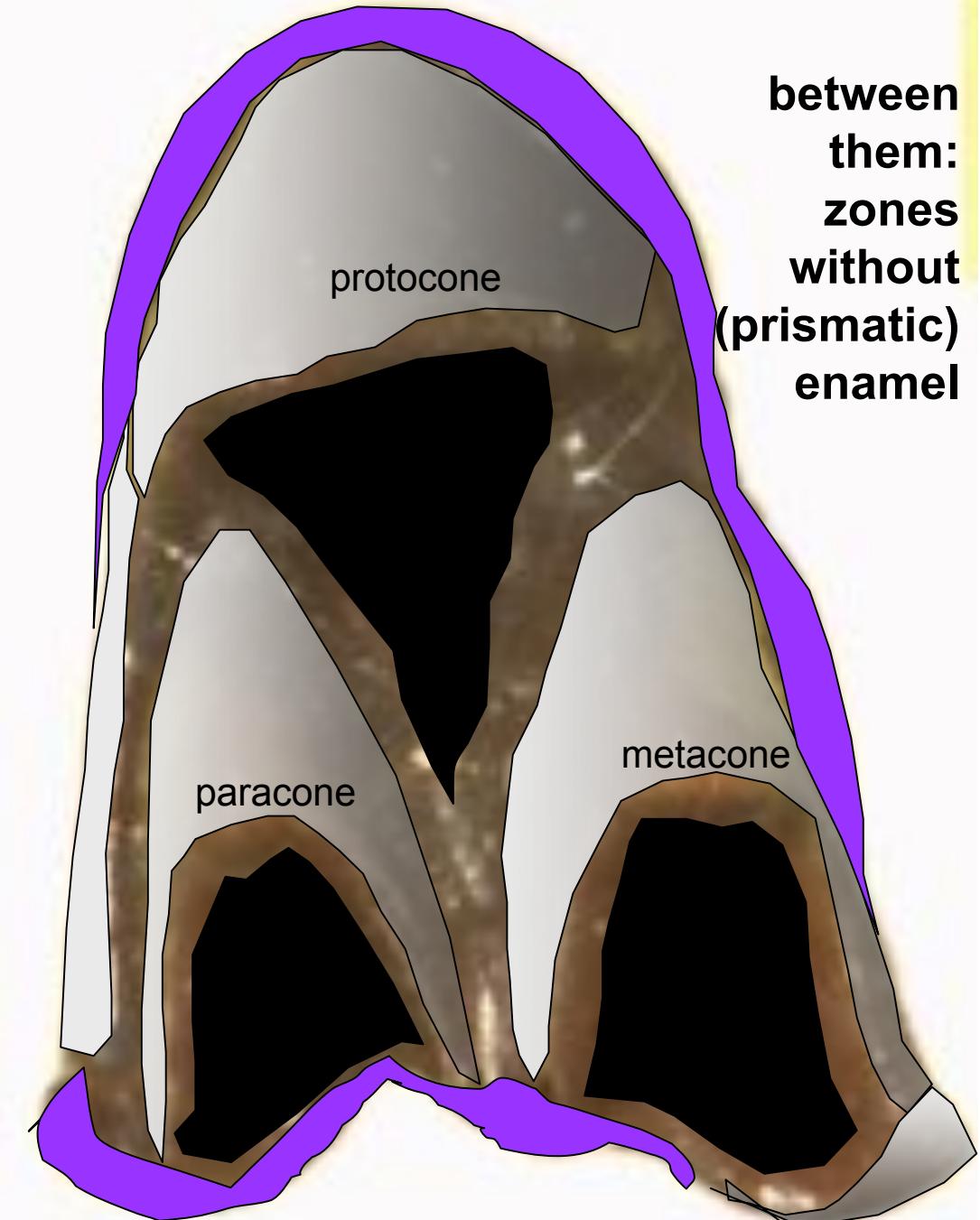
Three major cusps differ considerably in inclination pattern of enamel rods.  
I.e. in their positional history

protocone

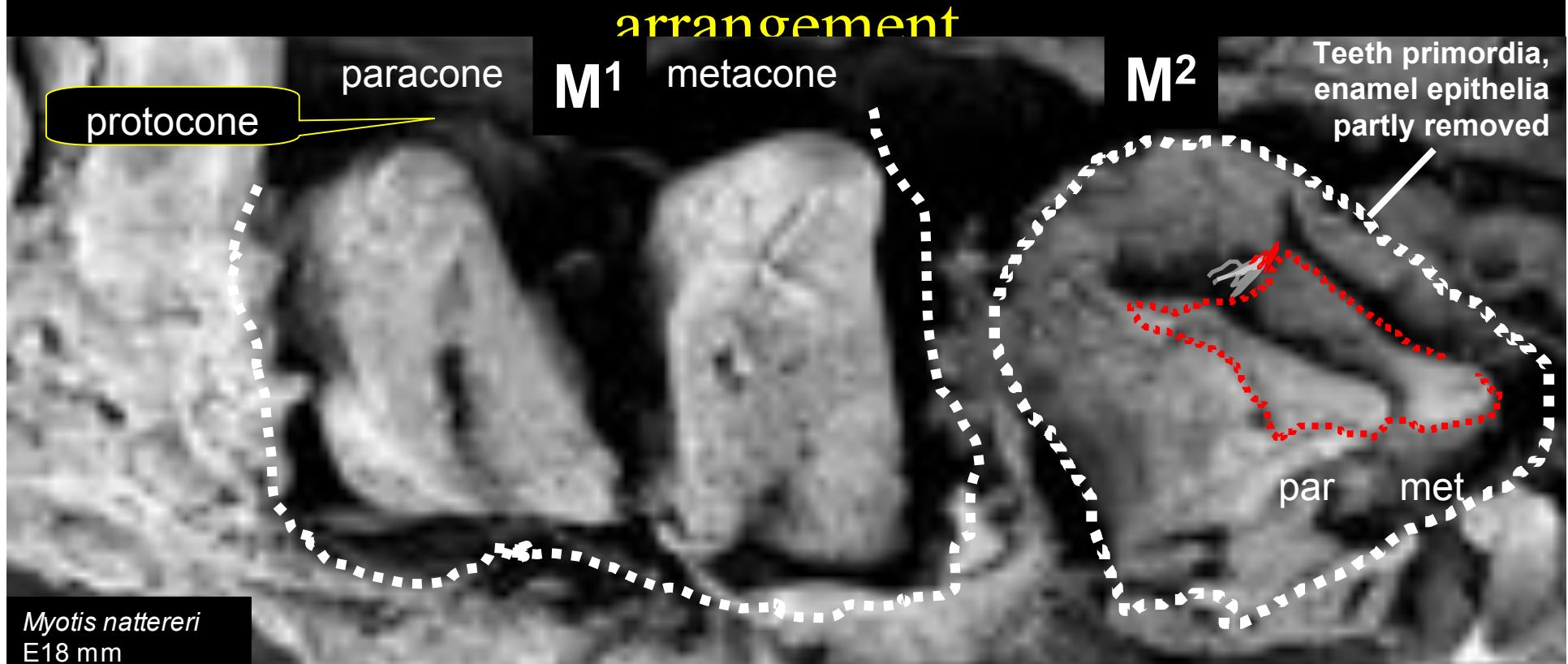
paracone



Cingula, and major crests with their shearing walls, present more or less **autonomous structural units** with different positional history



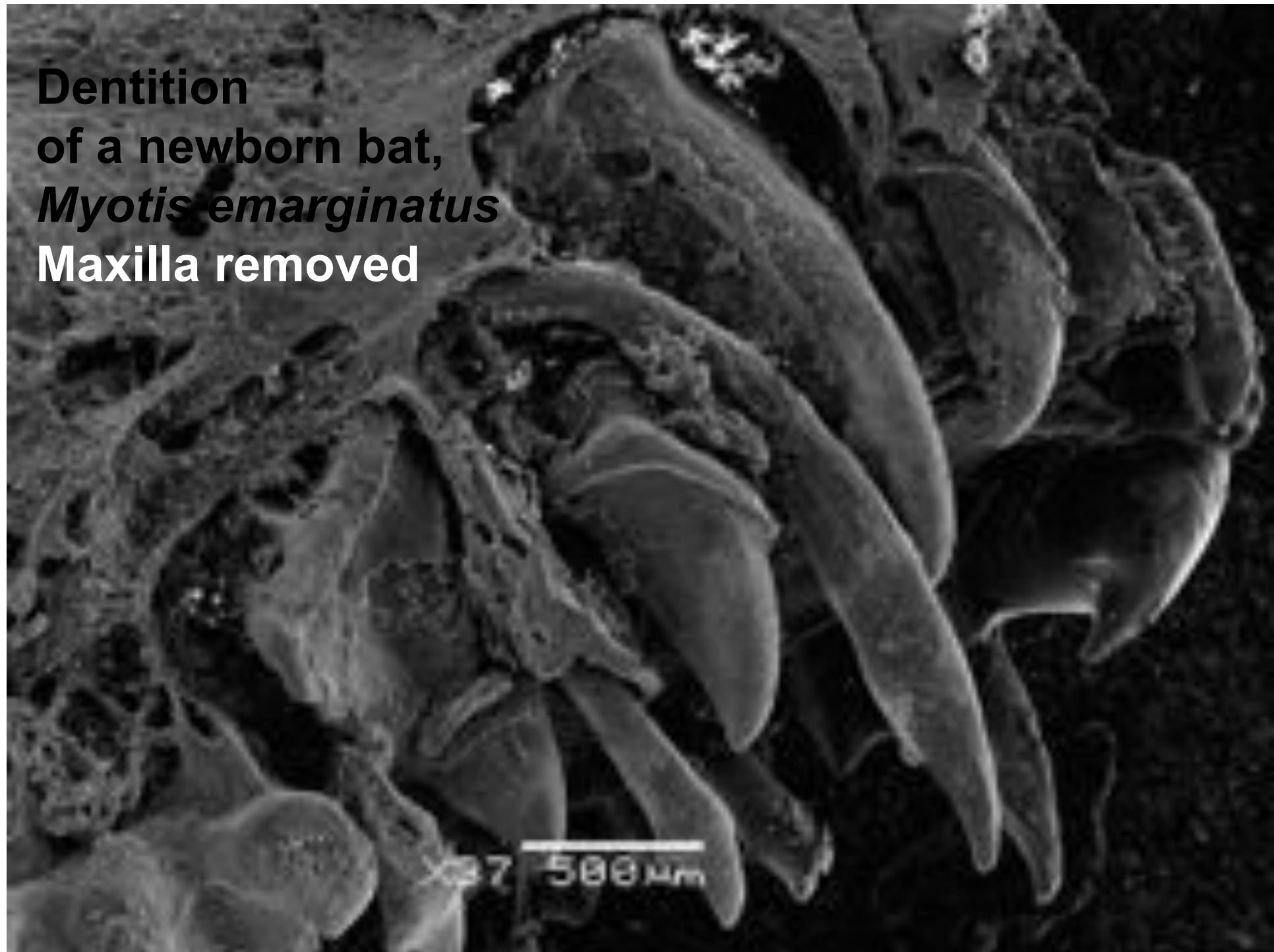
# Mutual positions of particular units in the embryonal tooth differ from the adult



- In a form of densely compressed structural units the teeth can grow large at relatively small spaces

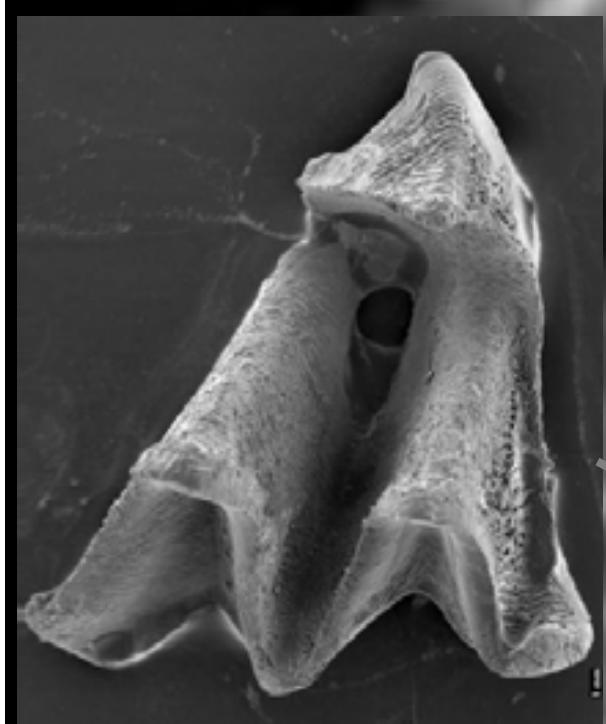
**Dentition  
of a newborn bat,  
*Myotis emarginatus***

Dentition  
of a newborn bat,  
*Myotis emarginatus*  
Maxilla removed



7 500  $\mu$ m

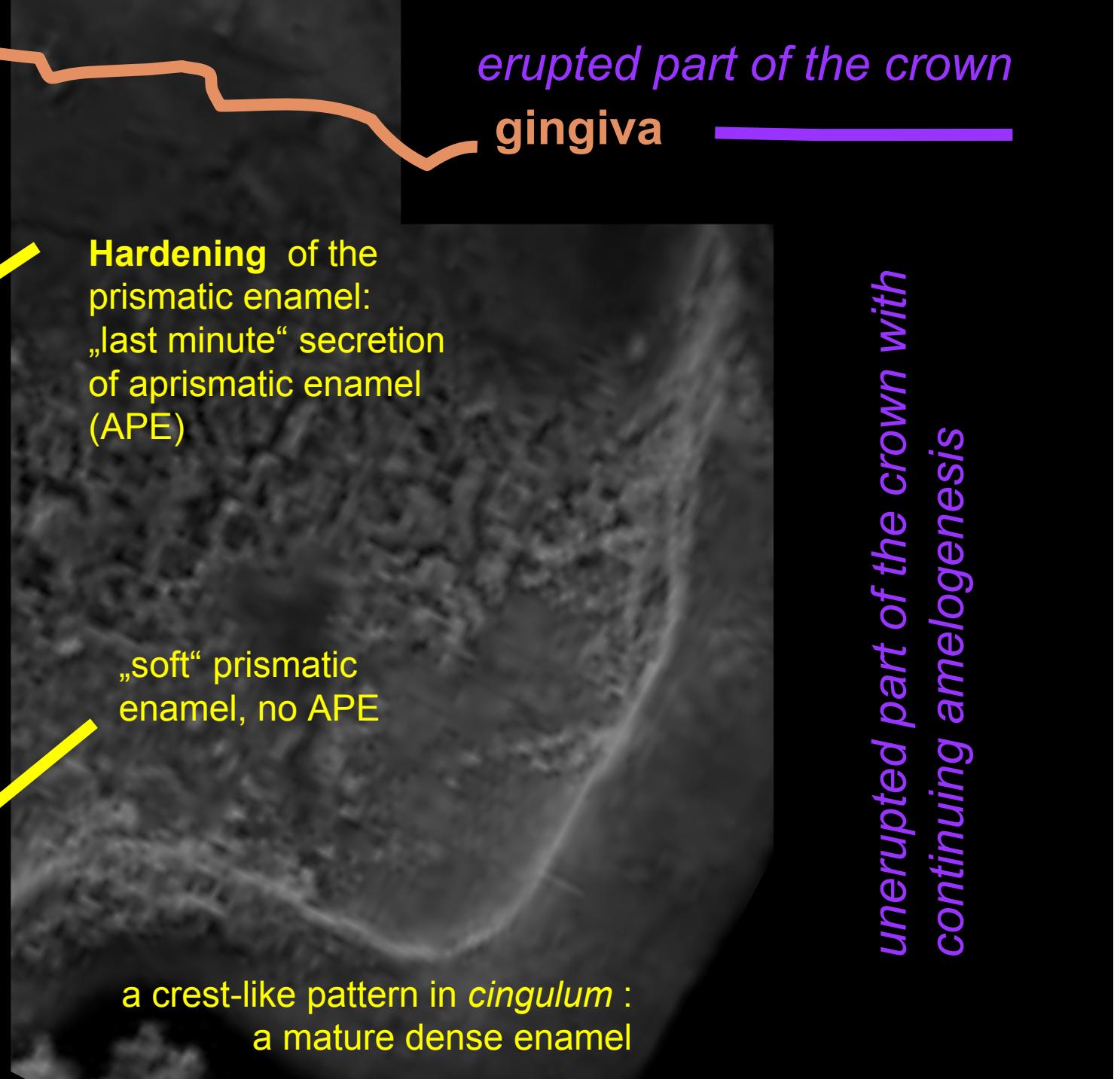
*Myotis myotis* juv P12  
beginning of M1 eruption



**Tribosphenic  
molar  
expands its  
size during  
eruption**

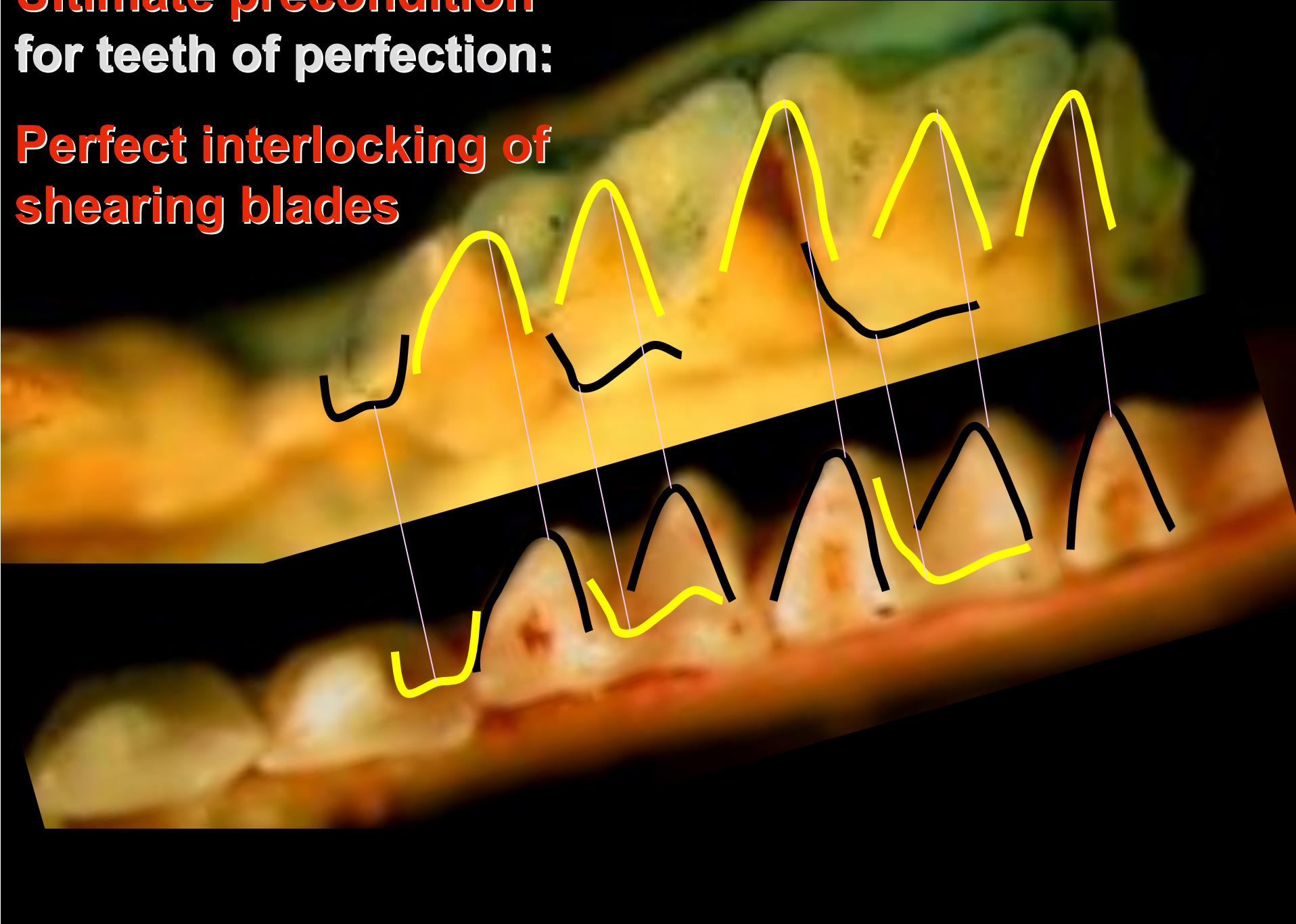


at eruption:  
**zones  
without  
(prismatic)  
enamel**



**Ultimate precondition  
for teeth of perfection:**

**Perfect interlocking of  
shearing blades**



A close-up photograph of a bat skull, specifically Otonycteris hemprichii, showing a cleft palate. The skull is mostly orange-brown with some white and greenish-yellow staining around the nasal and oral openings. The cleft is clearly visible in the center of the upper jaw.

Indeed, a very  
risky  
precondition

...

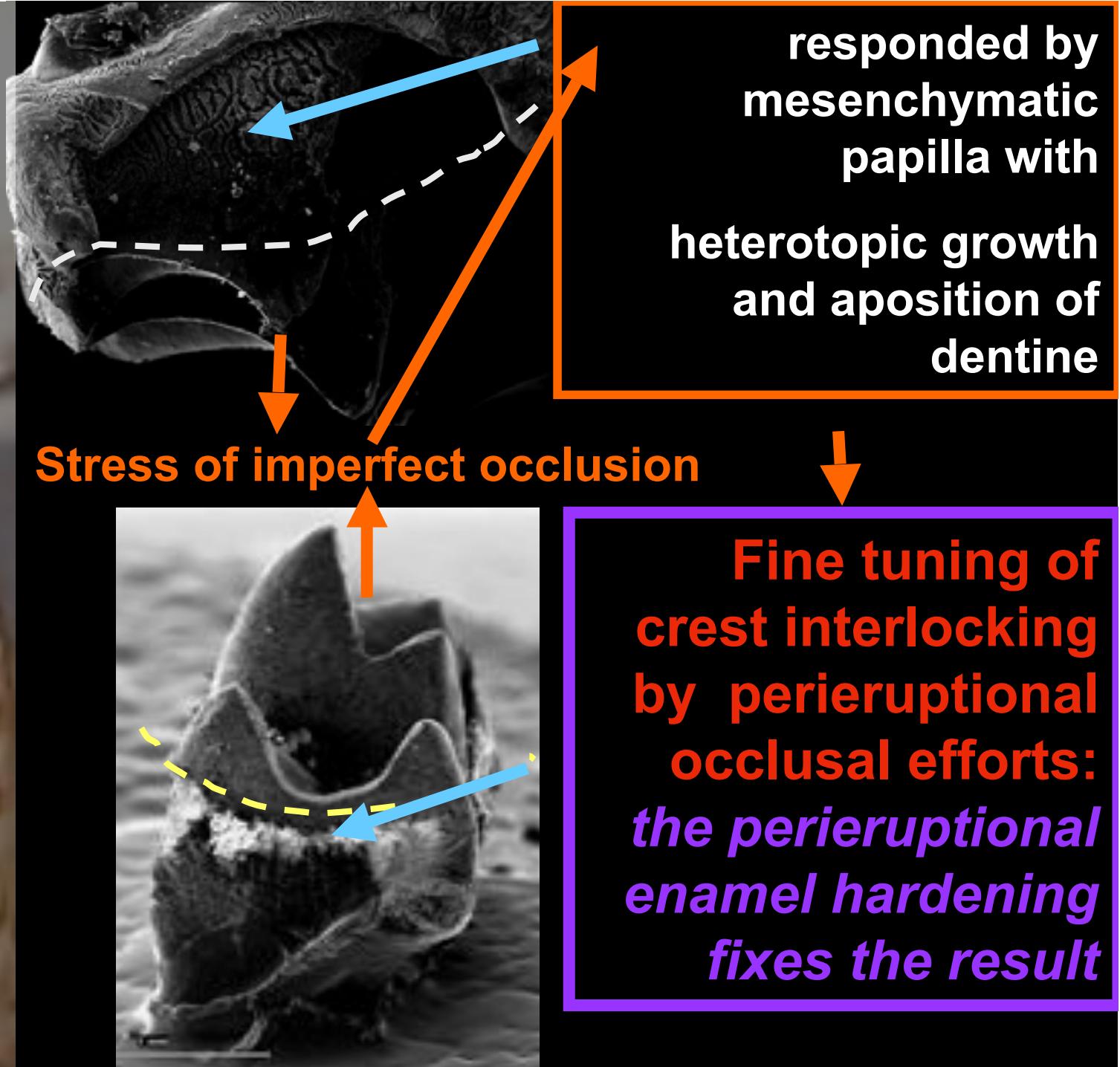
Any small  
misarrangement  
is fatal!

*Otonycteris  
hemprichii*

## ANSWER

Prolonged period of tooth eruption &

\*delayed enamel maturation and  
\*positional flexibility of structural modules:  
\*perieruptional growth and late reshaping of tooth crown





(i) Tribosphenic teeth are disposed to *grow and refine their shapes* throughout the perieruptional period, *i.e.* capable to respond to *ad hoc* cues of the actual

**(ii) The prismatic enamel and the last minute apposition of IPM/APE are the essential factors which make it possible**

(iii) Not the enamel epithelium is the  
major agent of molar  
morphogenesis  
but  
**mesenchymatic dental papilla**

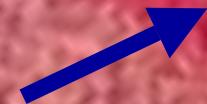
## Signalling from enamel knot

BMP  
FGF  
SH  
WNT

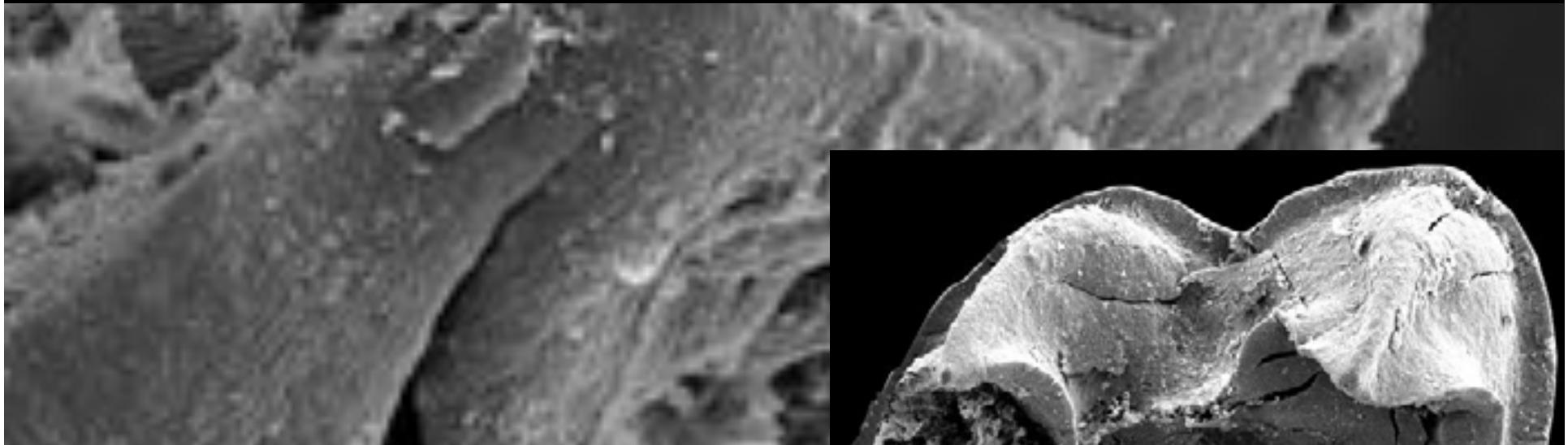
Enamel  
Knot

The papilla  
contributes not  
only by  
signalling to EK  
but its morpho-  
differentiation  
presents the  
essential  
*shaping agent*  
of the tooth  
design

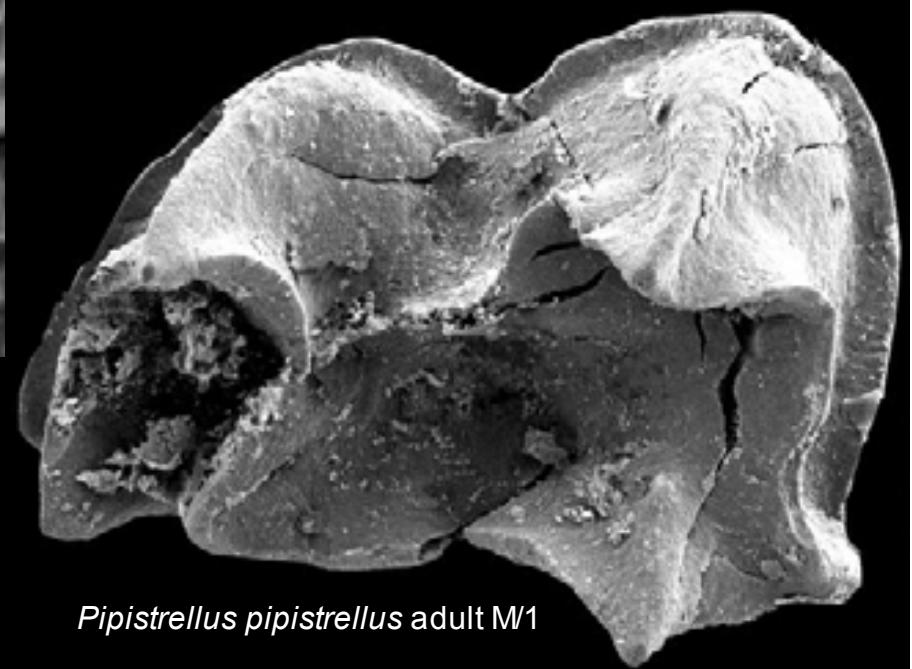
Shaping of mesenchyme  
surface predates the  
changes in enamel epithelium



The tooth with all fine details of its crown is designed in dentine collagen by mesenchymatic papilla



**Completely decalcified teeth :**  
**collagenous surface of dentin**  
**preforms all details of crown**  
**design (crests, cingula etc.)**



*Pipistrellus pipistrellus* adult M1

- Ultimate precondition for the molar teeth development: very large population of the mesenchymatic cells for the dental papilla
- *Source of it ?*

The once established mouth corner redirects the mesenchyme invasion medially – to the molar ridge and palate



Mouth corner



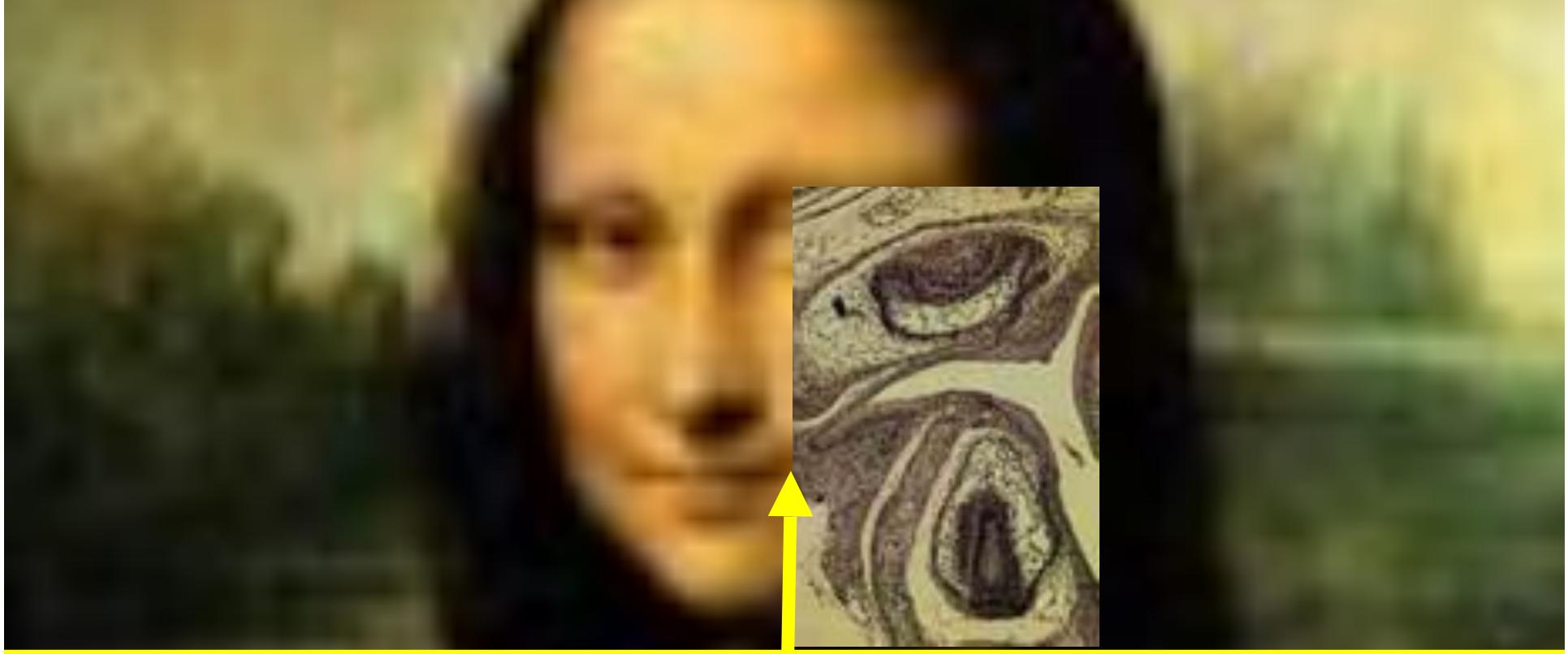
Monodelphis 5 days

The mouth corner redirects the expansion of the ectodermal epithelium in the inner part of the oral cavity: the molar OEZ and vestibulum oris  
Zone of mammal-specific arrangements  
(Lum et al. 1993)

forward invasion of the mesenchyme constrains an expansion of the ectodermal epithelium at mouth opening



**Embryonal mouth corner is associated with a distinct condensation of mesenchyme, supposedly a signalling center**



## ? The most influential mammalian apomorphy

Responsible for vestibulum oris, bucal region, organizing the cell populations for hard palate etc. (i.e. the prerequisites for suckling and prolonged ontogeny) and molars (i.e. the key tools of energetic efficiency of a mammal) as well.

### (iii) Adaptivní přestavby dalších soustav (pohybové, behaviorální, etc.)



Figure 6.2 Skult and deacon's speculative theory: developing movement systems in the ontogenetic trajectory of human movement from sensory input to movement output. © 2013 Pearson Education, Inc., publishing as Pearson Benjamin Cummings.

# Terestrická insektivorie

- Tribosfénické moláry (dilambd., zalamdb, euthenomorf.), absence specifických adapatcí tráv.traktu (malý žaludek krátké střevo etc.) - výjimka: neurotoxin (gl.submandibularis) - *Neomys, Blarina, Solenodon*











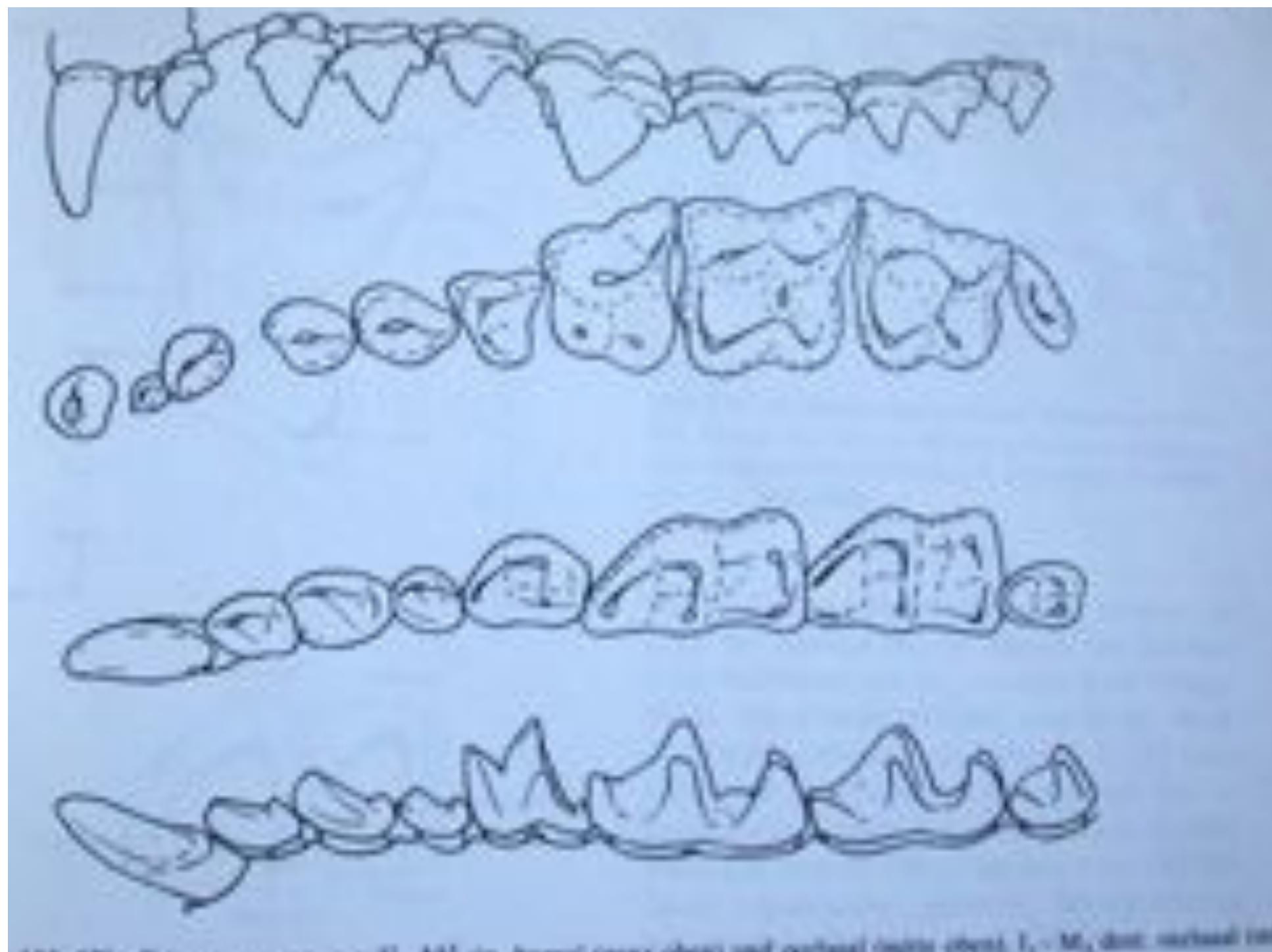


Figure 1. Four dental casts showing Class II, Class III, Class I, and Class IV malocclusions.

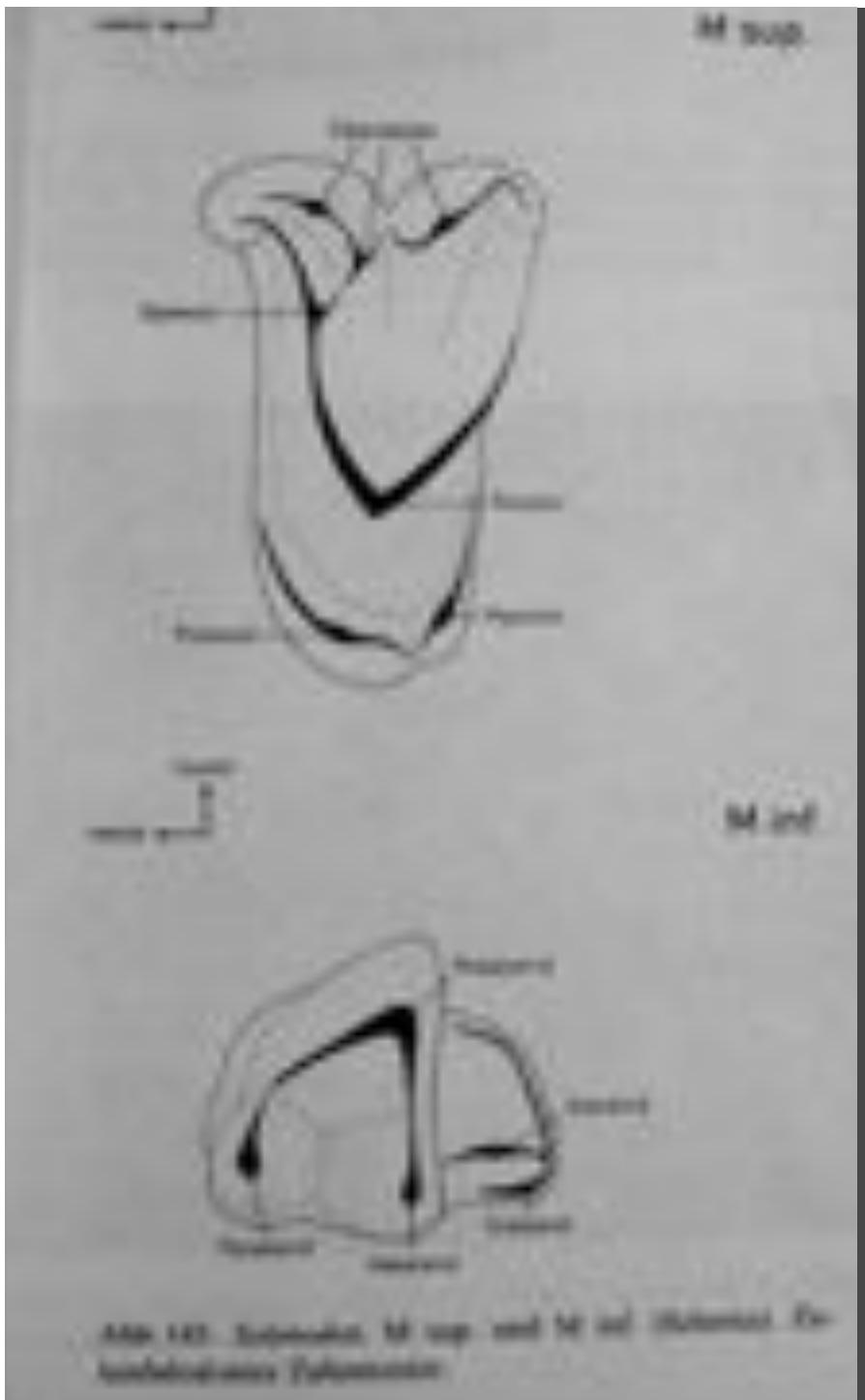


Abb. 147. Schematische M. cap. und M. ant. dargestellt. Per  
kontrastierende Farbung.

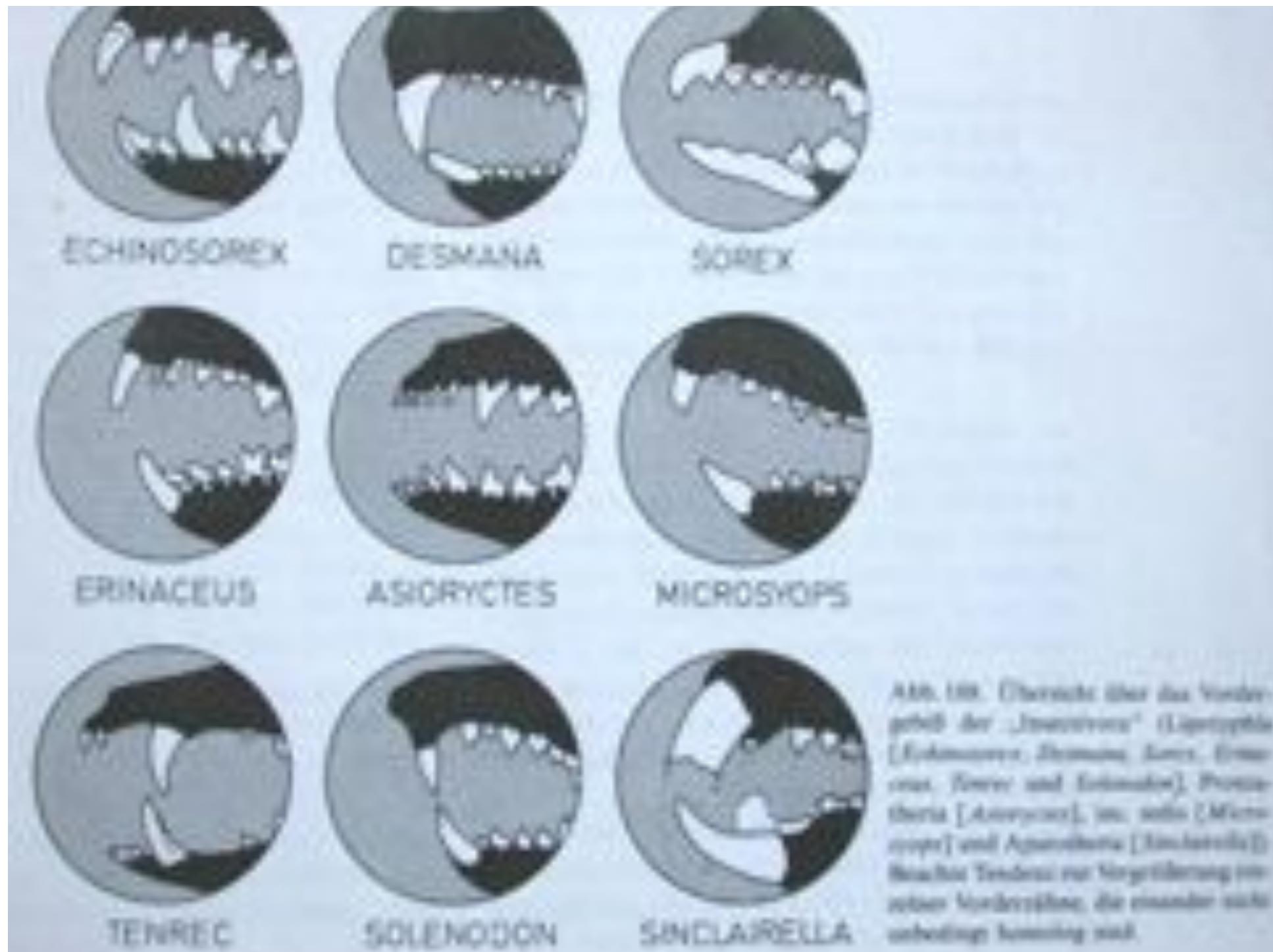


Abb. 188. Überblick über das Zahnschema der „Insektivoren“ (Leporophaile [Echinosorex, Desman, Sorex, Erinaceus, Tenrec und Solenodon], Procyontheria [Asidryctes], juc. solis [Microsyops] und Aegialomys [Sinclairella]). Nach der Tendenz zur Ausgrößerung von zentralen Molarzähnen, die rückwärts nach abnehmender Ausbildung zunehmen.

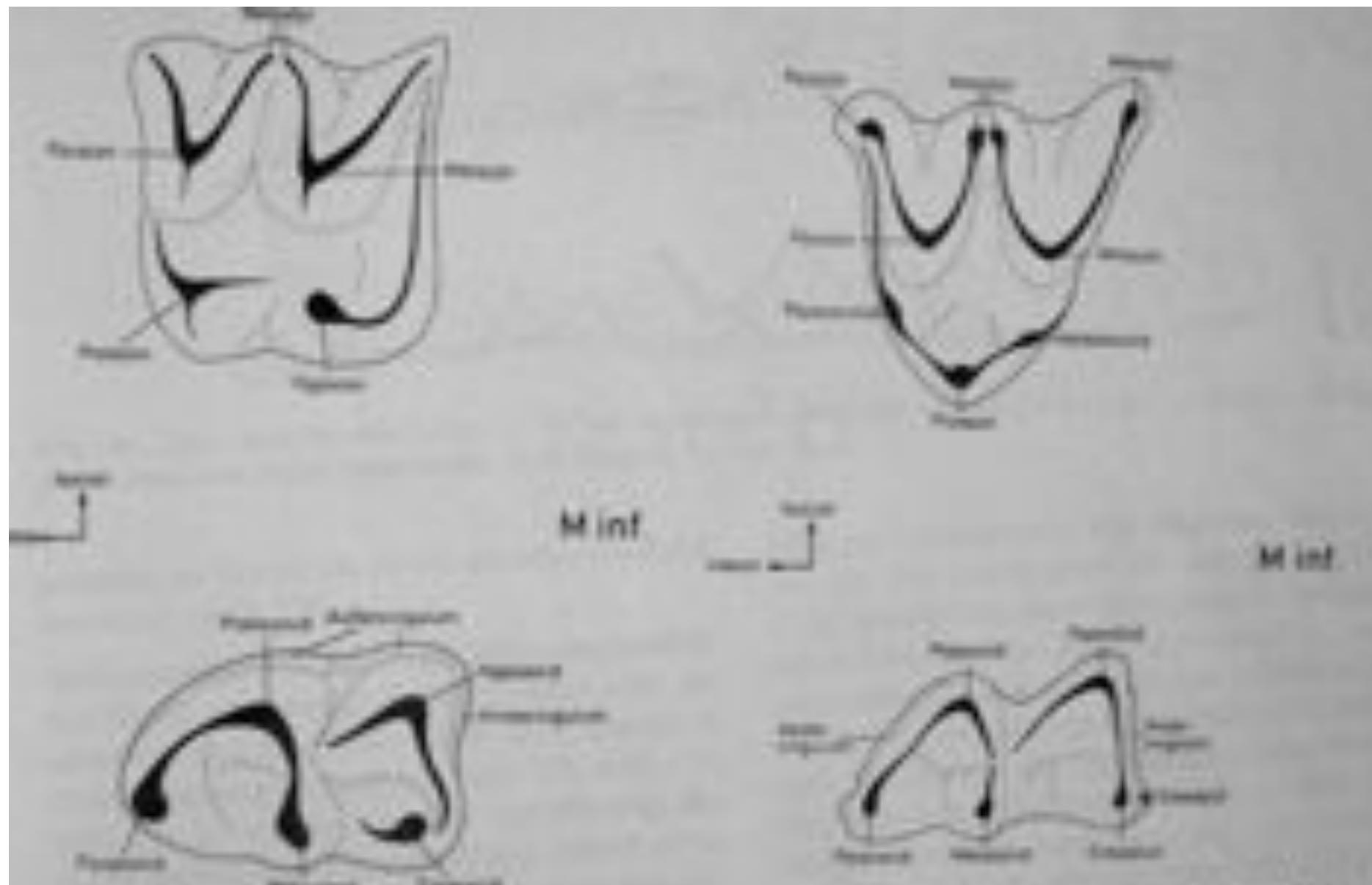


Abb. 137. *Abrothrix longipilis* (Gmelin). Muskus. Europa. M. und M<sub>1</sub> inf. (Schwarz).

Abb. 138. *Talpa* (*Talpidae*, rezent, Europa, M. sup. und M<sub>1</sub> inf. (Schwarz)). Beobachtungen: Mammalothek und Eisenberg.

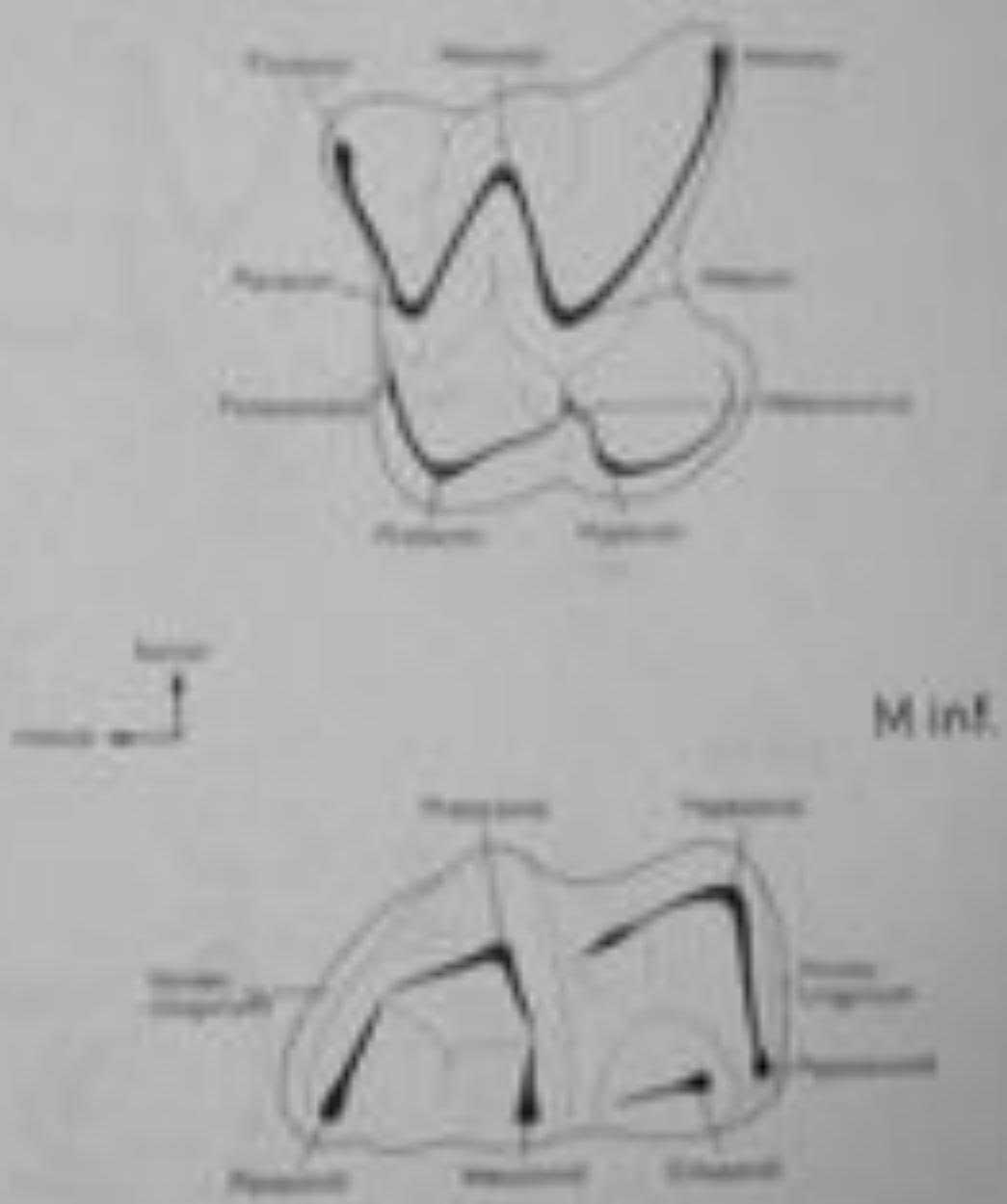


Abb. 335. Crocodylus (Crocodylus, Alligator), Europa. M. int.  
1. Anatomische Zeichnung. 2. Muskulatur des Mundes. M. int.



ECHINOSOREX



ERINACEUS



NEOMYS



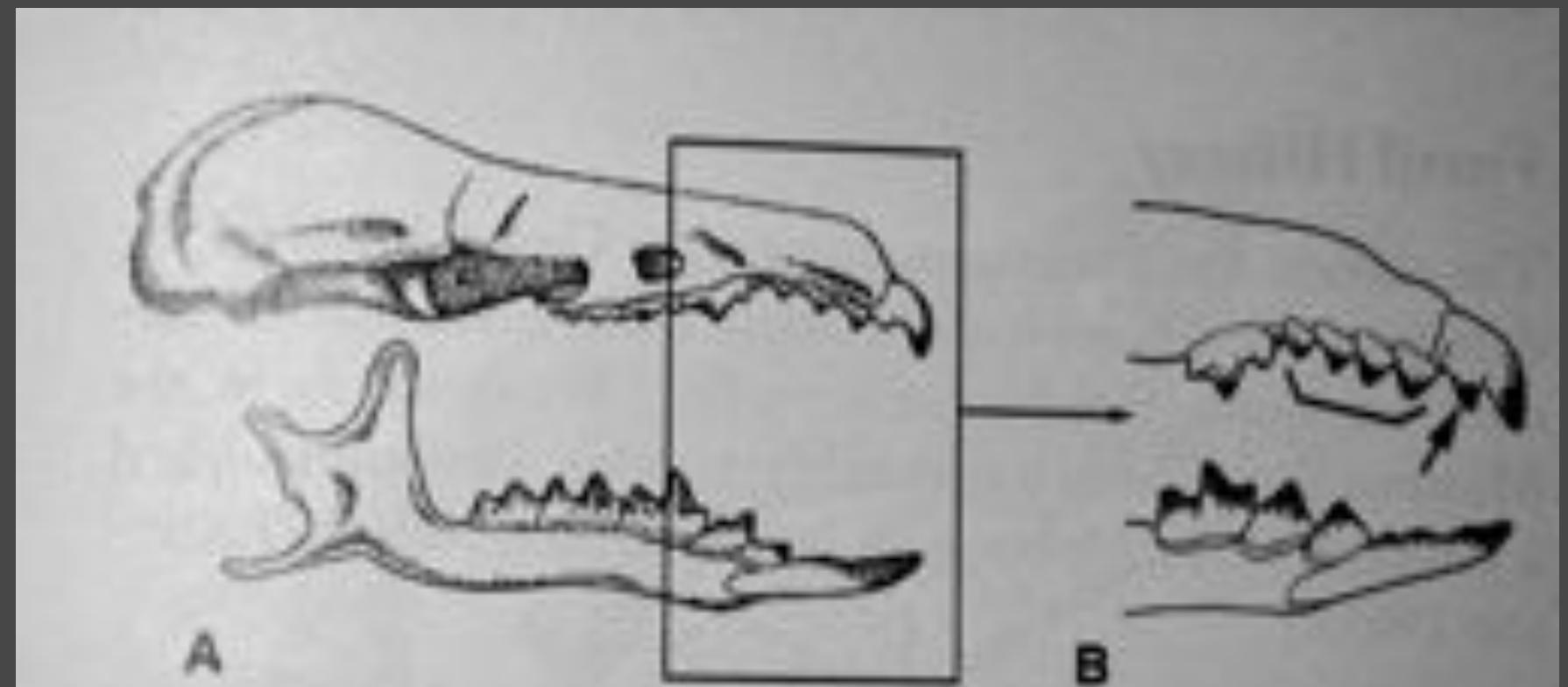
BRADYPUS



TALPA



OCTODON



**Figure 11.11** Characteristic features of shrew skulls.

(A) A typical shrew skull. Note the lack of the auditory bullae and zygomatic arch. (B) The enlarged anterior portion of a red-toothed shrew showing the distinctively pigmented enamel, procumbent first lower incisor, secondary cusp on the first upper incisor (arrow), and unicuspids (bracket). The incisors function as tweezers picking up

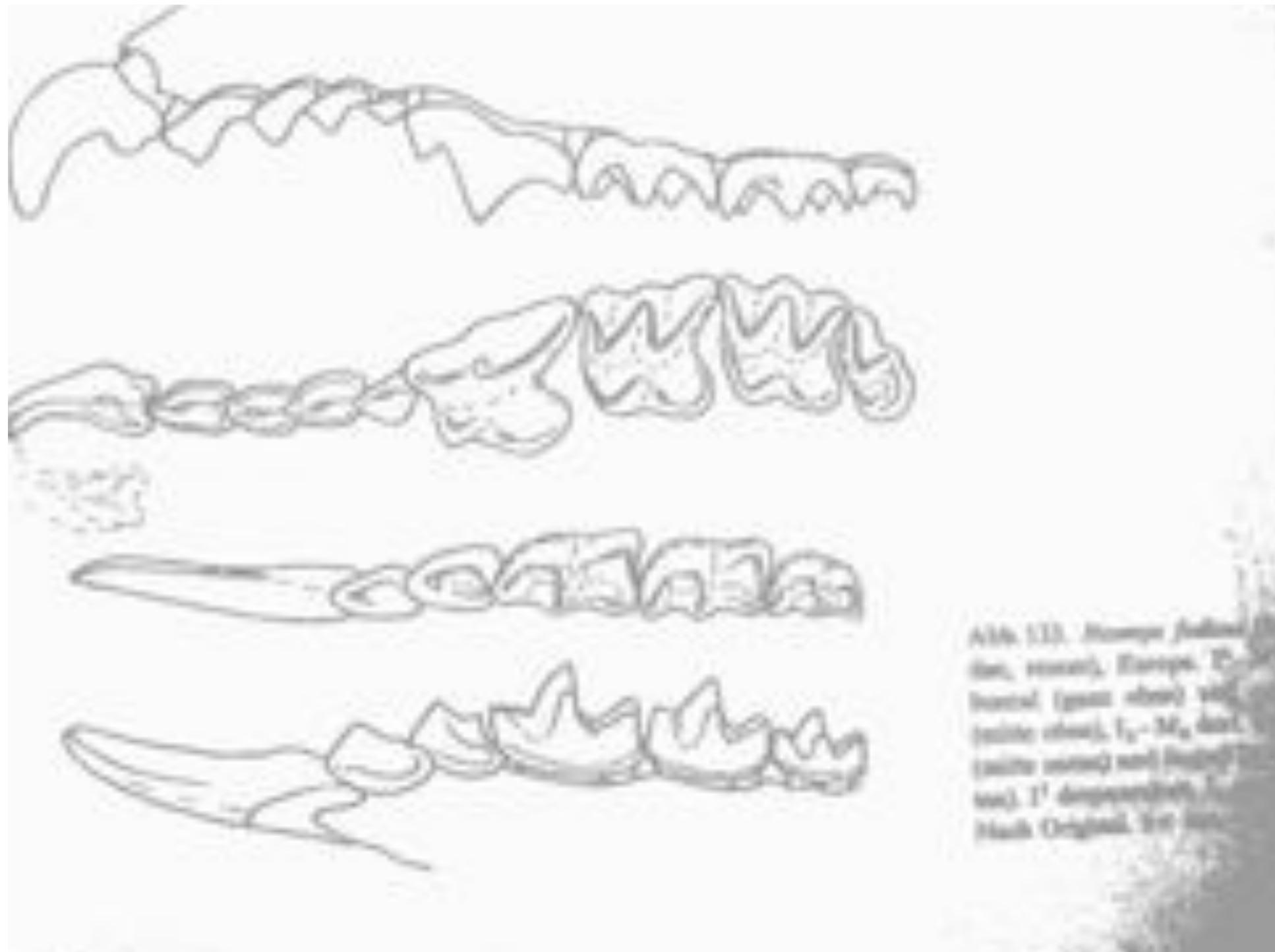
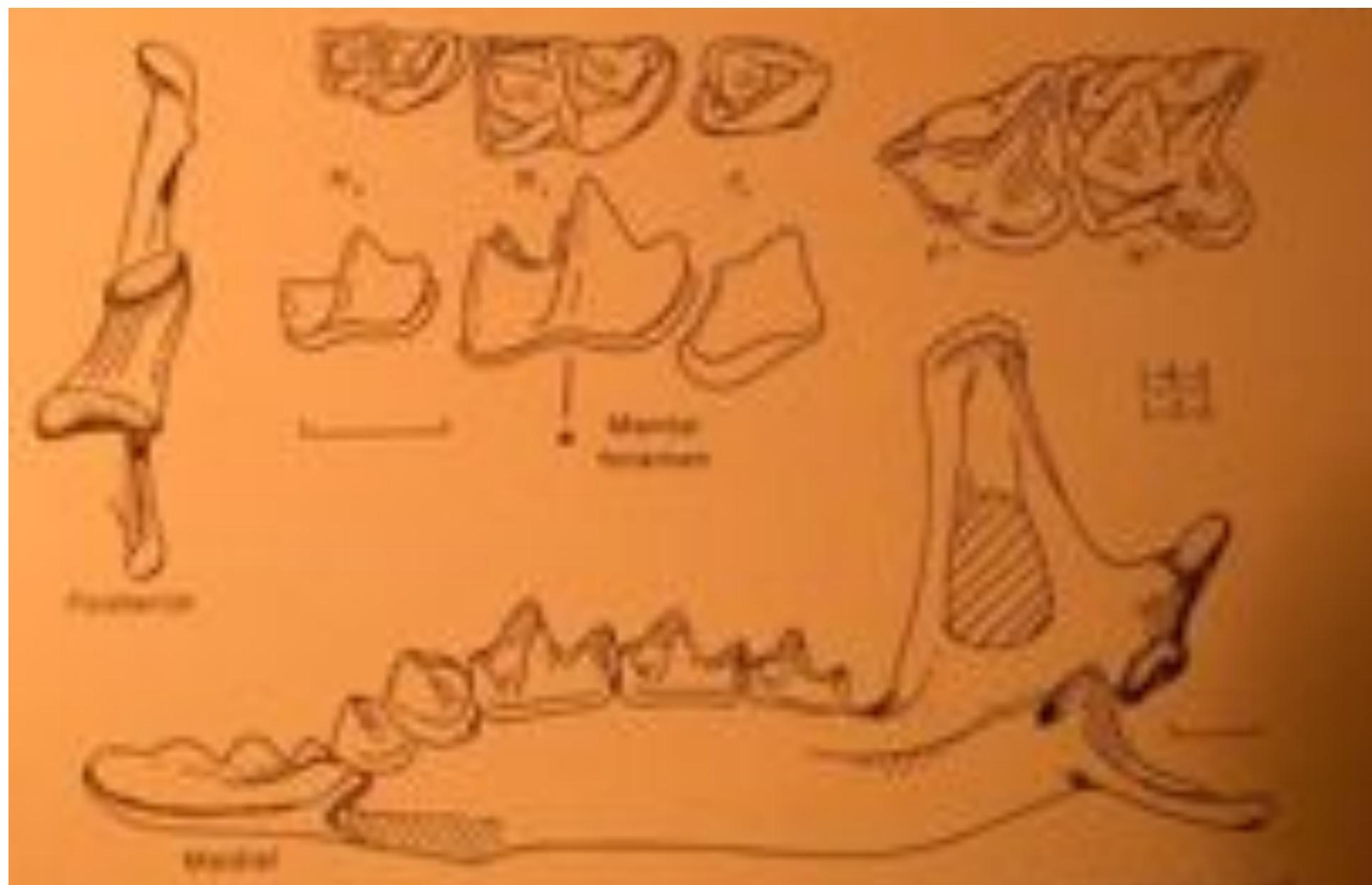
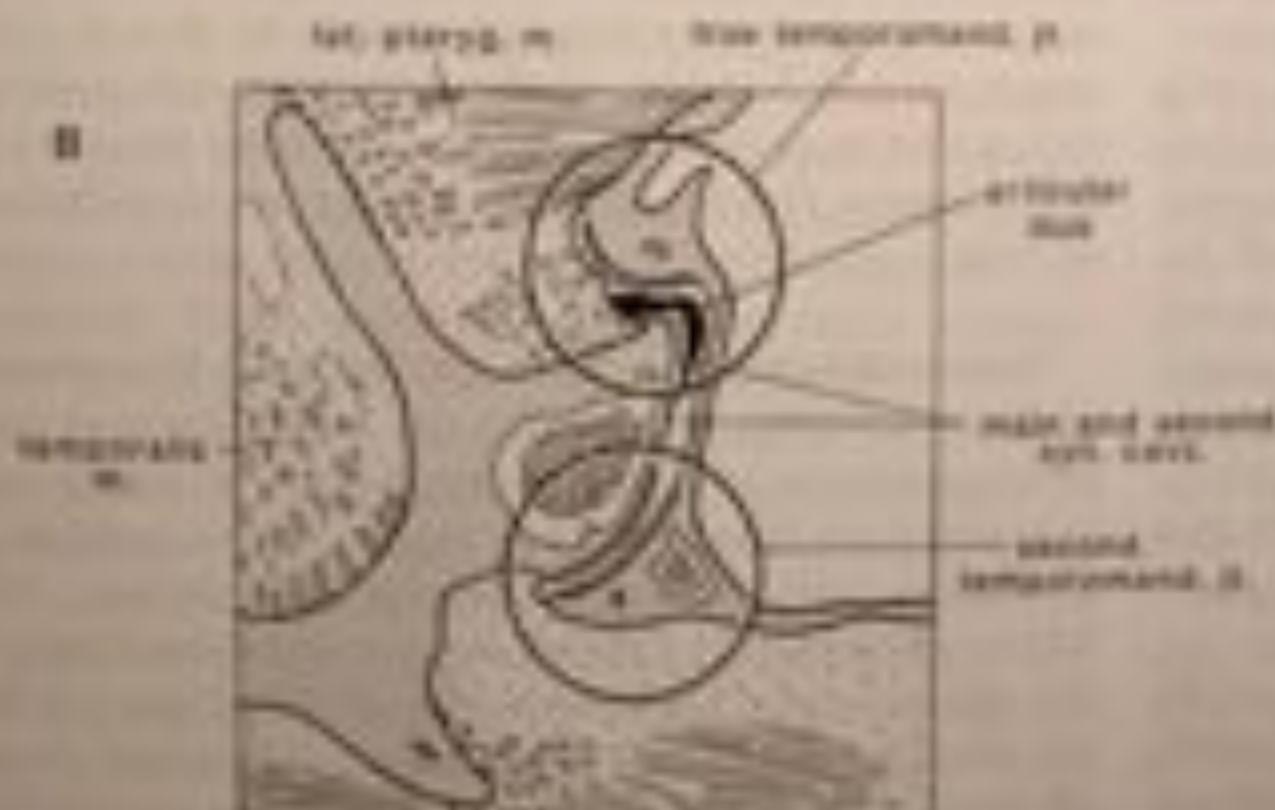
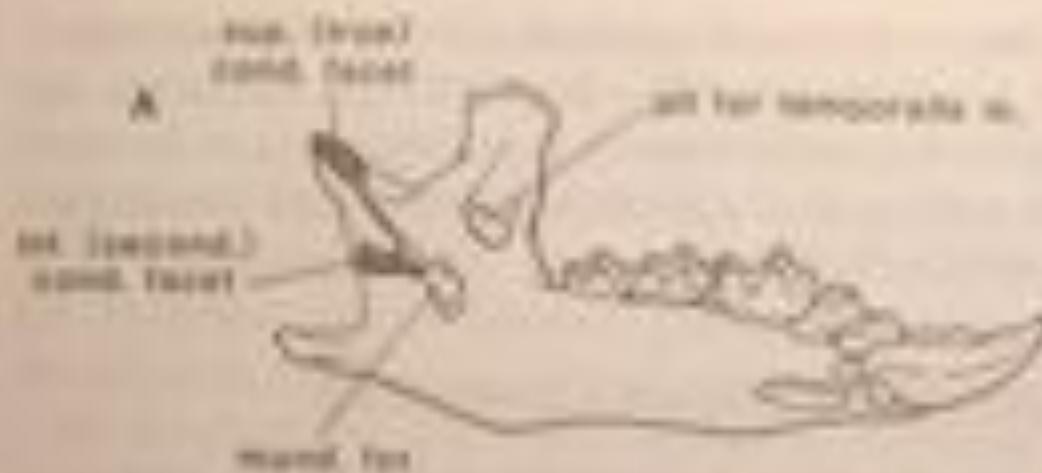
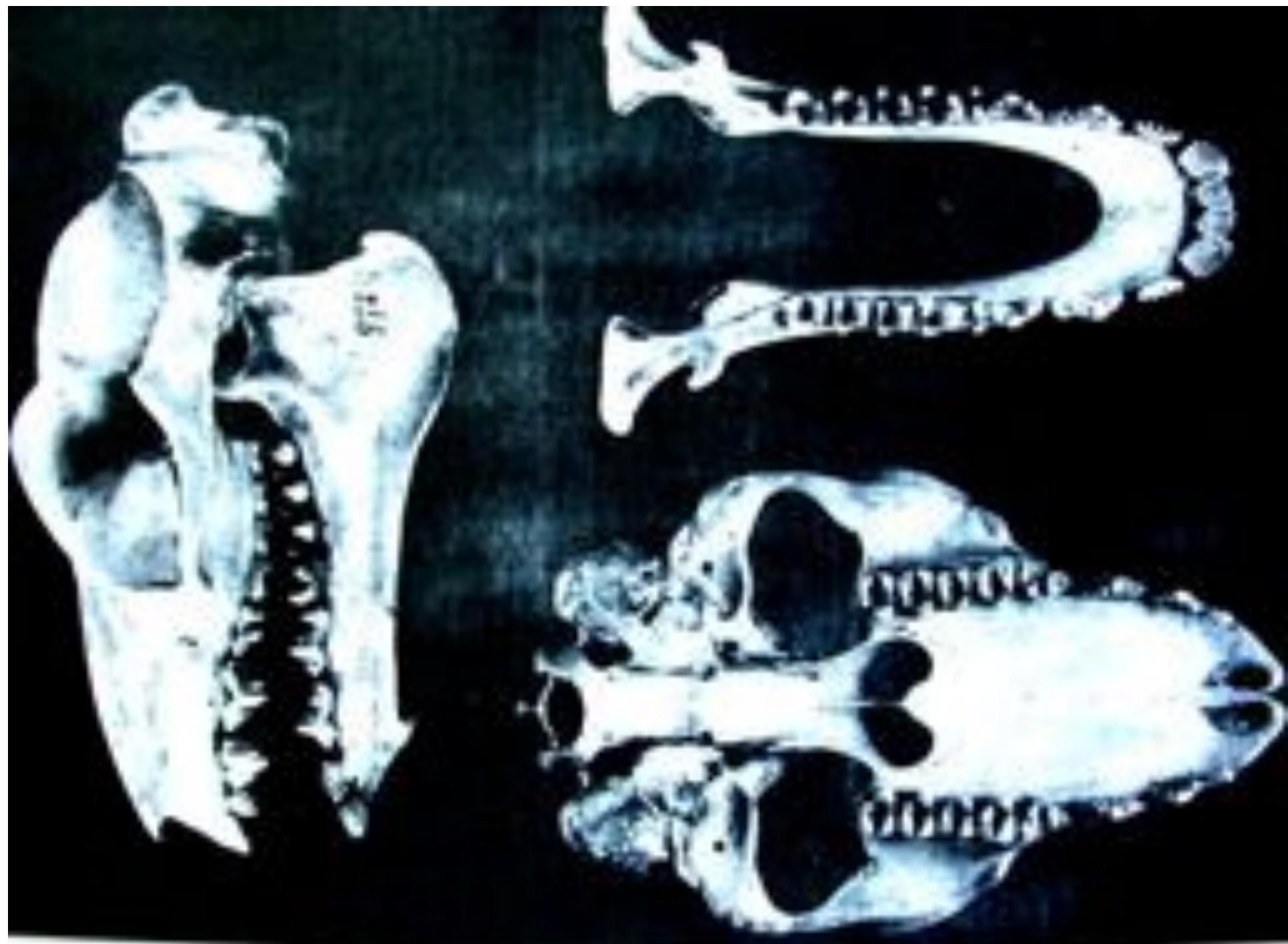


Abb. (13). *Blattaria*, *Phylloptera*, recent, Europe. Dorsal (upper above) and ventral (lower above)  $\Sigma$  (male above),  $T_1 - M_2$  dentate (male ventral) and dentate (male dorsal),  $T^1$  denticulate. (Male). Original. 3x magn.









- Cynocephalus



- Lemur







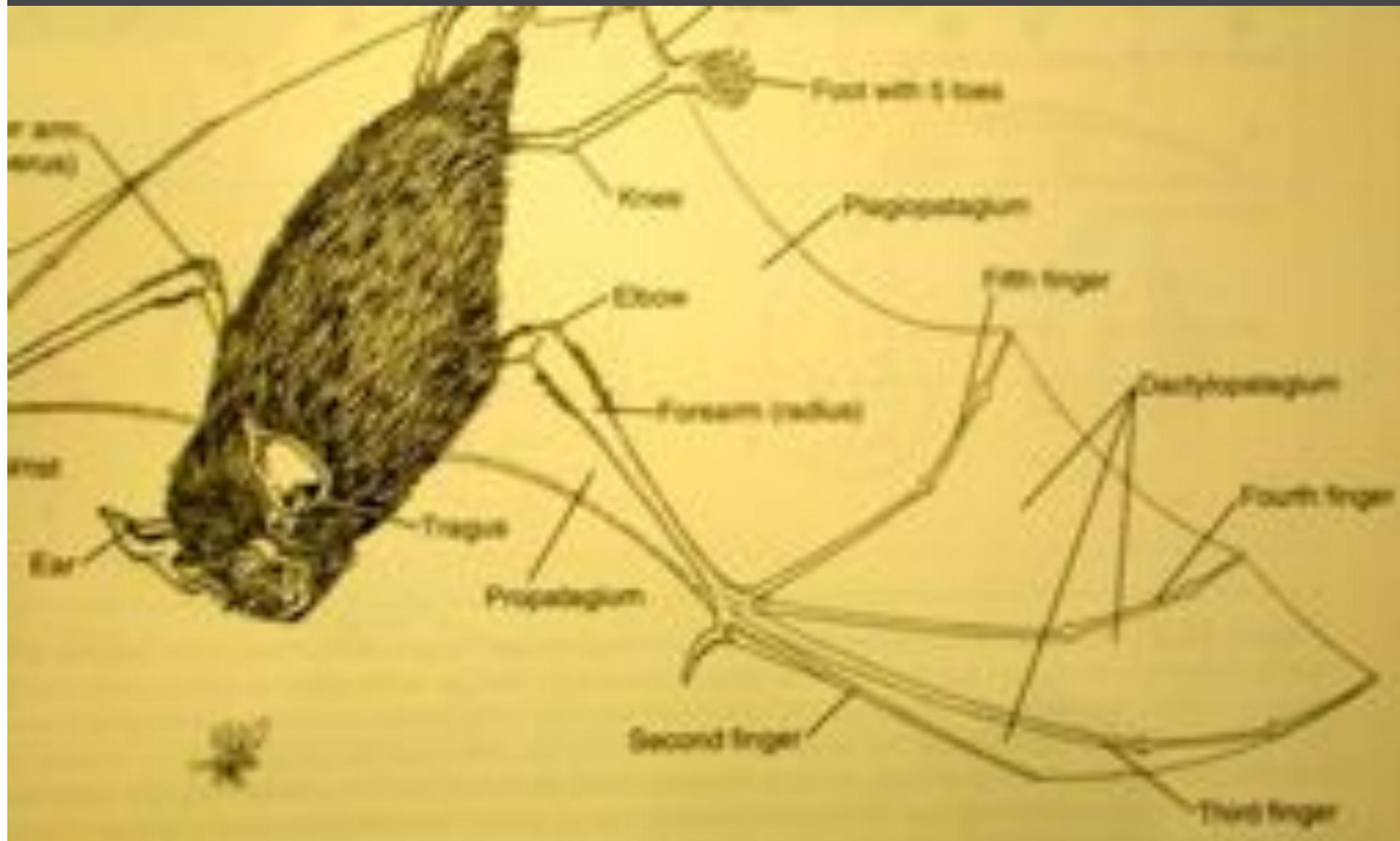


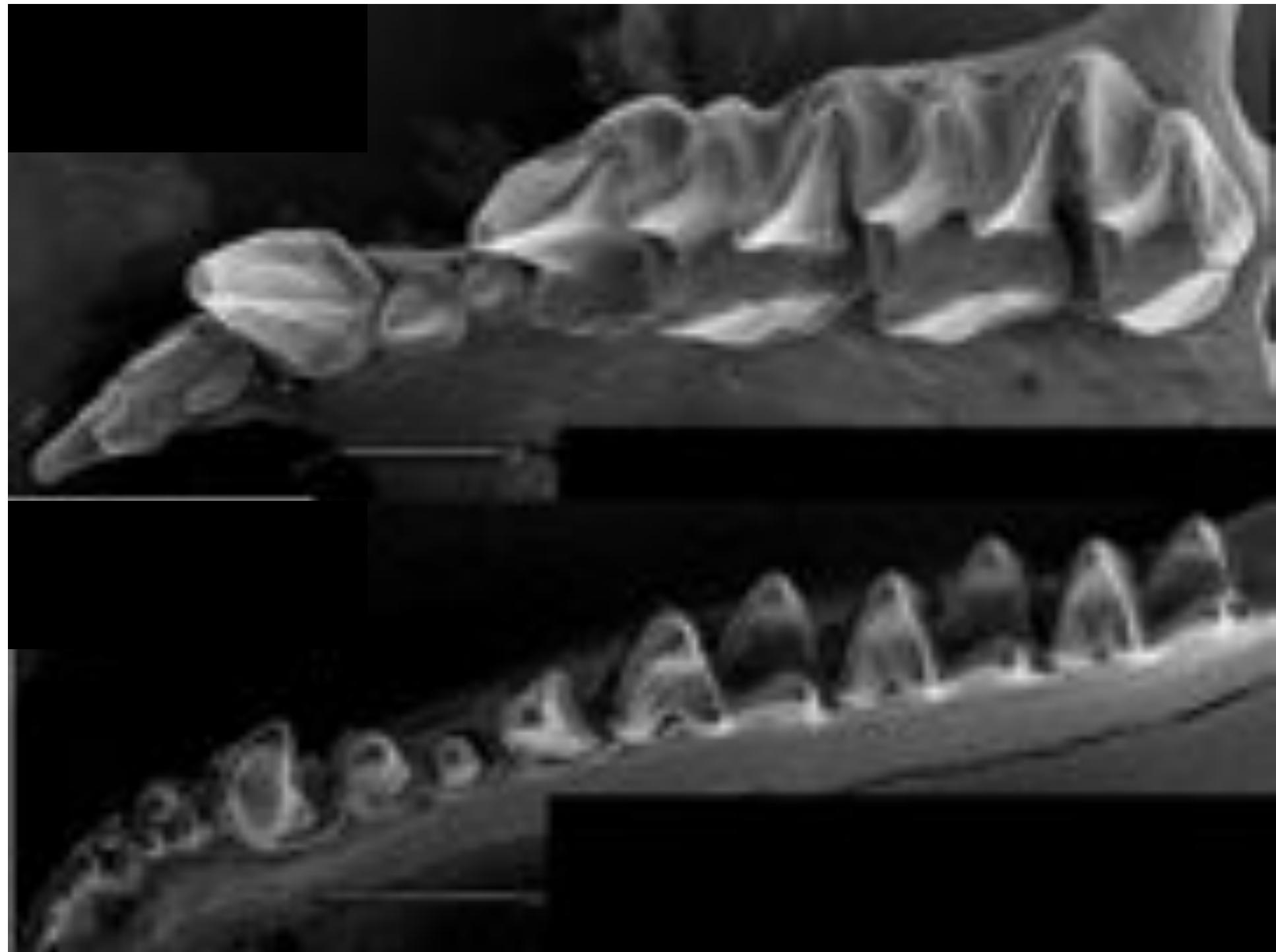






# Vzdušná insektivorie



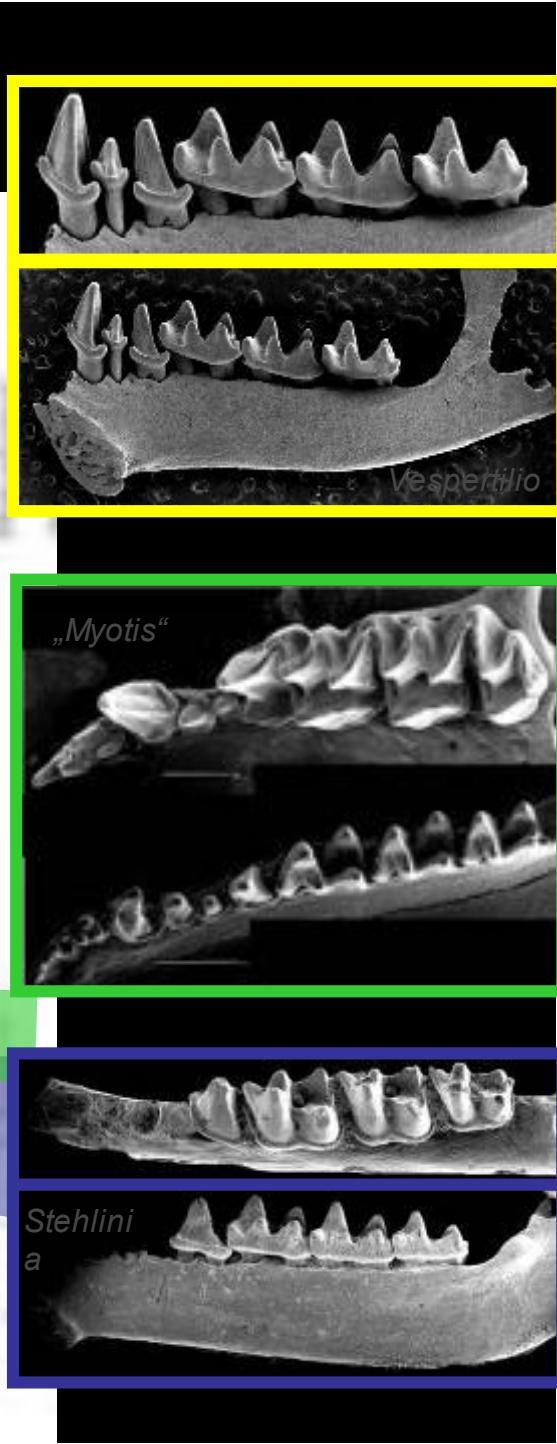
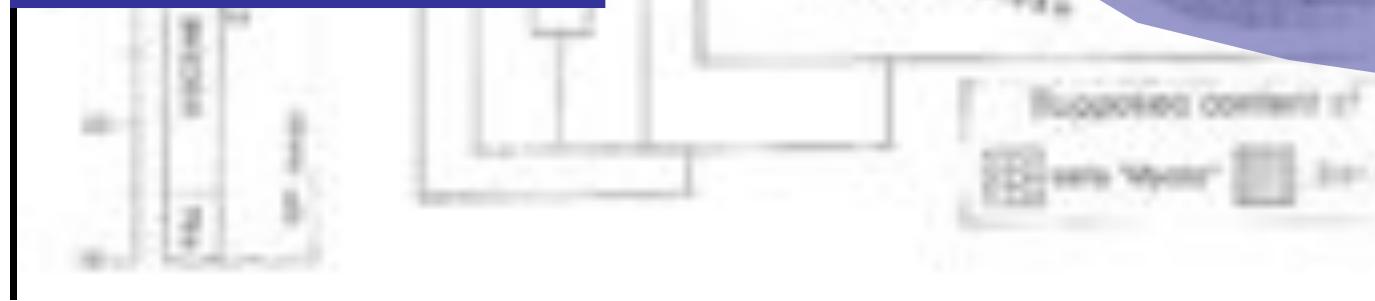
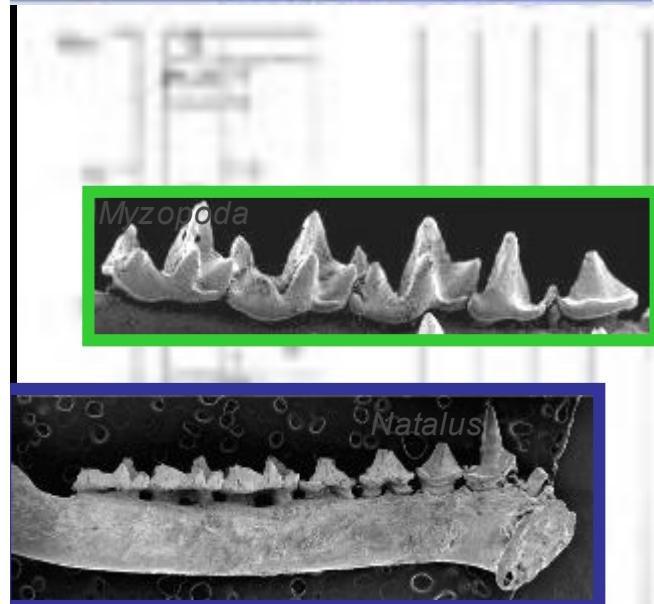


# Functional vs. Phylogenetic significance of the fine dental characters



Horáček 1985

Successive grades of dental rearrangements in vespertilionid bats (*Stehlinia*, „*Myotis*“, advanced) as suggested by the European fossil record



# Myrmecovorie

- Paralelně u různých skupin: redukce dentice, prodloužení čelistí, jazyka, zvětšení slinných žláz, hrabavé nohy (drápy), pasivní ochrana (bodliny, pancíře, šupiny):

Monotremata: *Tachyglossus, Zaglossus*

Edentata: *Dasyurus, Cyclopes, Myrmecophaga, Tamandua* etc.

Pholidota: *Manis*

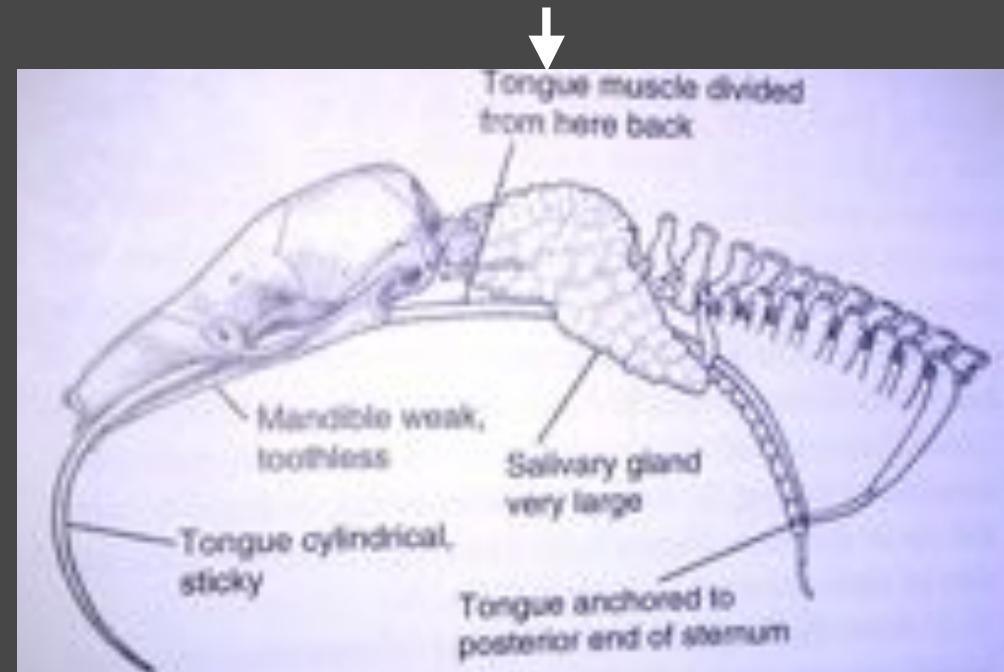
Tubulidentata: *Orycteropus*

Carnivora: *Proteles, Otocyon,*

## Sanguivorie:

Chi: Phyllostomidae

Desmodontinae



# Tubulidentata: *Orycteropus*



# Edentata ( Xenarthra ) - chudozubí: 4 f. 13 g., 29 spp. S (N) Am

Bradypodidae - lenochod tříprstý, 1g., 3 sp.

Megalonychidae - l. dvouprstý 1g, 2sp

Dasypodidae - pásovcovití 8, 20 sp.

Myrmecophagidae - mravenečníkovití 3 g., 4 sp.





Tachyglossidae - ježurovití : *Tachyglossus, Zaglossus*

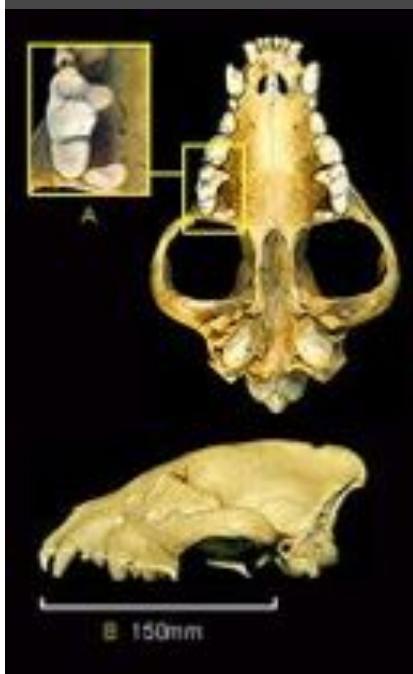
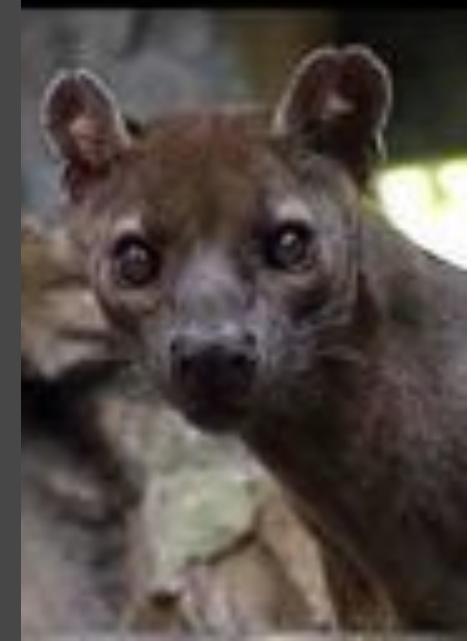




*Proteles cristatus*

# Carnivorie

- Zejm. pohybové a sociální adaptace
  - **Carnivora** - diversifikace (cf.RQH)
  - Partim: Marsupialia: Didelphomorpha, Dasyuromorpha, Placentalia: Insectivora, Chiroptera, Rodentia, Primates, Scandetia, Cetartiodactyla (Suidae, *Cephalotes*, *Orcinus*)



a sekundární divergence ..

- Piscivorie:

Didelphidae: *Chironectes*

Tenrecoidea: *Limnogale*, *Potamogale*

Insectivora=Lipotyphla: *Neomys*, *Galemys*, *Desmana*

Carnivora: *Lutreola*, Lutrinae, Phocidae

Otariidae

Cetartiodactyla: Odontoceti

Rodentia: *Ichtyomys*, *Hydromys*

Cancrivorie (a mlži):

– *Odobaenus*, *Enhydra*, *Hydromys*

- Planktonovorie (zejm. drobní korýši *Euphasia* aj., Apendicularia etc.):

Mysticeti, Phocidae: *Lobodon*, *Ommatophoca*



# Herpestidae























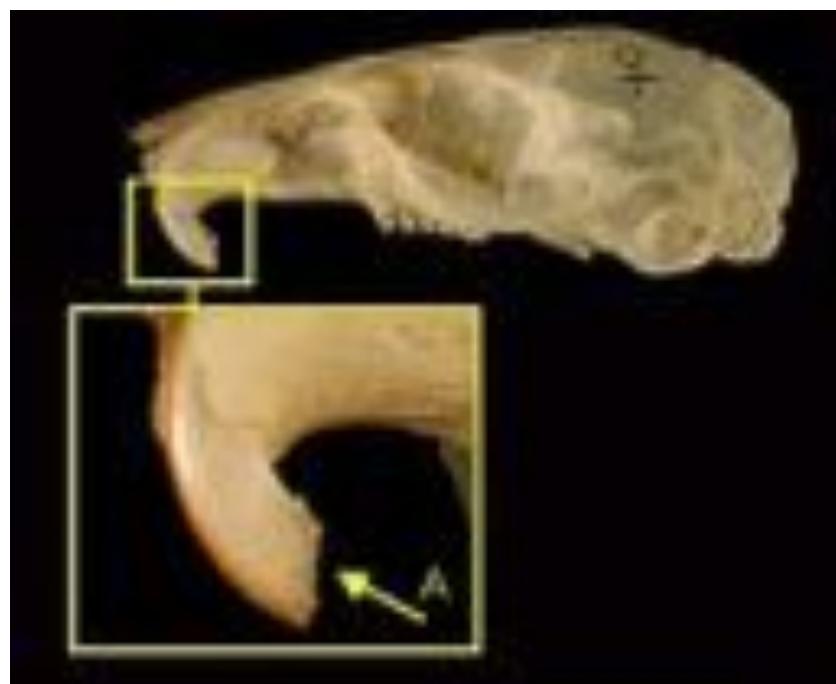
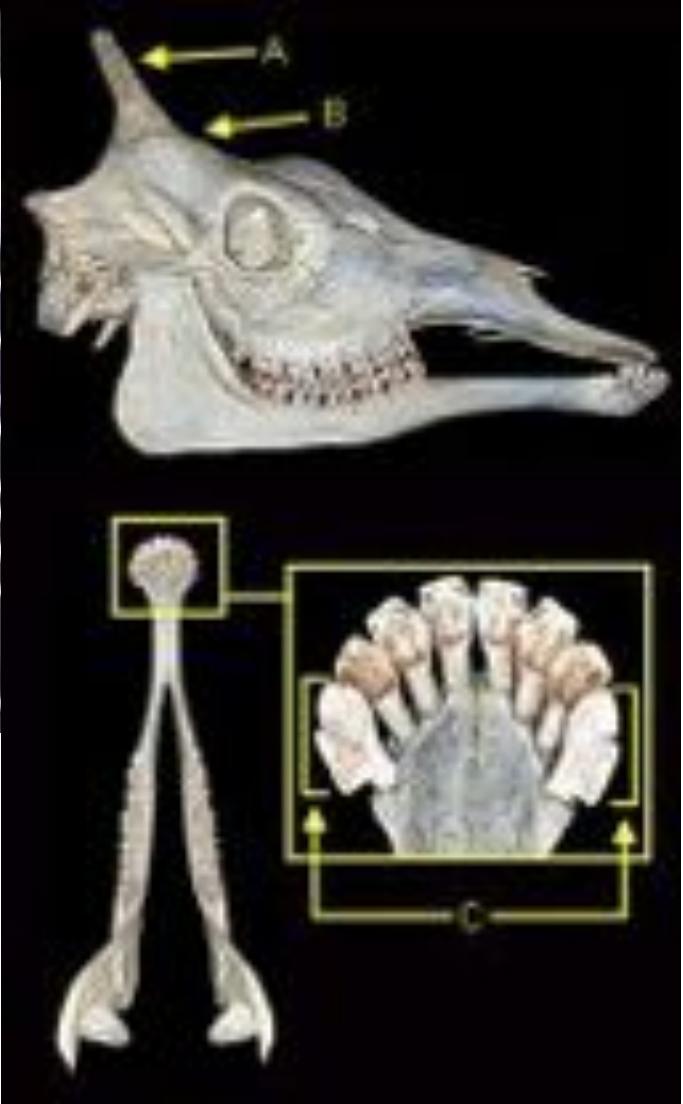
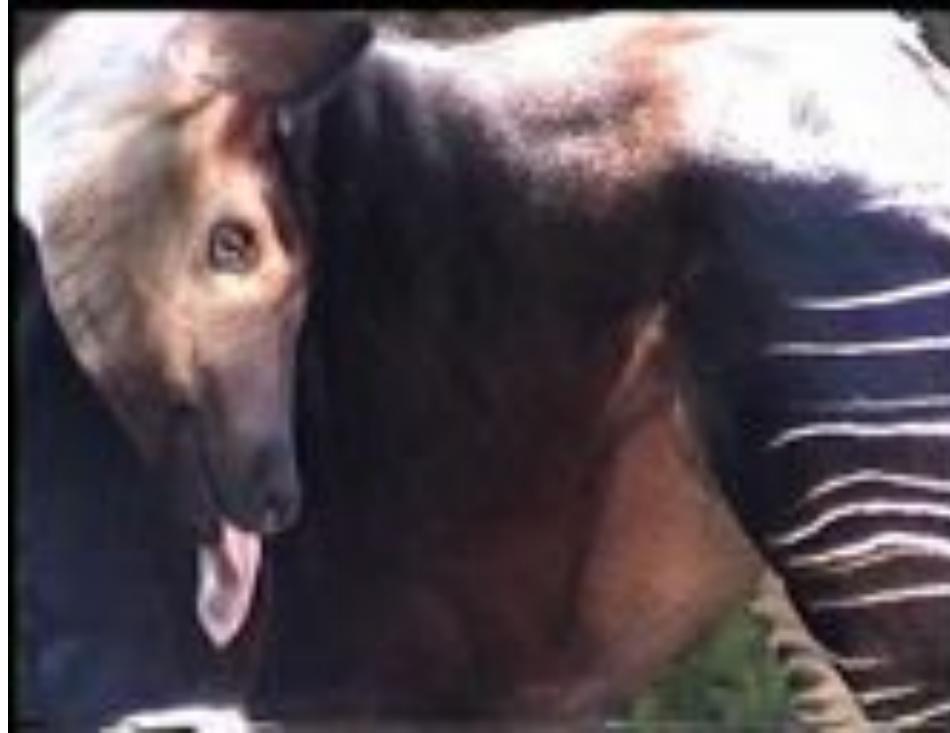


# Faunivorie vs. Herbivorie

- Frugivorie - součást základního rozvrhu
  - Specialisovaná frugivorie:
    - Např. Primates, Carnivora: Procyonydae: *Potos*, Viveridae: *Paradoxurus* aj.
- Nektarivorie, Palynovorie
  - Marsupialia: *Tarsipes*
  - Chiroptera: Pteropodidae, Phyllostomidae
  - Primates:

# Foliovorie, graminivorie

- Široce dostupná potrava: velmi atraktivní strategie (i vývojově nejatraktivnější: jako základní trofické orientace designuje 18 savčích řádů), současně ale velmi nákladná na specifické adaptace a z různých důvodů dosti riskantní (13 řádů vymřelých)
  - Dentice a chrup: lofodontie, selenodontie, molarisace dentice, hypsodontie až hypselodontie
  - Prostorný a dlouhý trávicí trakt
  - Fermentace:



Herbivorie:  
Folio- & Graminivorie

**INSECTIVORE**  
Short intestine  
no cecum



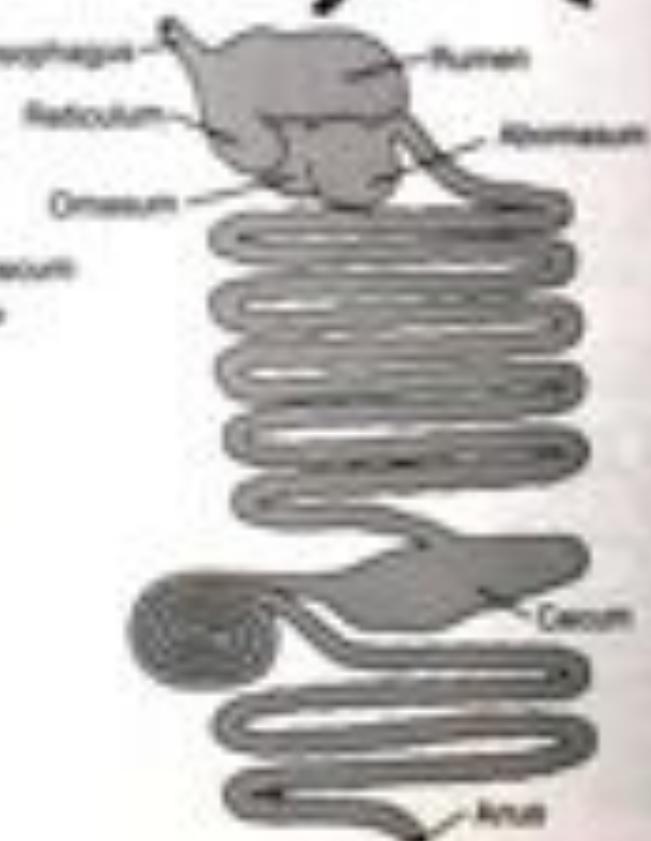
**CARNIVORE**  
Short intestine  
and cecum,  
small cecum



**INDIGESTIVE  
HERBIVORE**  
Simple stomach,  
large cecum



**RUMINANT  
HERBIVORE**  
Four-chambered stomach  
with large rumen; long  
small and large intestine





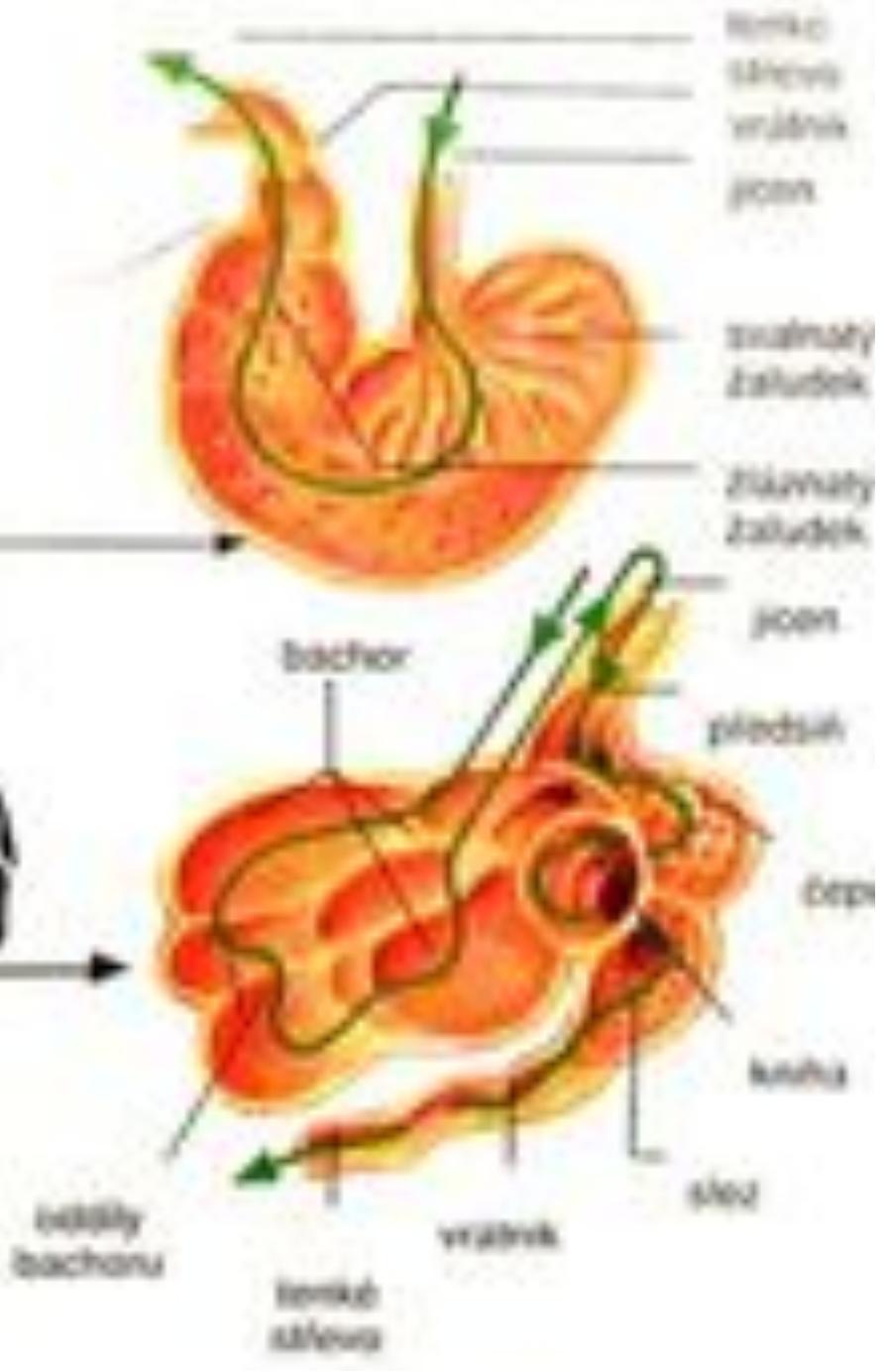
zebra



wildebeest  
topi



gazela  
Thomsonova



bolistý trachonu

bernik  
střeva

vrátko  
střeva

bernik  
střeva  
vrátko  
střeva

zvláštny  
žaludek

zvláštny  
žaludek

jícen

pídelník

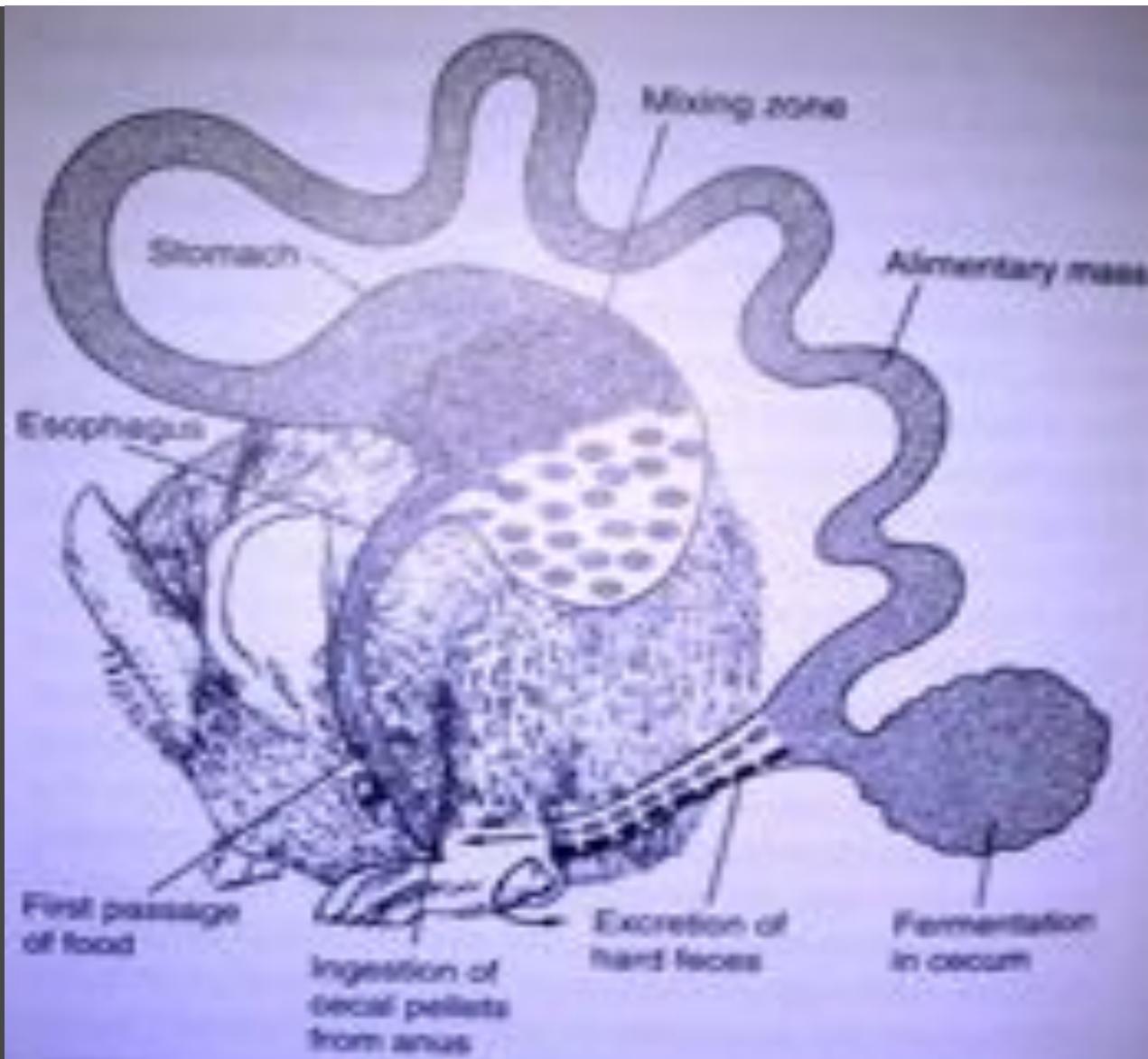
bernička

kuchyň

šleha

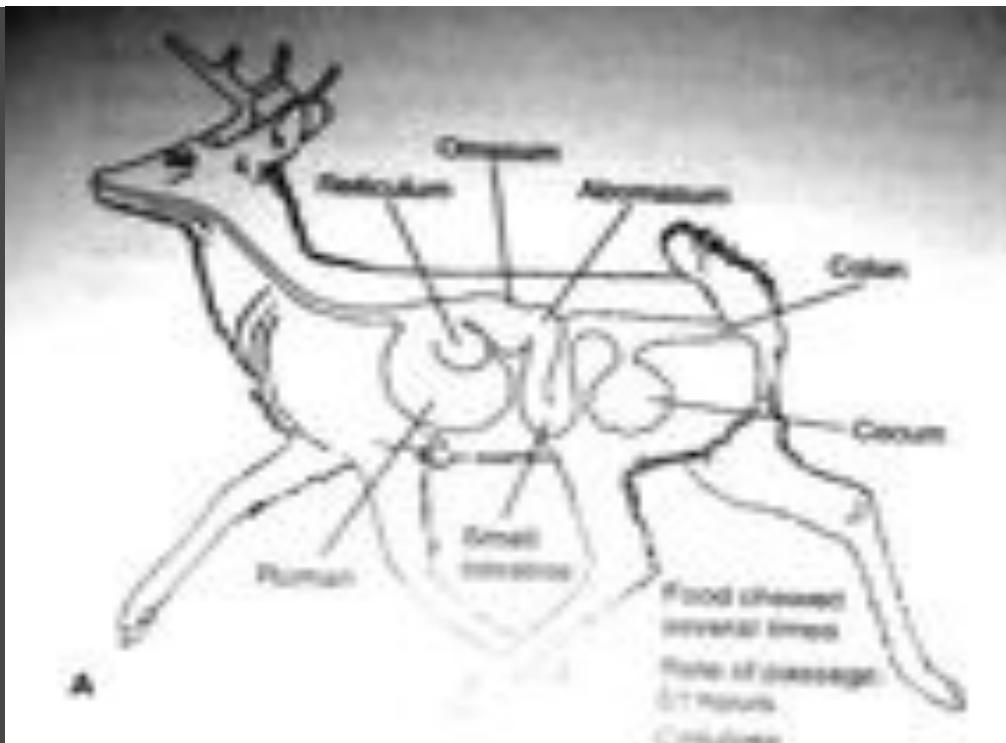
# Ad Foliovorie

- Caecotrofie
  - Lagomorpha
  - Rodentia
  - Soricidae

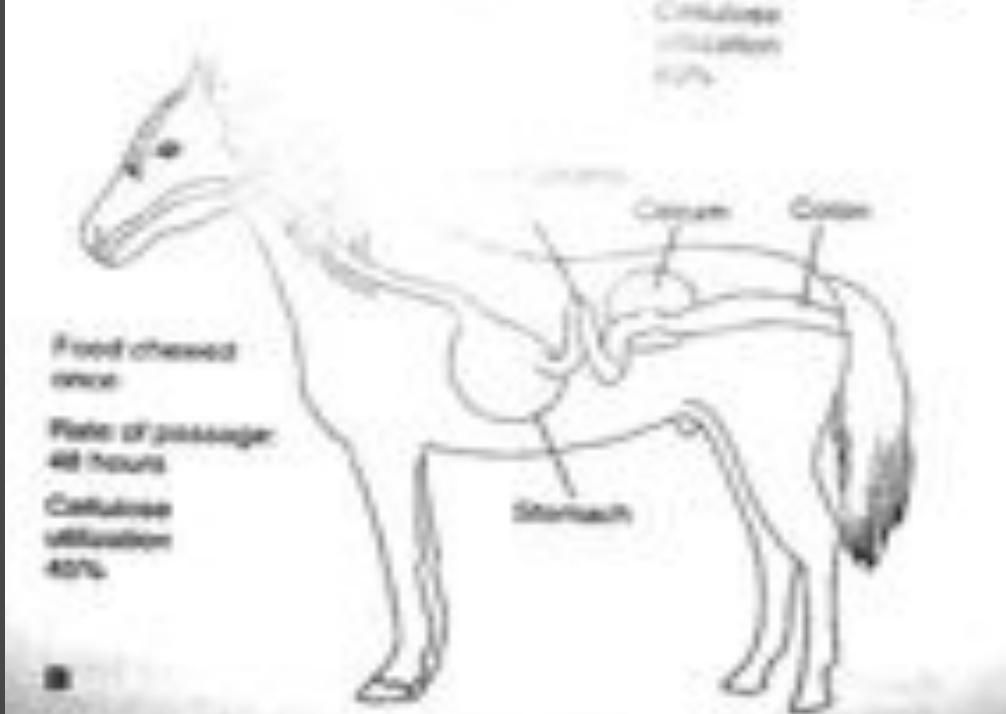


**Figure 6.11. Coprophagy.** Coprophagy occurs in shrews, rodents, and lagomorphs. The digestive tract of lagomorphs is highly modified for coping with large quantities of vegetation. The alimentary tract is a long cecum, which contains bacterial flora to aid in the digestion of cellulose.

- Digastrický typ



- Monogastrický typ



# Foliovorie - Graminivorie

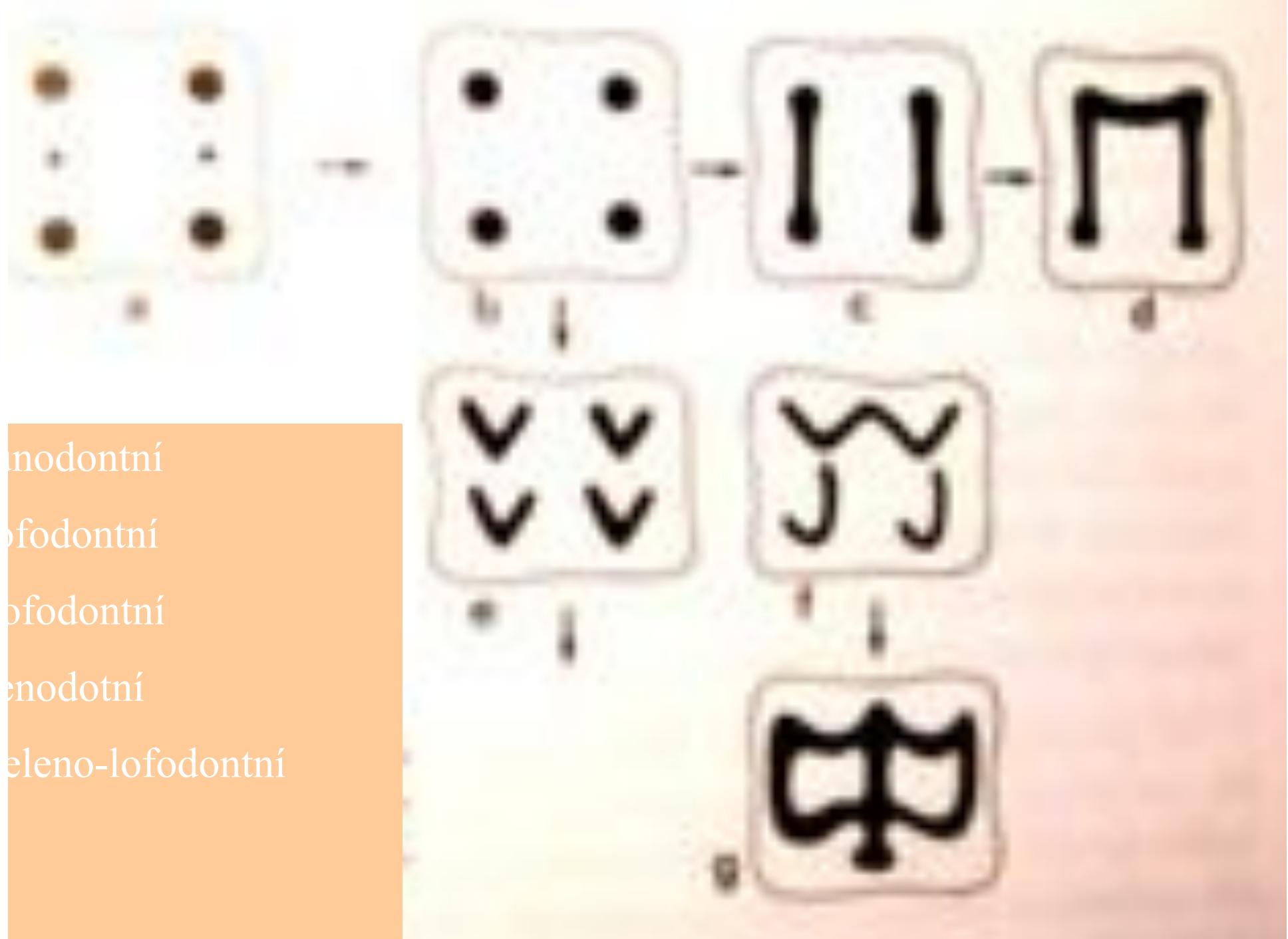
| Fermentace:   | <b>Monogastrický<br/>(ceaculidní) typ</b>             | <b>Digastrický<br/>(ruminantní) typ</b>                                     |
|---|---|---|
| <i>Mladá zelená hmota, meristemy- toxins (alkaloidy)</i><br>Protein<<celulosa | Toxin přímo do krve !<br>Nutné velké objemy !         | Fermentace + oxidace – destrukce toxinů, Vysoká efektivita využití proteinu |
| <i>Starší stadia rostlin: taniny, SiO-vlákna</i><br>Proteiny>celulosa         | Atrice zubů,<br>Trávení v ceaku – rozklad taninu - OK | Vláknina, taniny – omezují fermentaci – snížení efektivity !                |

## Monogastrický - caeculidní fermentace (caecum)

|             |   |      |
|-------------|---|------|
| Metatheria: | Diprotodontia mit Ausnahme der Petrogale- | 1-20 |
| Eutheria:   | Primate (außer Colobidae)                 | 1-20 |
|             | Proboscidea                               | 1-20 |
|             | Hyracoidae                                | 1-20 |
|             | Perissodactyla (Elch, Rhinoceros, Pferde) | 1-20 |
|             | Suidae: <i>Sus</i> , <i>Phacochoerus</i>  | 1-20 |
|             | Sirenia                                   | 1-20 |
|             | viele Rodentia                            | 1-20 |

## Digastrický - ruminantní fermentace (rumen)

|             |  |      |
|-------------|--|------|
| Metatheria: | Potoroinat, Macroscelidat                    | 1-20 |
| Eutheria:   | Colobidae                                    | 1-20 |
|             | Bradypodidae                                 | 1-20 |
|             | Hippopotamidae                               | 1-20 |
|             | Tarsiidae                                    | 1-20 |
|             | Suidae: <i>Babirusa</i> , <i>Hylochcerus</i> | 5-40 |
|             | Tylopoda                                     | 1-20 |
|             | Tragulidae                                   | 1-20 |
|             | Pecora                                       | 1-20 |













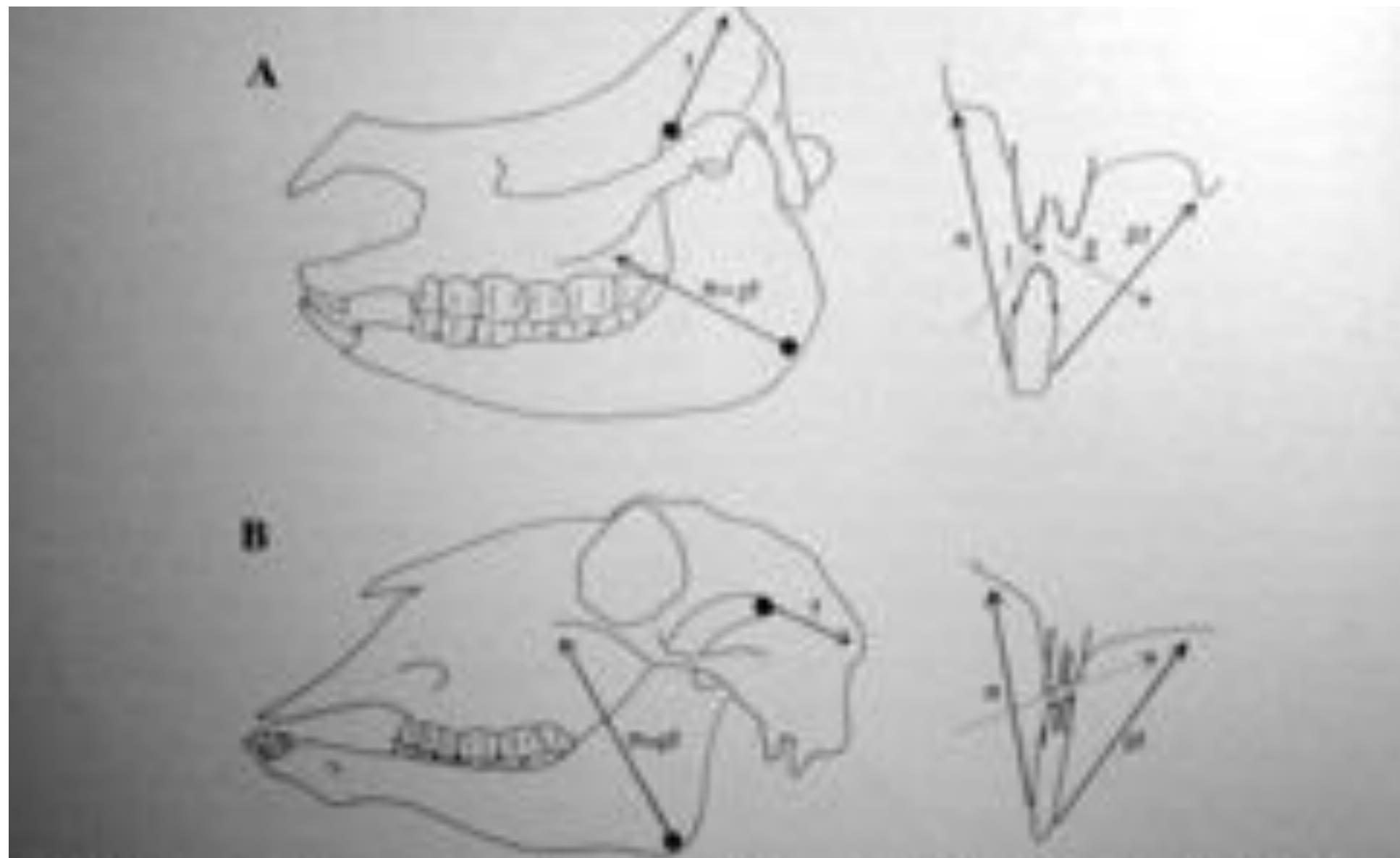


Fig. 1A, sagittal schematic representations of the main masticatory muscle layers. — *Blarina canadensis* (A), with one plane masticatory morphology. — *Oligoryzomys* (B), with one plane masticatory morphology. To the right are three-dimensional movement patterns. The single-plane arrangement allows greater overlap in muscular activity during the power stroke. The curved arrows indicate directions of lesser motor movements during the power stroke, that are not meant to indicate the full set of possible movements. I and II refer to the phases of the power stroke. M = masticator muscle, P = jaw joint.



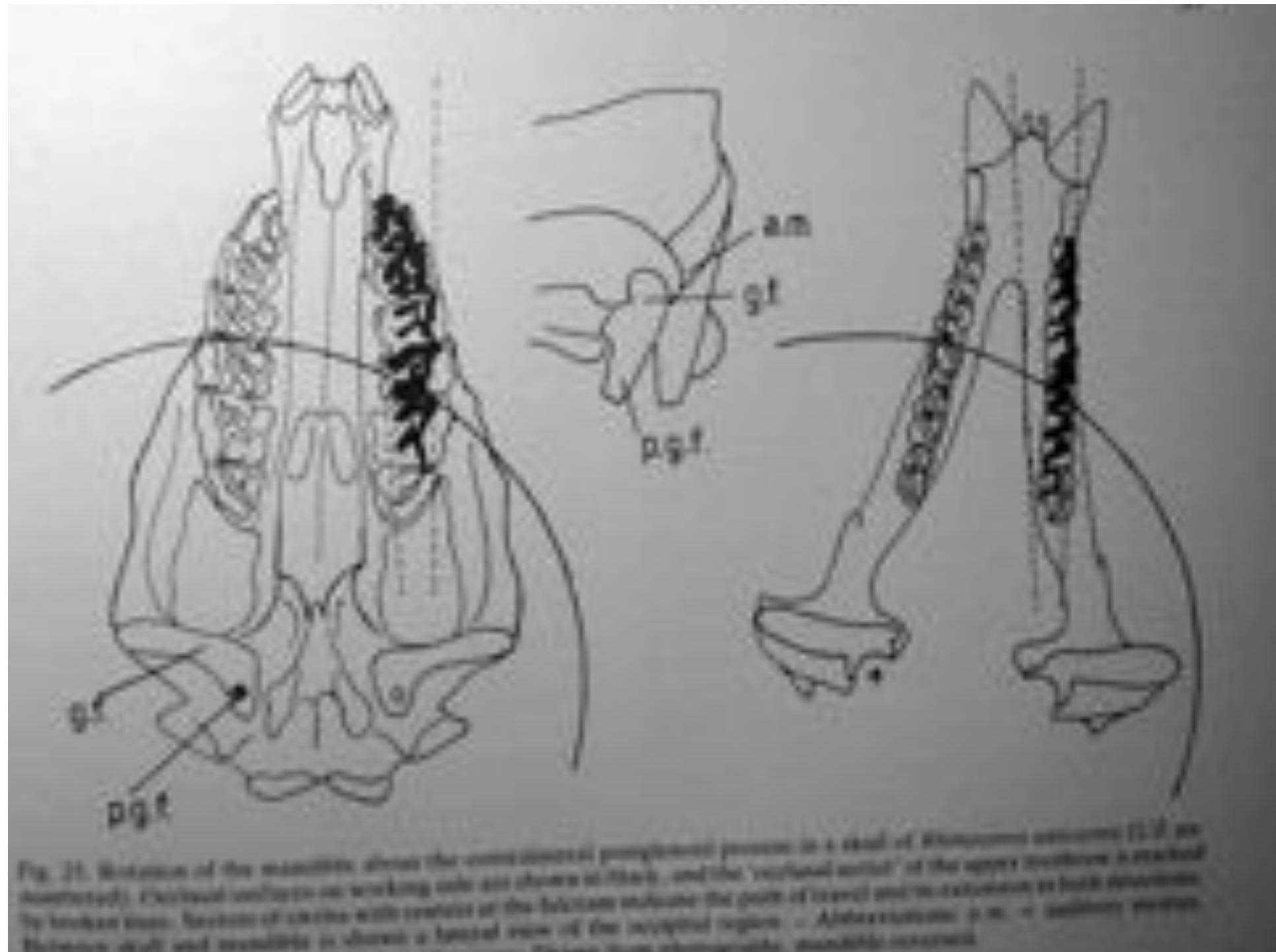
### ECTOLOPHOdont



### PLAGILOPHODONT



Figure 1. Ectolophodont (*Diprotodon* *horridus*) and plagiolophodont (*Genyornis newtoni*) upper molars. Adapted from Fox (1991).



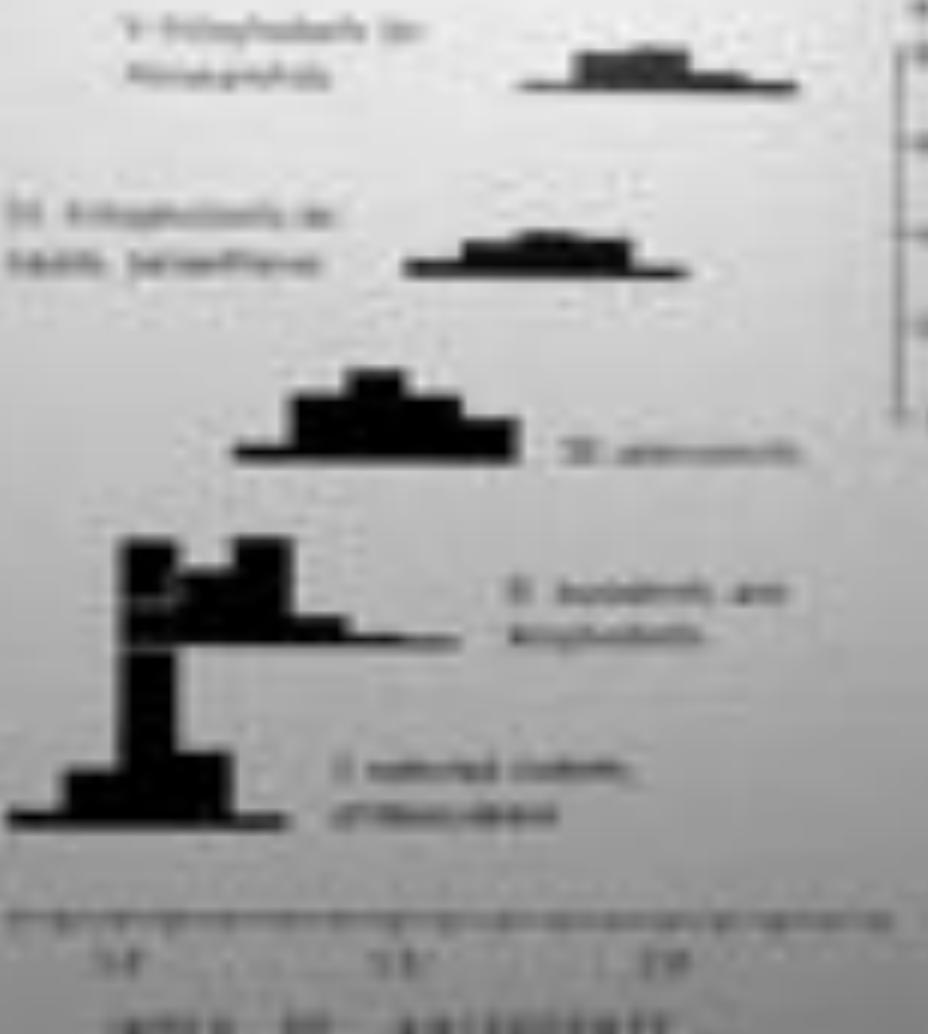


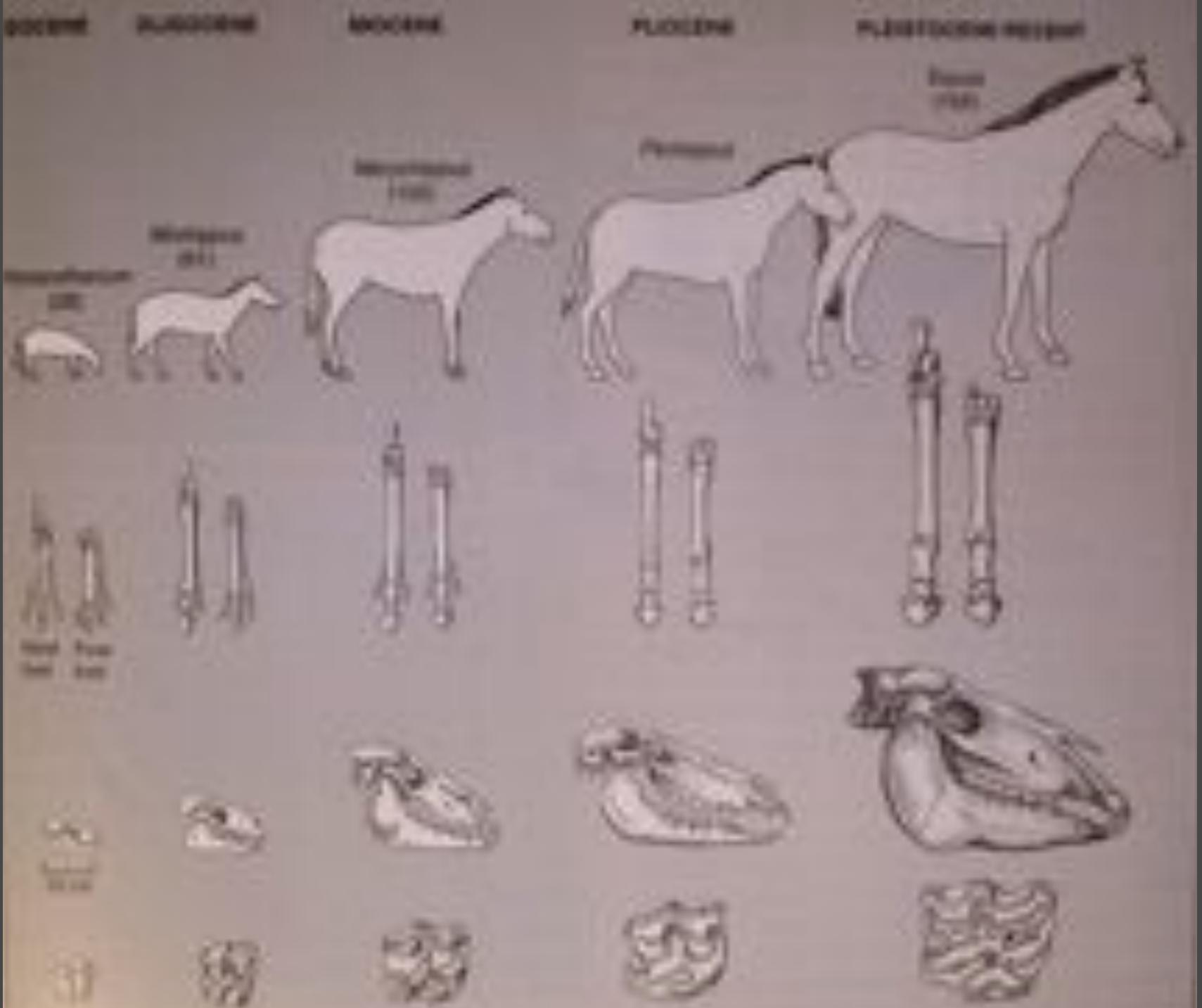
Fig. 10. Five histograms showing the distribution of cumulative density of estimated species richness for different species richness estimation methods. The x-axis denotes estimated richness, and the y-axis denotes frequency of estimated richness.

of the estimated richness distributions for the different methods. The x-axis denotes estimated richness, and the y-axis denotes frequency of estimated richness. The distributions for the different methods are very similar, with the highest frequency occurring between 60 and 80 estimated richness units. The distributions are skewed towards higher richness values, indicating that the estimated richness is often overestimated.











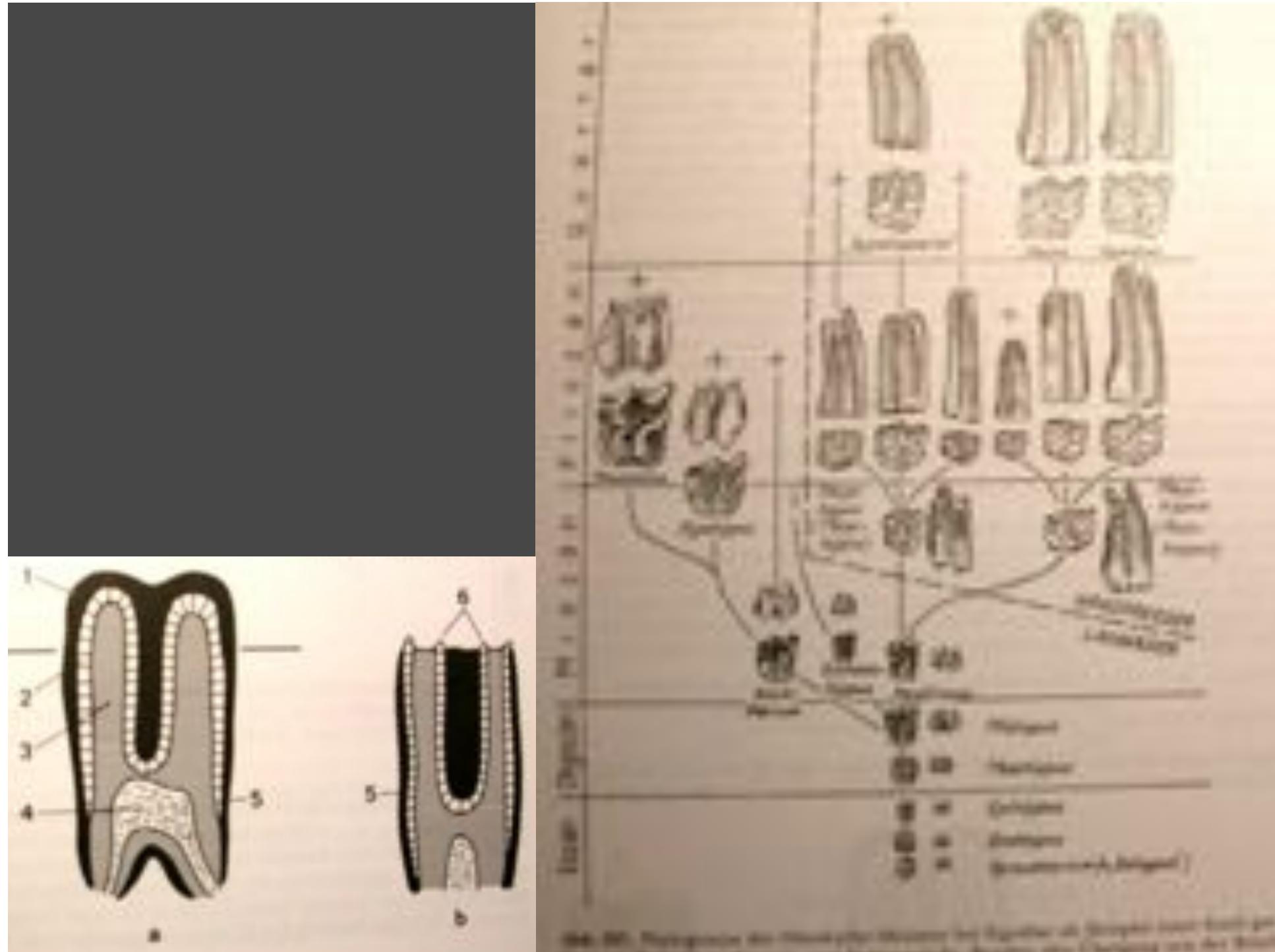


Abb. 50: Photographie des Mäusezähns nach Histologie der Zähne des Mäusezahns nach dem Schleicher und Schüppen.



#### Important vein characteristics



dark



medium



light



very light



thin



thick

Choosing the right vein is important for the success of dialysis because your treatment depends on how well the blood flows through the vein. Your doctor will consider several factors when choosing the best vein, including its location, its thickness, and whether it has been used before. In addition, your doctor will consider your overall health, including any medical conditions you may have, as well as any medications you are taking.



Figure 10.6 Seven major reservoirs, which developed from dark circles originally, represent an older type of notation used before the molecular version. The present book prefers a graphic. Any colour or various strategies among the colors of

the reservoirs are members of the Pennsylvania Block, USA, Pennsylvania, Minnesota, Florida, and Mexico. This represents over 80 percent human cases with no racial distinction.

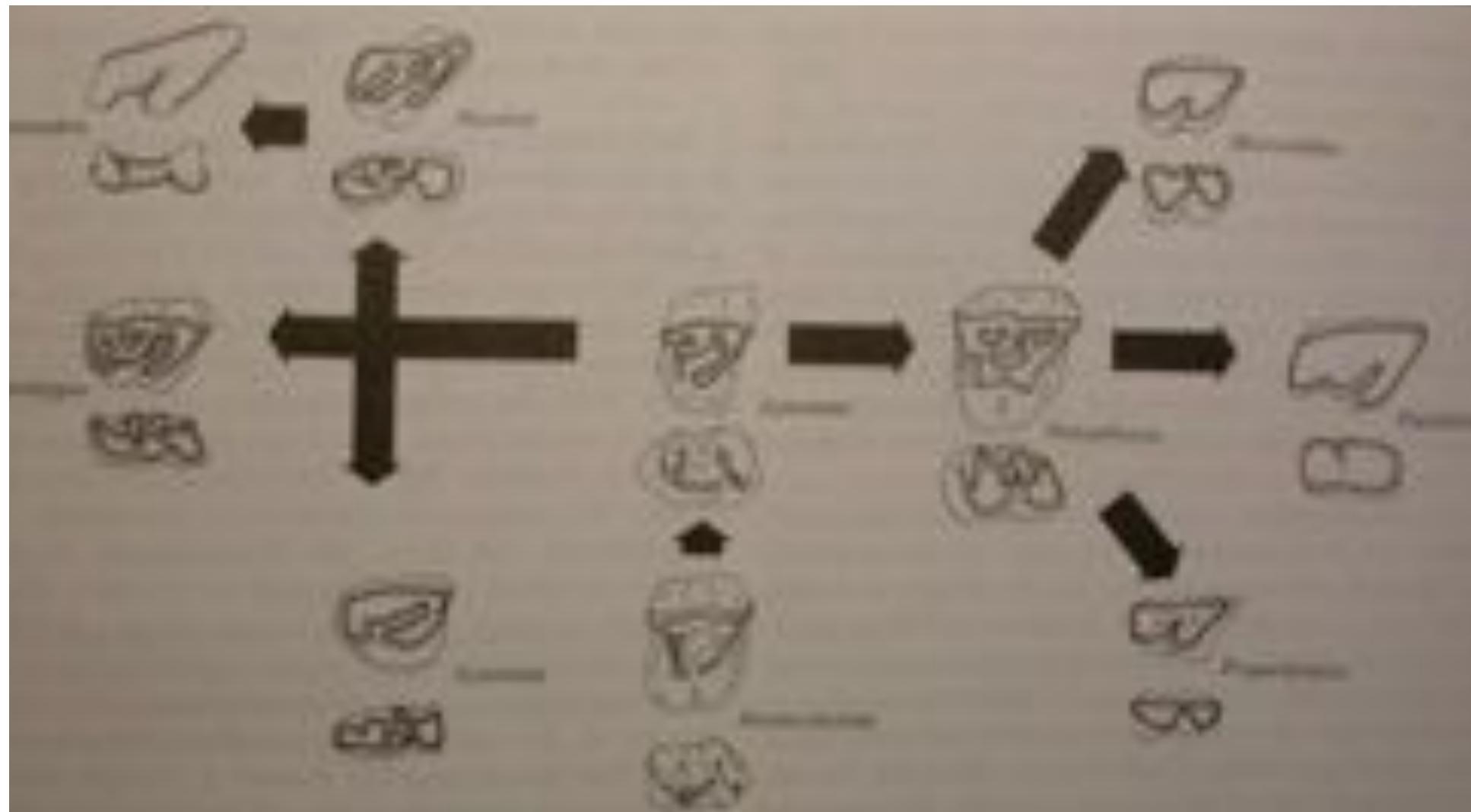


FIG. 10. Dental morphologies among South American ungulates. Hypothetical position of nonmolarous molar patterns (Macrauchenia patachonica) among the South American ungulates, including an upper molar present, a molar absent, and the position of the upper molar present. Actually, however, molarophytes may be derived from a post-differentiated by anterior dentition, in which a molar is lost to other molars. For *Proterotherium*, a molarophyte absent is

*Macrauchenia* (*Macrauchenia* (*Macrauchenia*), or *Hippotherium* (*Proterotherium*)). The selenodont molar *Macrauchenia*, *Hippotherium*, and *Thylacotherium* have a complete crown. *Hippotherium* and *Thylacotherium* have a complete crown. *Macrauchenia* is a proteminal hypsodontid group consisting of a second bicuspid, one molar, and two premolars. On either side of the molar, the molars *Lamennaisia* (*Lamennaisia*) are usually represented by two molarophytes (*Argenteoceraspis*, including a differentially large upper molar) formed by the union of three 1. order molars.

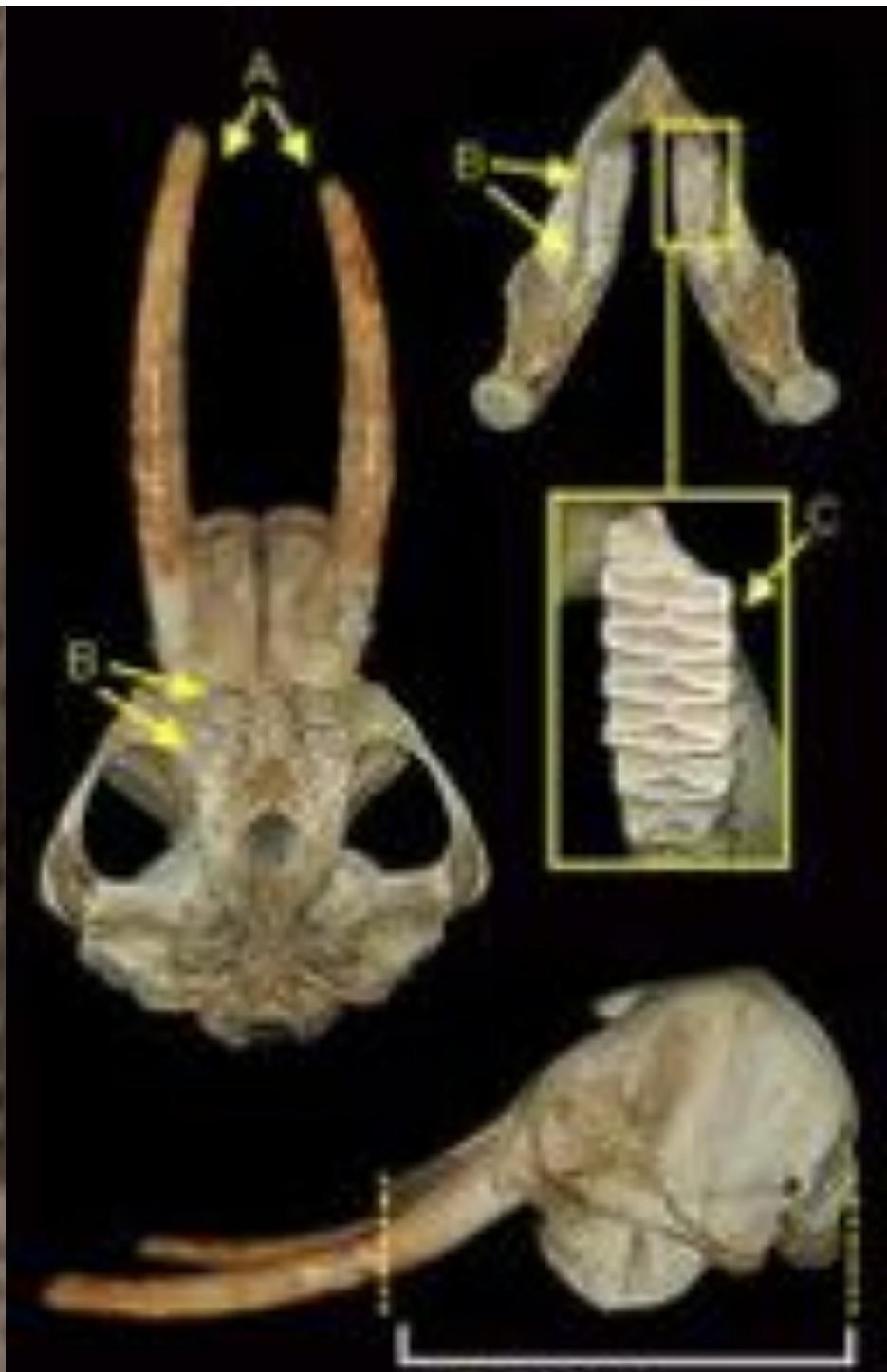
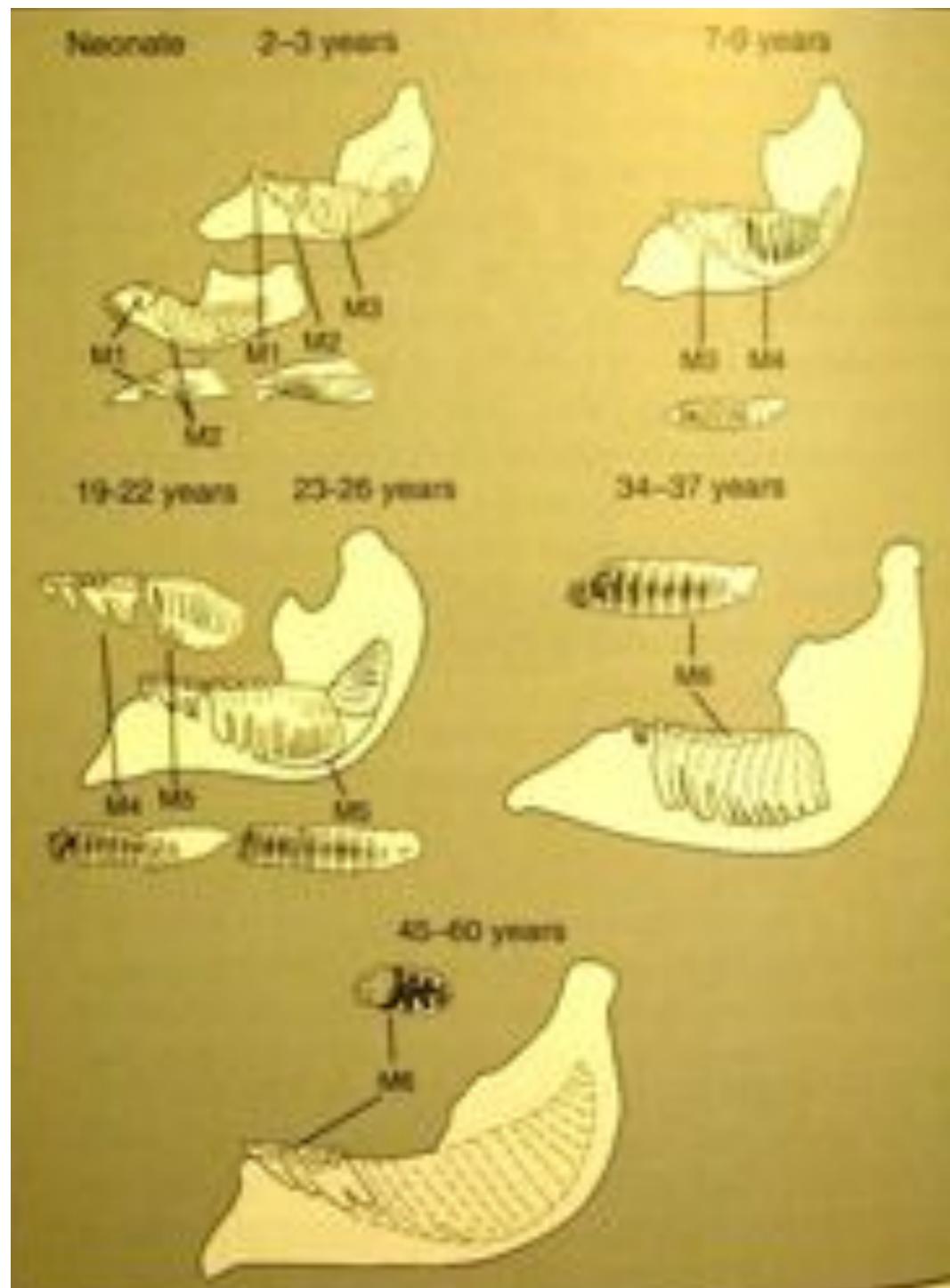


Figure 11.4. *Uteopterus* demonstrating the pachyostosis. The skull has evidence of severe bony overgrowth on the snout, caused by the early action of the osteoclasts.





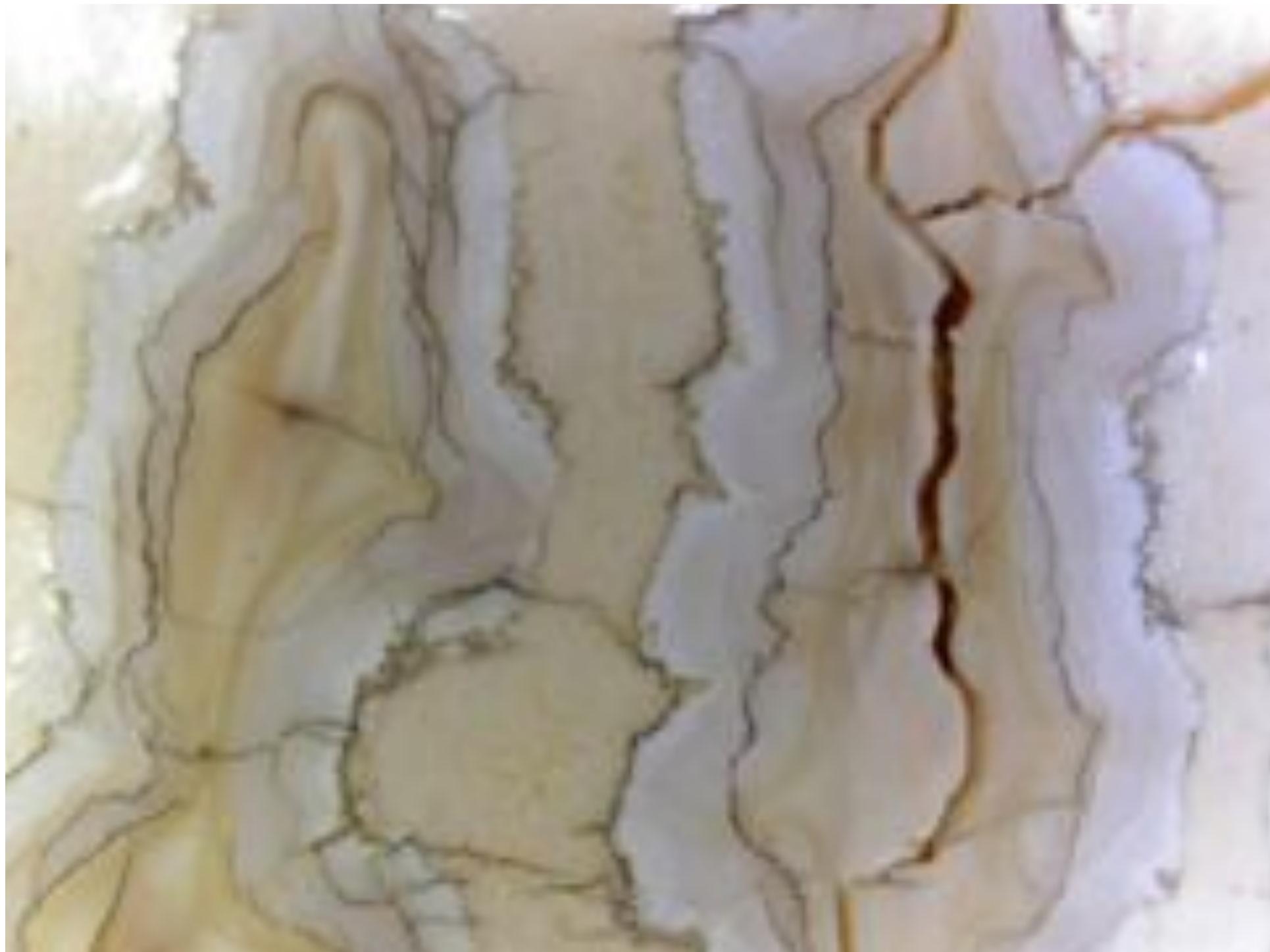




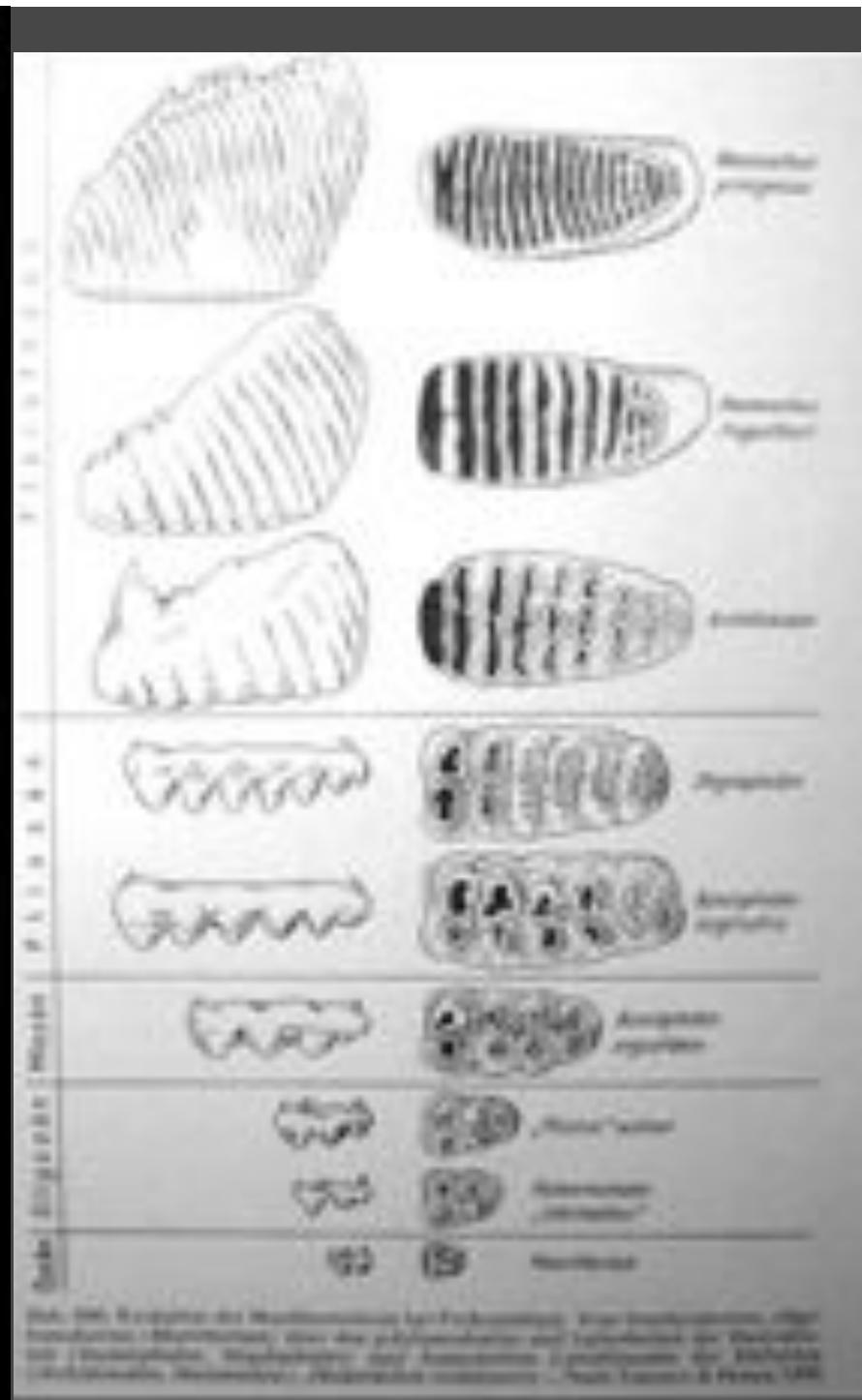
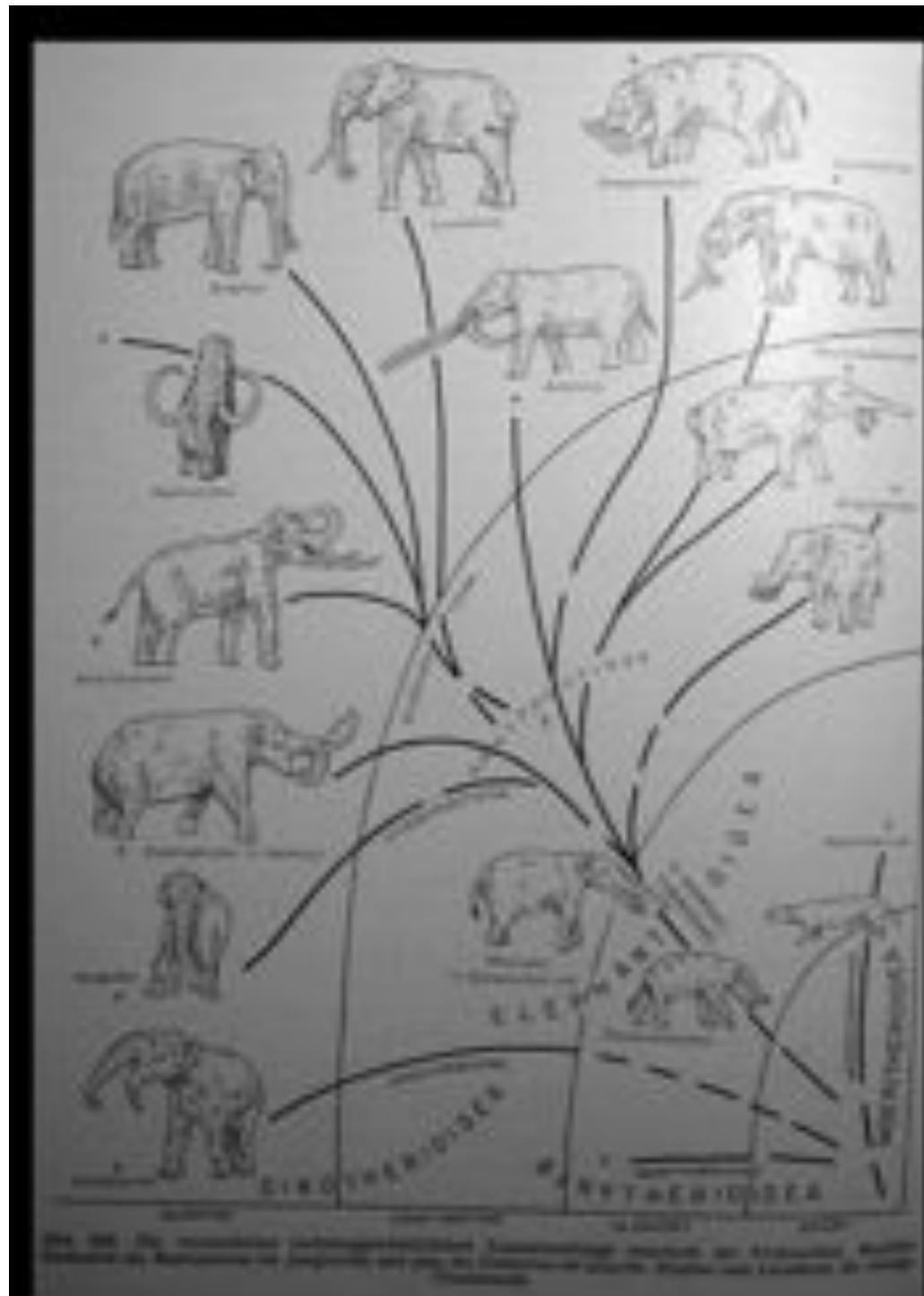


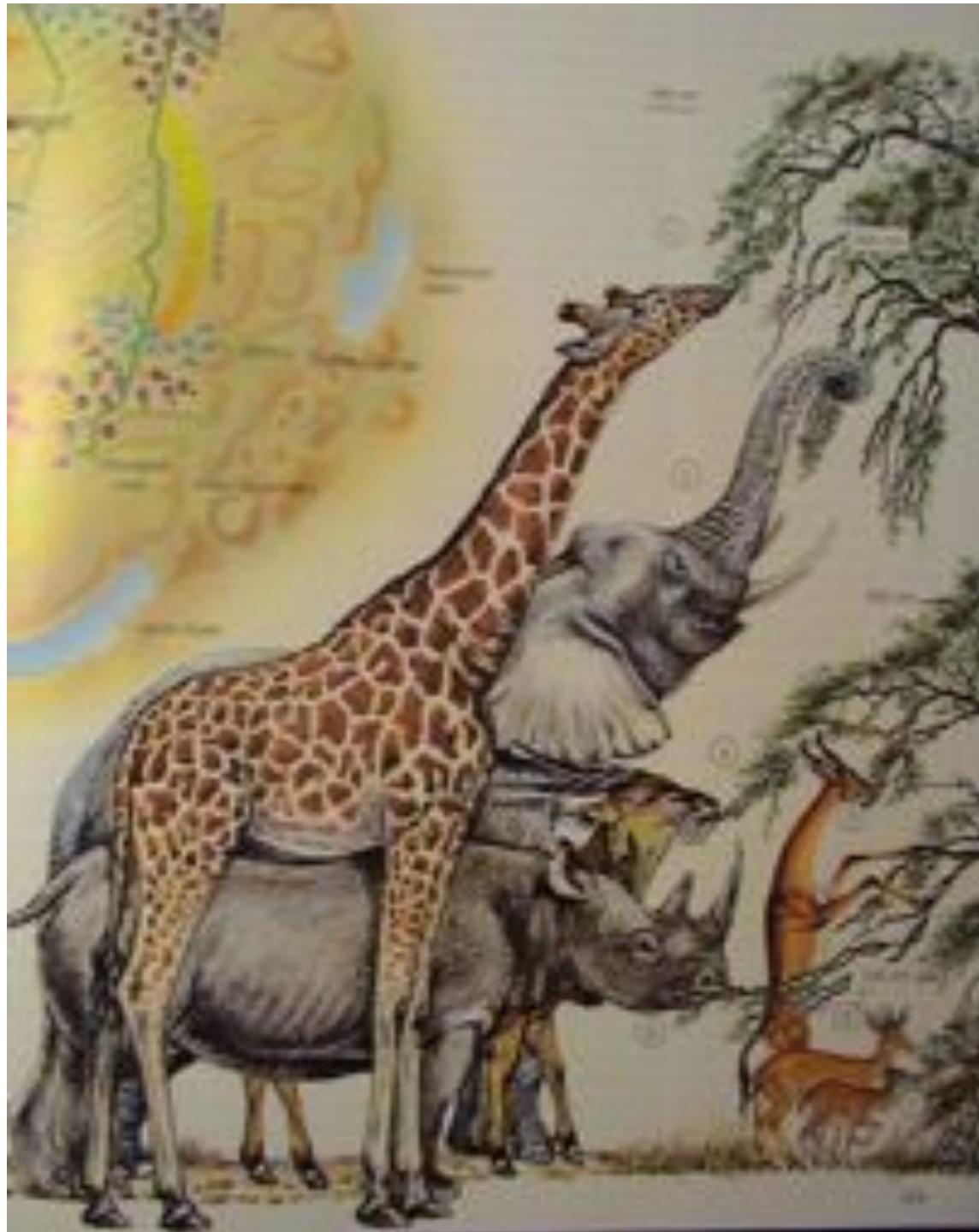












Rozdělení  
zdrojů:  
diferenciace nik a  
vývojová  
diversifikace v rámci  
základních strategií  
(vývojových  
jednotek)  
a) velikostní škálování,  
b) specialisace  
travicího systému a  
potravní strategie

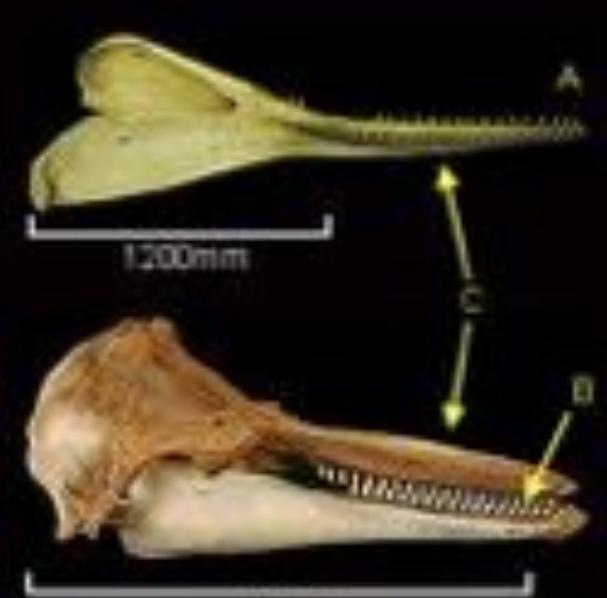
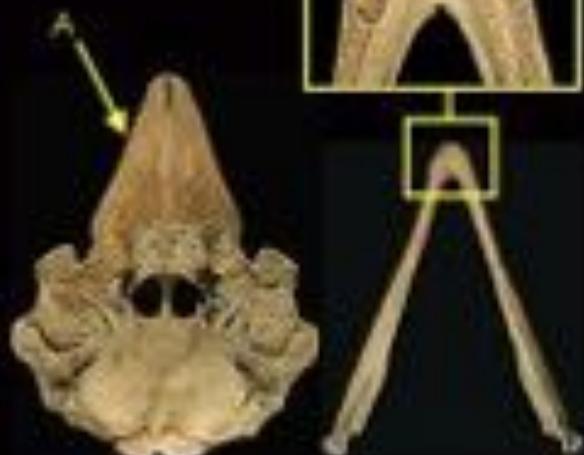
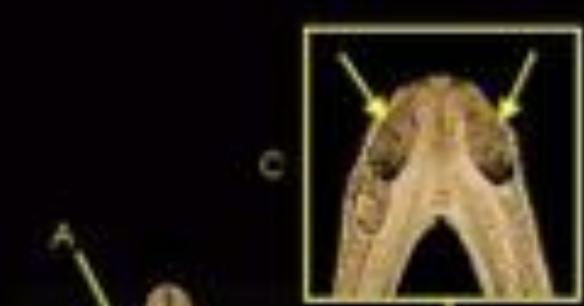


*Dendrolagus* NG



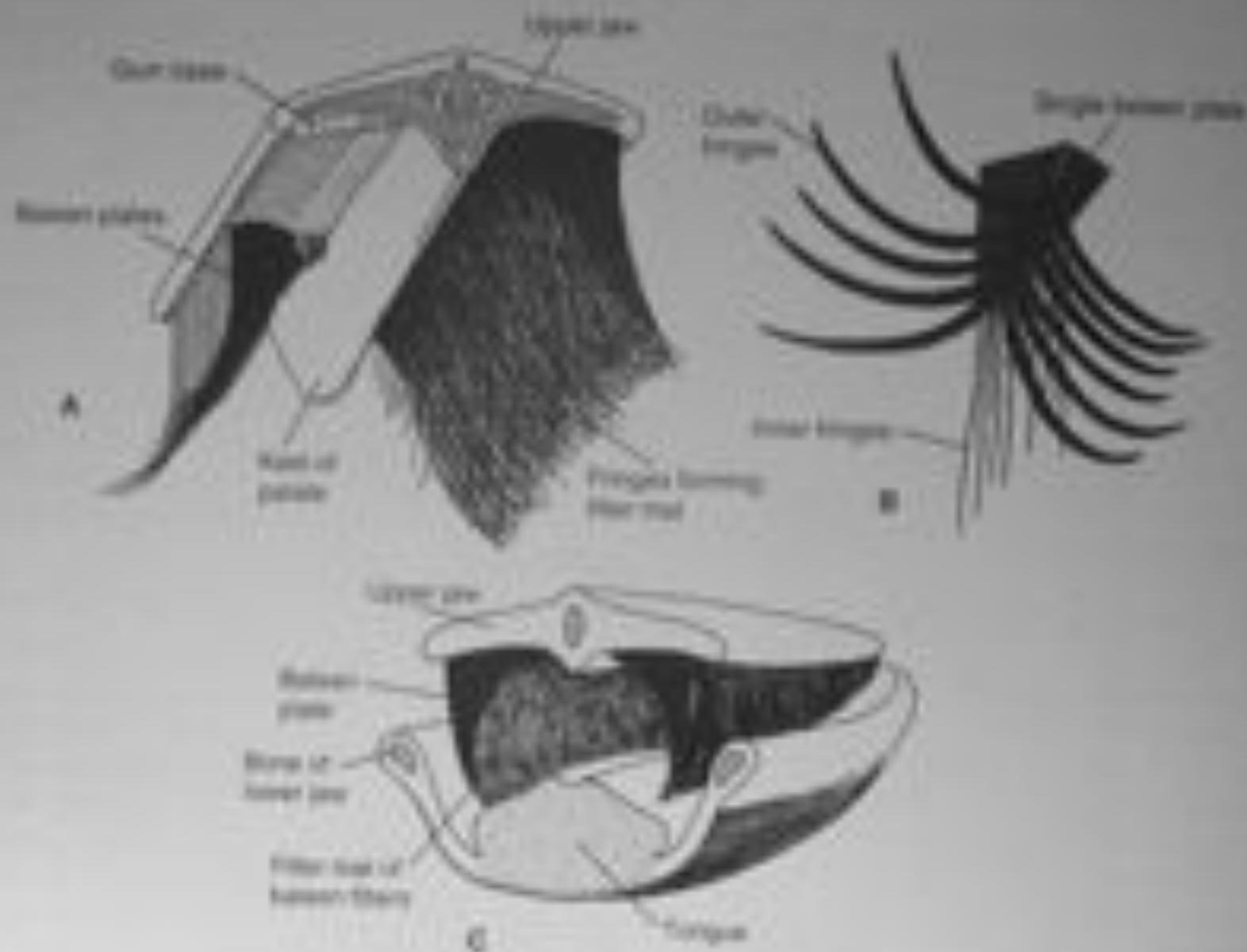
Zcela specifické –  
vodní savci (zejm.  
kytovci)











**Figure 16.8** Saliva. (A) Arrangement of glands in the oral mucosa. Buccal plate = buccal mucosa; lingual plate = lingual mucosa of the mouth. (B) Drawing of a tongue. The size and number of papillae vary greatly as evidenced as human is separated from nonhuman primates. (C) The tongue contains several rows of circumvallate papillae containing the taste buds. (Illustrations by Bruce Goldfarb)