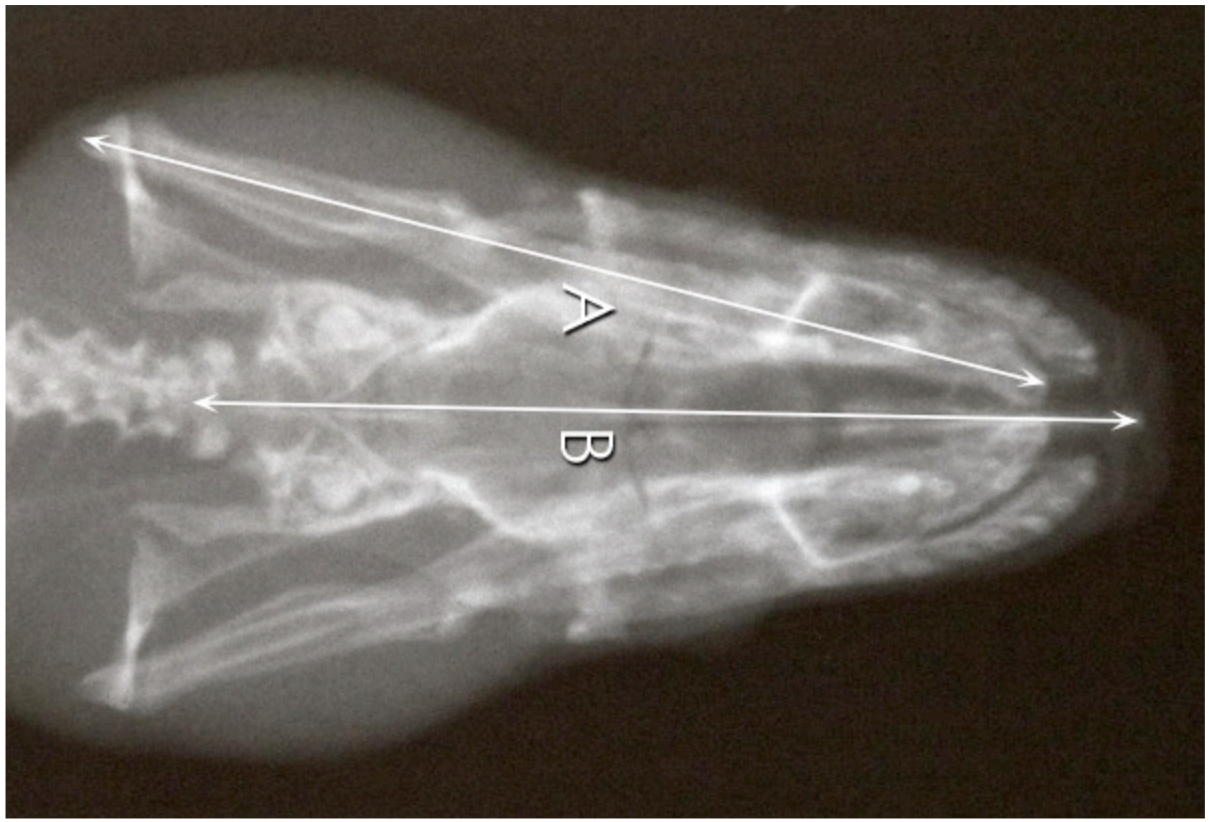
Comparative Vertebrate Morphology

Skeletal System: The Skull



J. Zool., Lond. (2005) 267, 363–369 © 2005 The Zoological Society of London Printed in the United Kingdom doi:10.1017/S0952836905007624

Does prey size induce head skeleton phenotypic plasticity during early ontogeny in the snake *Boa constrictor*?

What's on tap today?

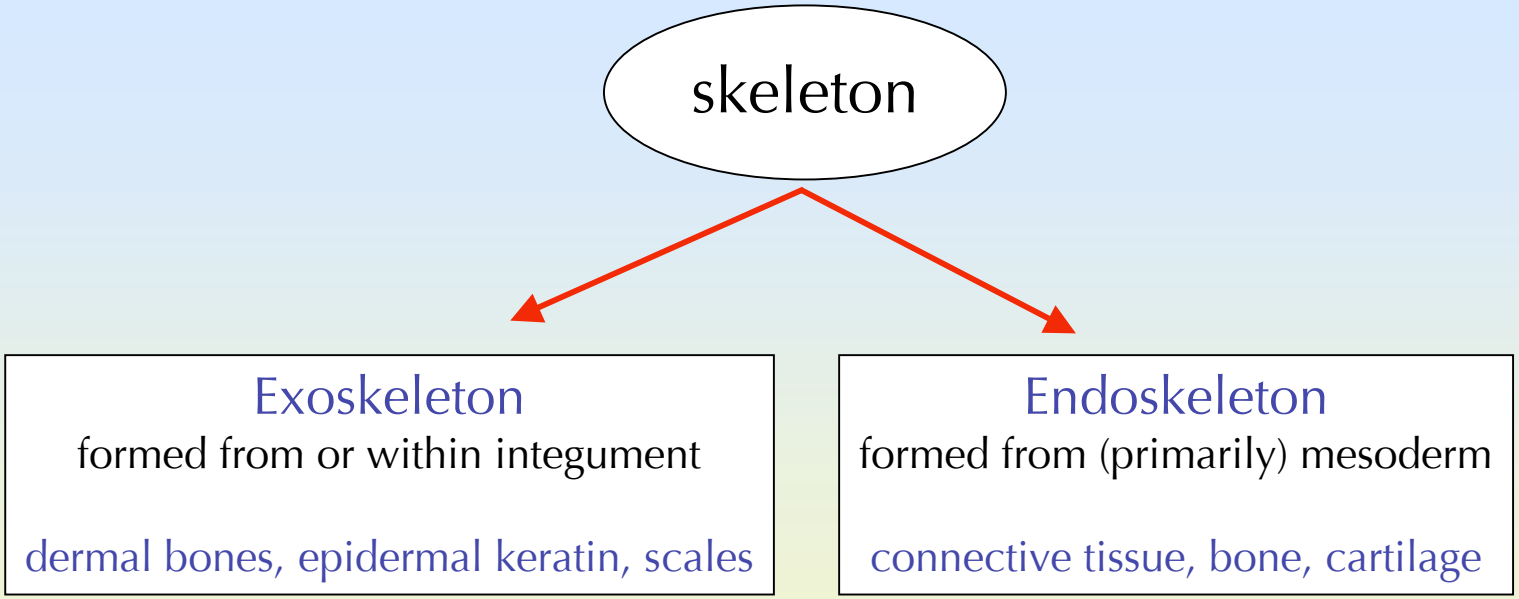
Skeletal System - The Skull

1. Splanchnocranium
2. Chondrochranium
3. Dermatochranium
4. Cranial Kinesis - Functional Morphology of the Skull

The Skeleton: Cranial & Postcranial

Functional Roles

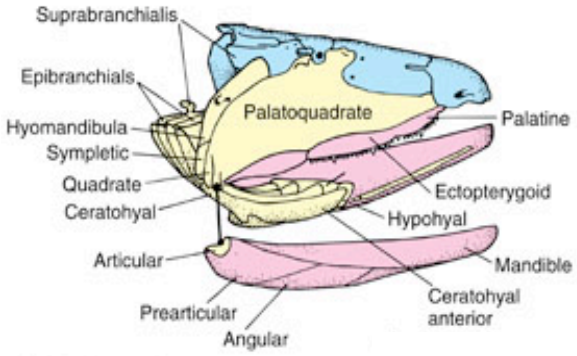
1. Provides shape
2. Supports body mass
3. Coordinated system of levers
4. Protection of underlying tissues and viscera



Cranium: the vertebrate skull

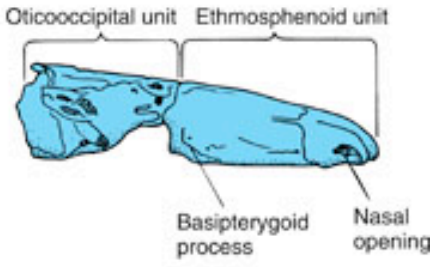
composed of three phylogenetically distinct parts

Splanchnochranium (yellow)



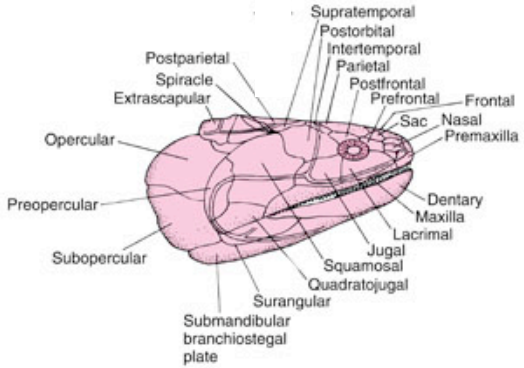
- a.k.a. *visceral cranium*
- support pharyngeal slits in protochordates; *ancient*

Chondrocranium

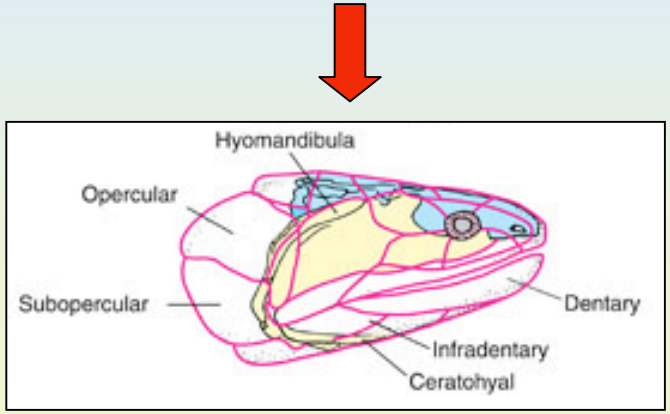


- brain support
- endochondral bone
- cartilage

Dermatocranium



- outer skull structure
- dermal bone



Chondrocranium development

Cartilages
(anterior to posterior)

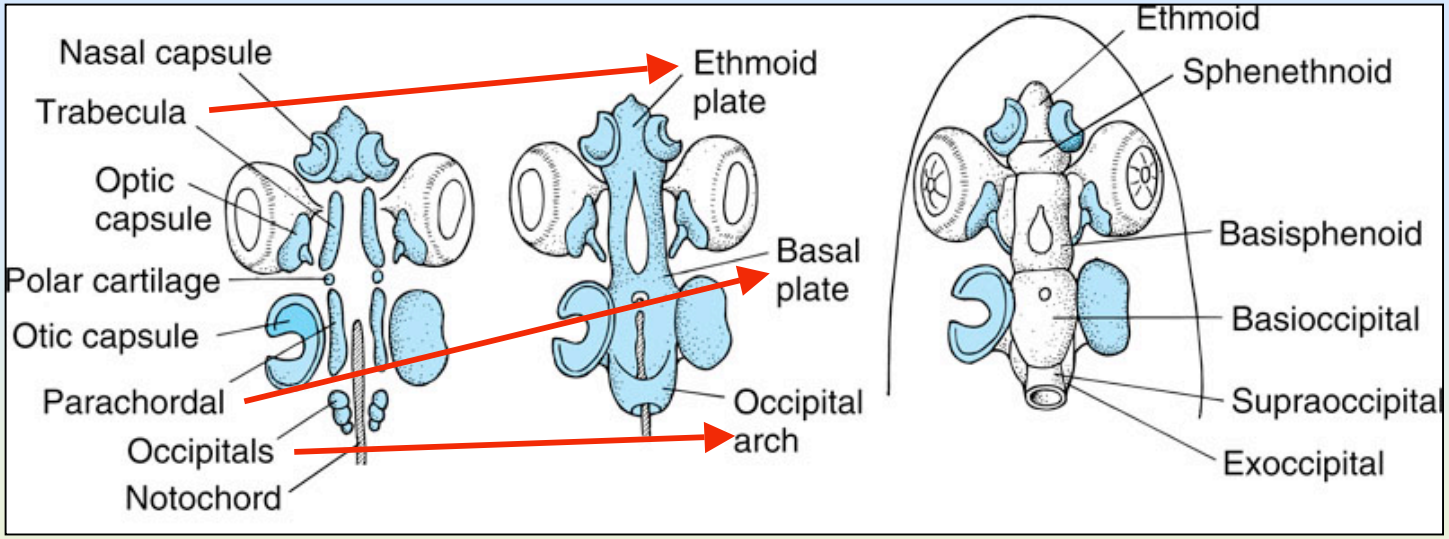
Trabeculae
Polar cartilage
Parachordals
Occipitals

Sensory Capsules
(anterior to posterior)

Nasal
Optic
Otic

Contributors

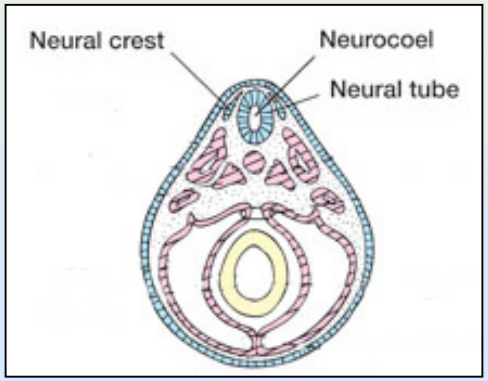
Neural crest
(nasal/otic capsules, trabeculae)
Mesenchyme
(all other chondrocranium regions)

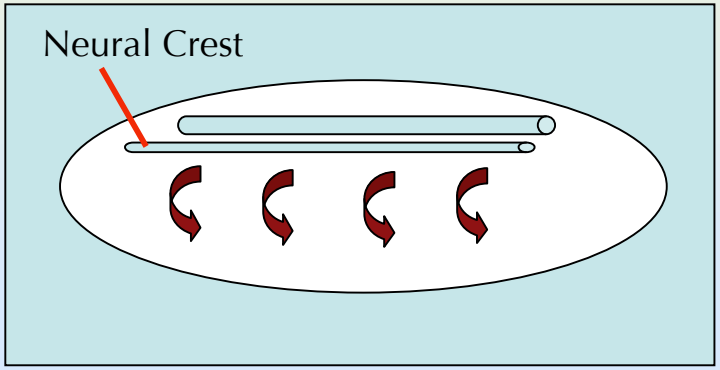


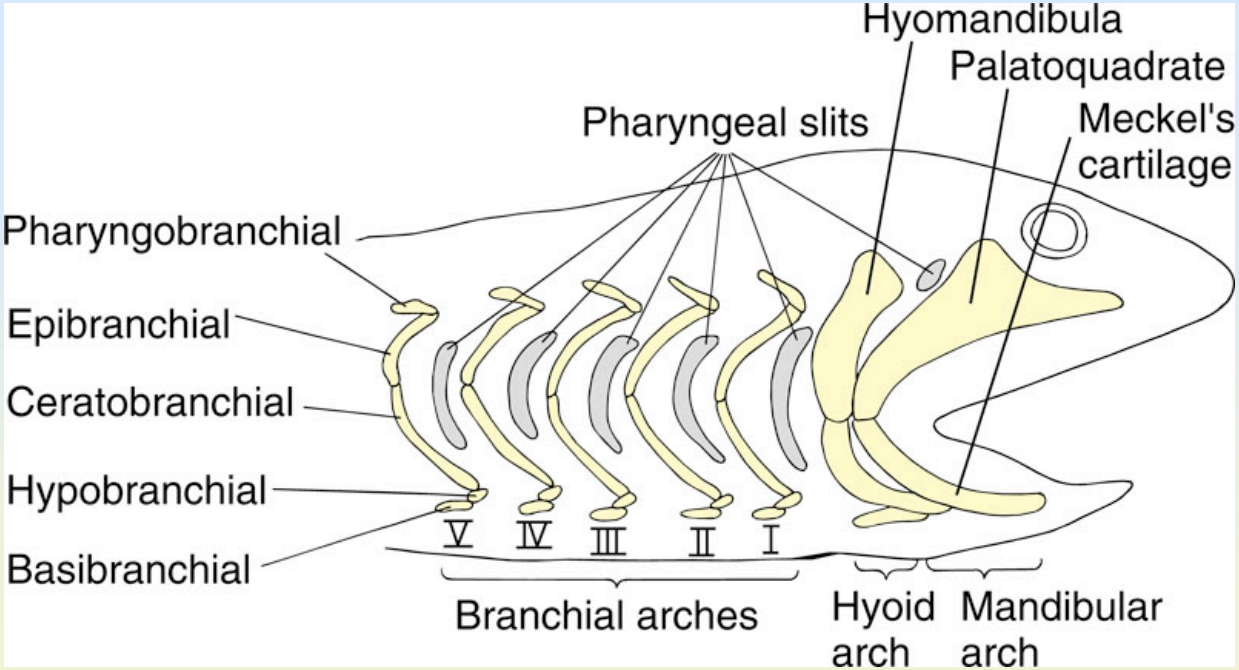
Ossification
(except elasmobranchs)

Splanchnocranium development

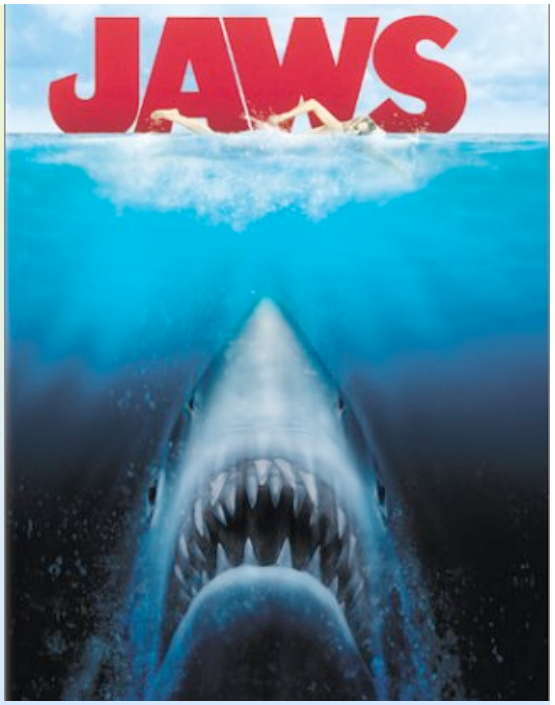
Neural Crest Cell Origins



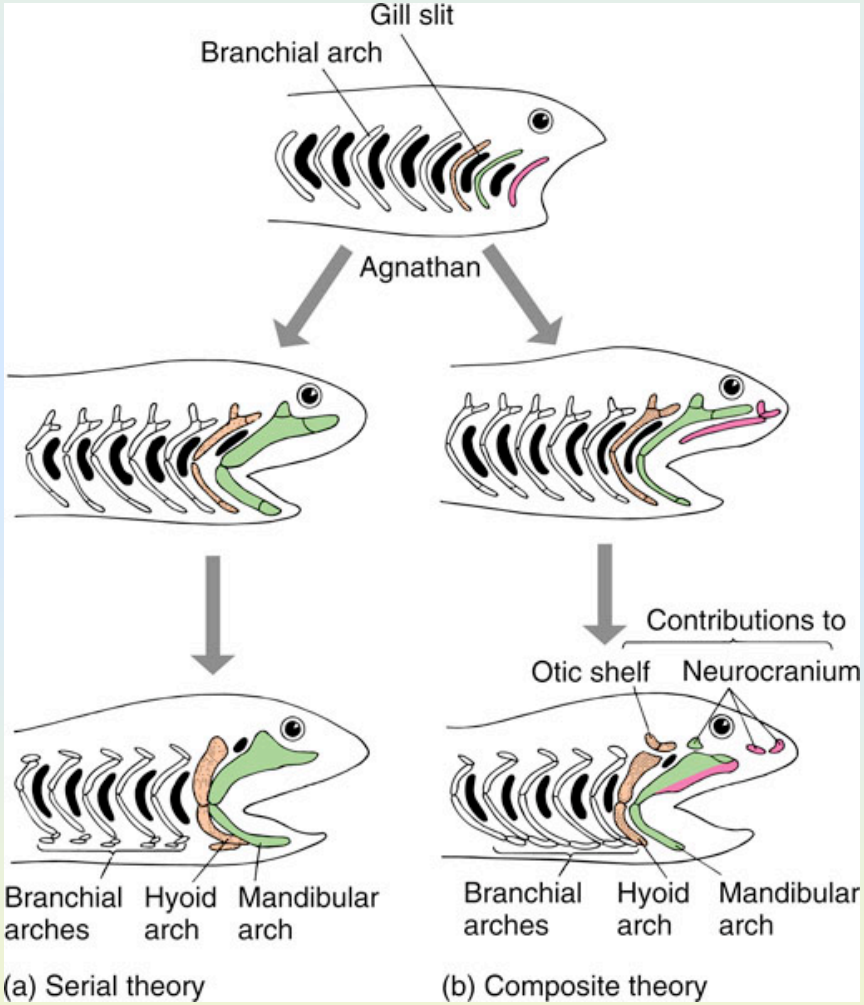




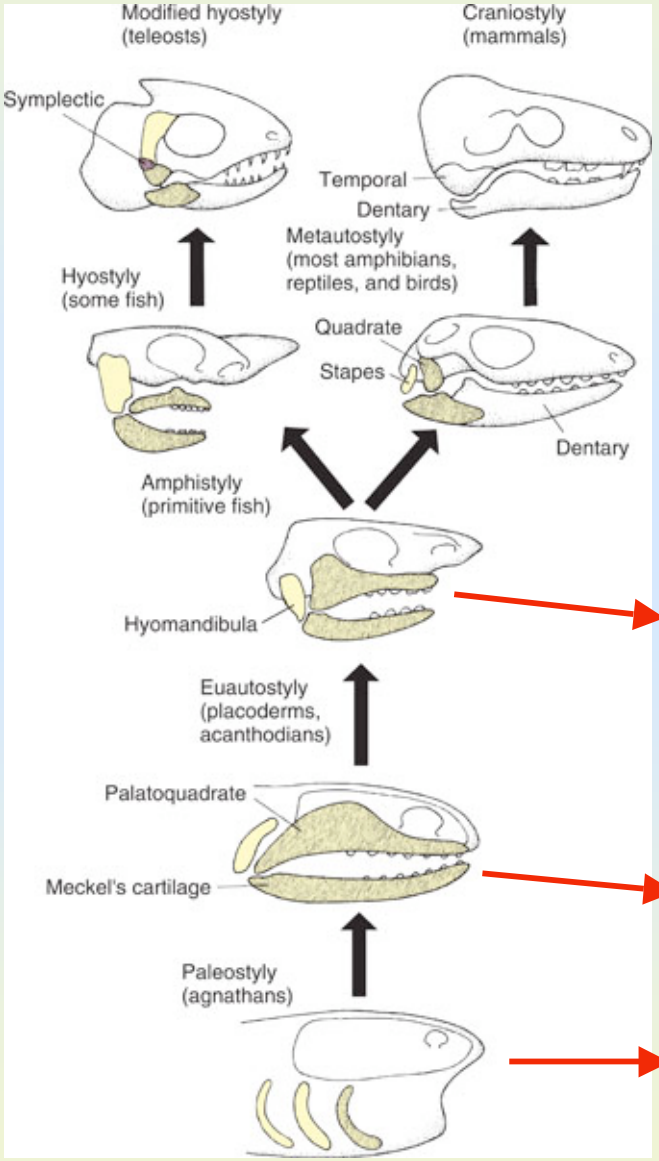
The Origin of



Rooted in the branchial arches…but how?



Jaw Suspensions



Craniostyly: entire upper jaw incorporated into skull; lower jaw suspended from squamosal bone

Metautostyly: jaw attached to skull via quadrate (the posterior palatoquadrate); hyomandibular becomes the *stapes* involved in hearing (amphibians, birds, reptiles).

Hyostyly: entire mandibular arch connected to skull by hyomandibular (bony fishes); emergence of *symplectic bone*

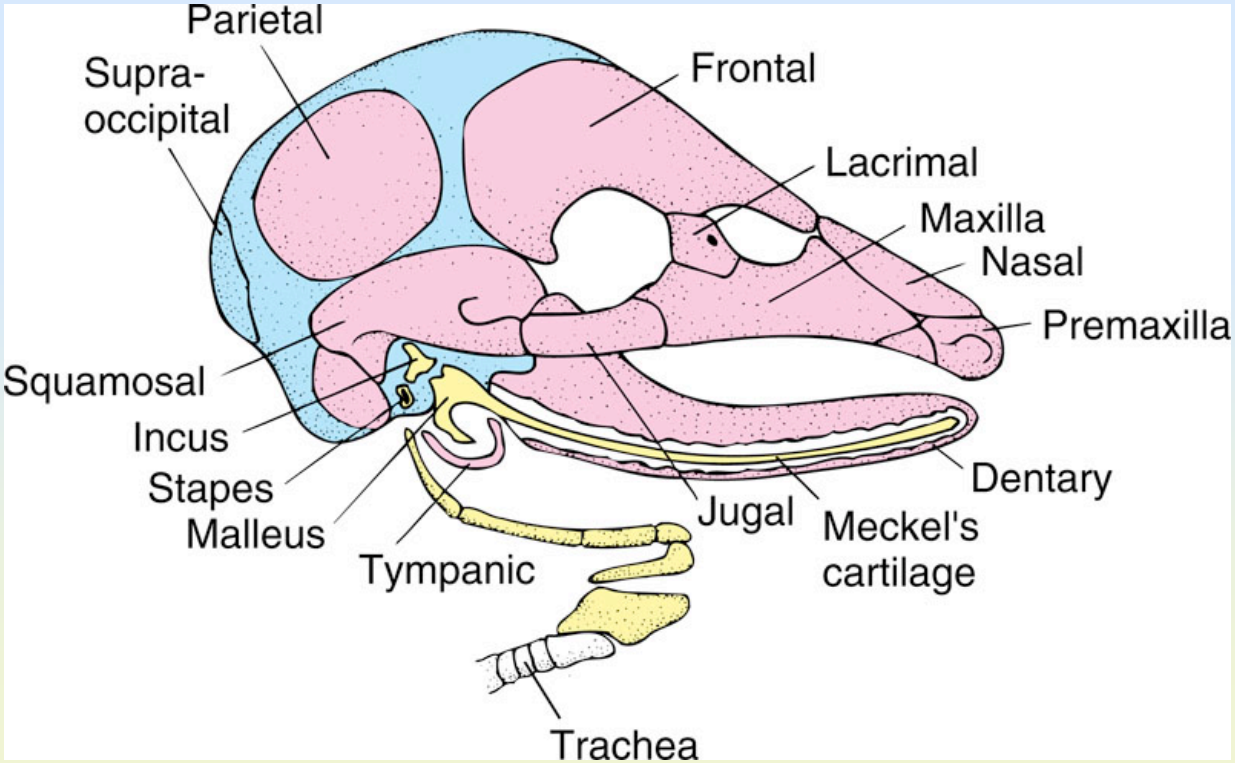
Amphistyly: 2 articulations of mandibular arch with skull - ligament connecting palatoquadrate to skull and hyomandibular articulating posterior portion (sharks, some other fish)

Euautostyly: mandibular arch suspended from skull w/o help from hyoid arch (placoderms)

Paleostyly: none of arches attach directly to skull (agnathans)

Mammalian Jaws (Craniostyly)

* Lower jaw consists of dentary bone
* Palatoquadrate becomes *incus*
* Meckel's cartilage becomes *malleus*
* Splanchnocranium (SC) not associated with jaws or suspension
* *SC* provides foundation for dentary, and middle ear bones



Dermatocranium development

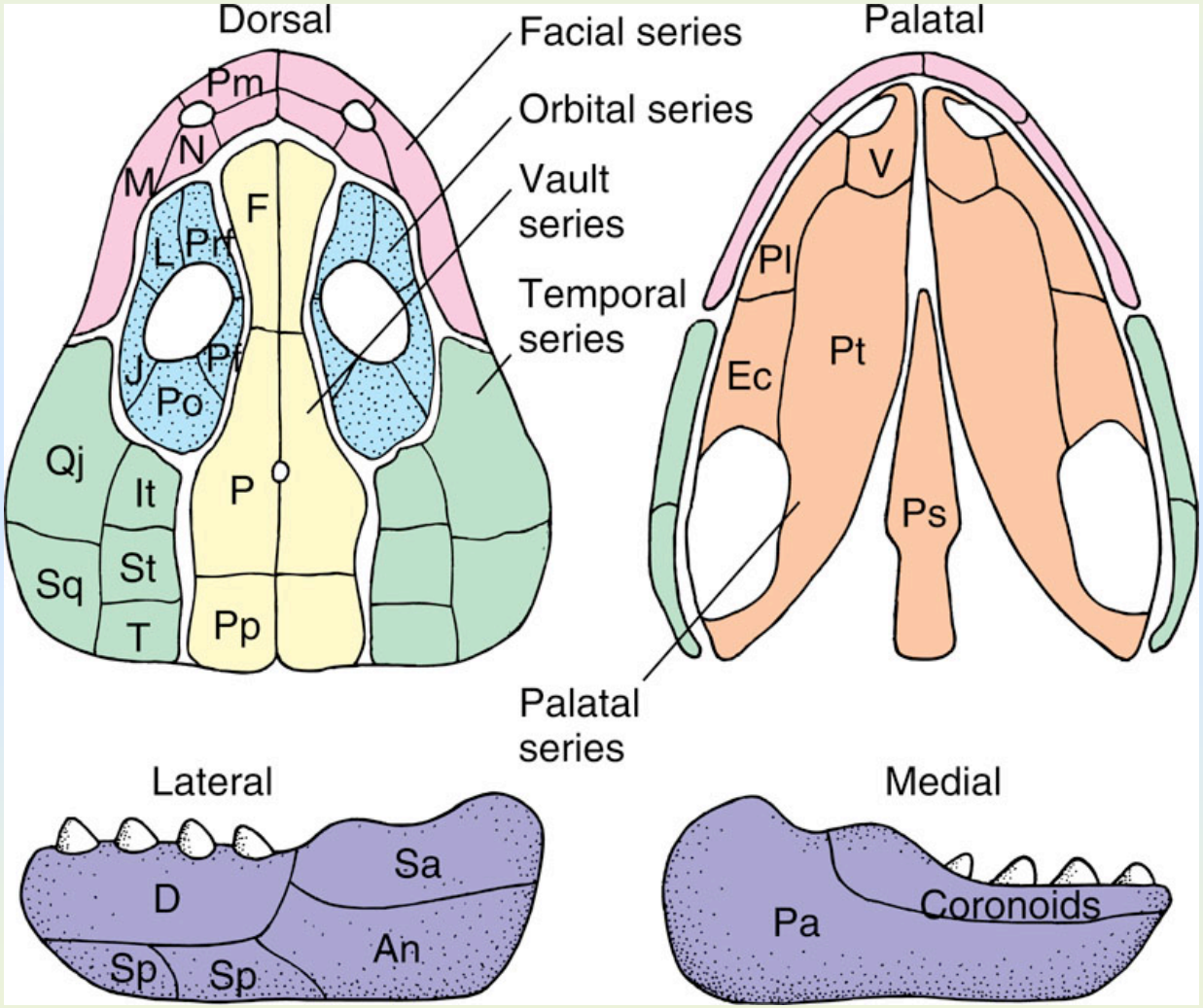
Dermal bones of the skull

Derived from withdrawl of external dermal bones (armor) inward

FUNCTIONS & FORMATIONS

1. Protective casing of the brain
2. Forms roof of mouth
3. Encases splanchnocranium
4. Scaffolding for teeth
5. Arises from ossification of dermis

Dermatocranium morphology I



Facial series:

Premaxilla (Pm)
Maxilla (M)
Nasals (N)

Orbital series:

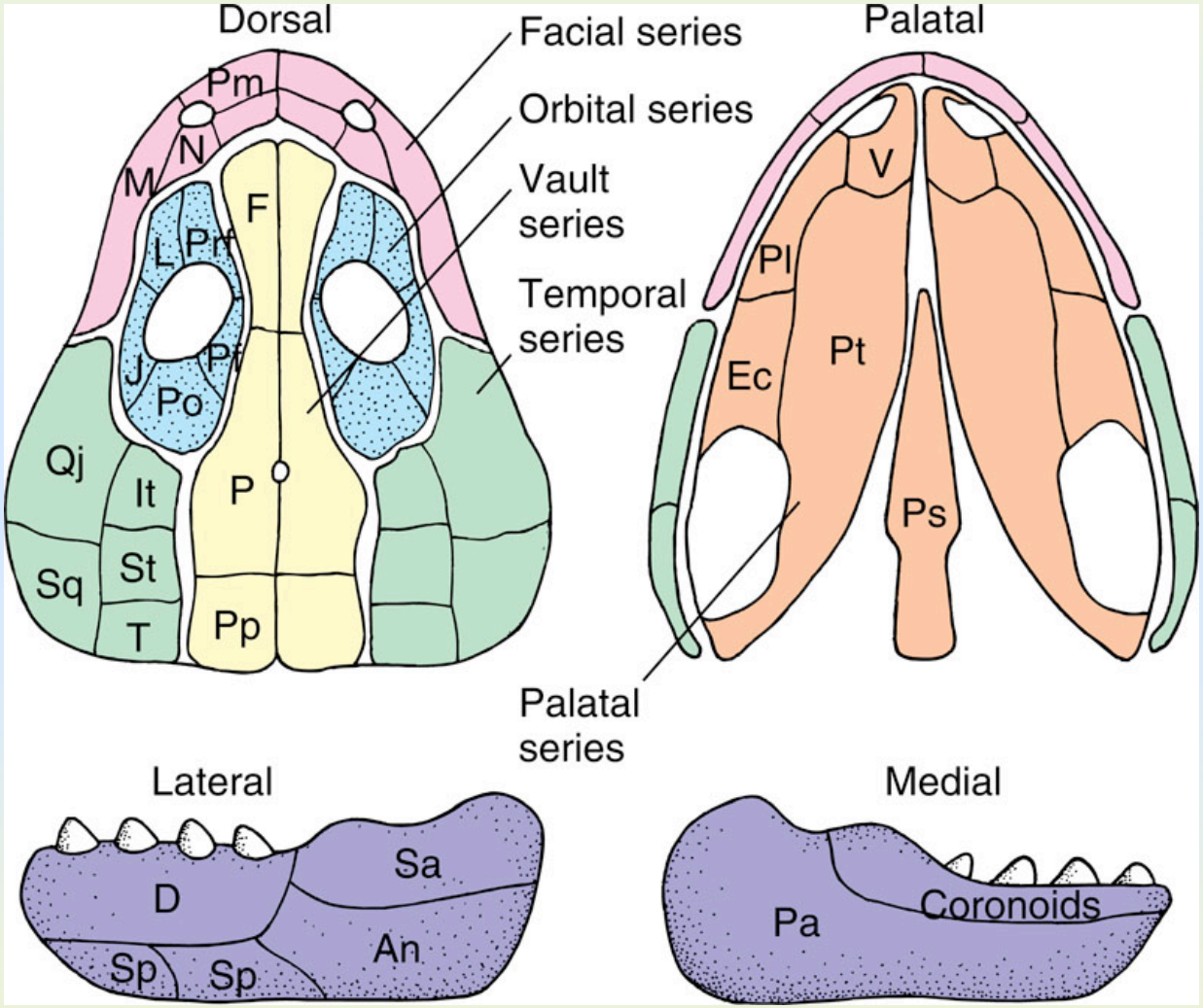
Lacrimal (L)
Prefrontal (Prf)
Postfrontal (Pf)
Postorbital (Po)
Jugal (J)

Temporal series:

Intertemporal (It)
Supratemporal (St)
Tabular (T)
Quadratojugal (Qj)
Squamosal (Sq)

Please understand Table 7.3

Dermatocranium morphology II



Please understand Table 7.3

Vault series:

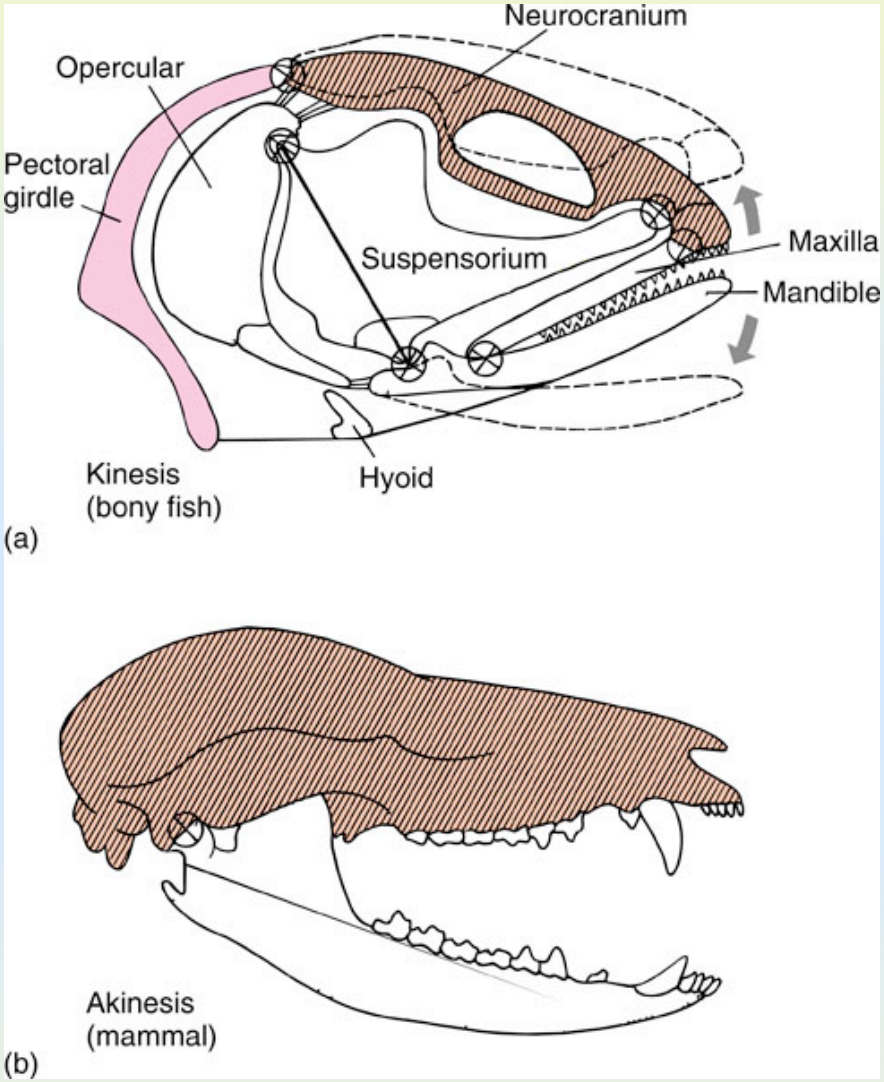
Frontal (F)
Parietal (P)
Postparietal (Pp)
Parietal foramen (pineal)

Palatal series:

Pterygoid (Pt)
Vomer (V)
Palatine (Pl)
Ectopterygoid (Ec)
Parasphenoid (Ps)

Mandibular series:

Dentary (D)
Splenials (Sp)
Angular (An)
Surangular (Sa)
Prearticular (Pa)
Coronoids



Cranial Kinesis

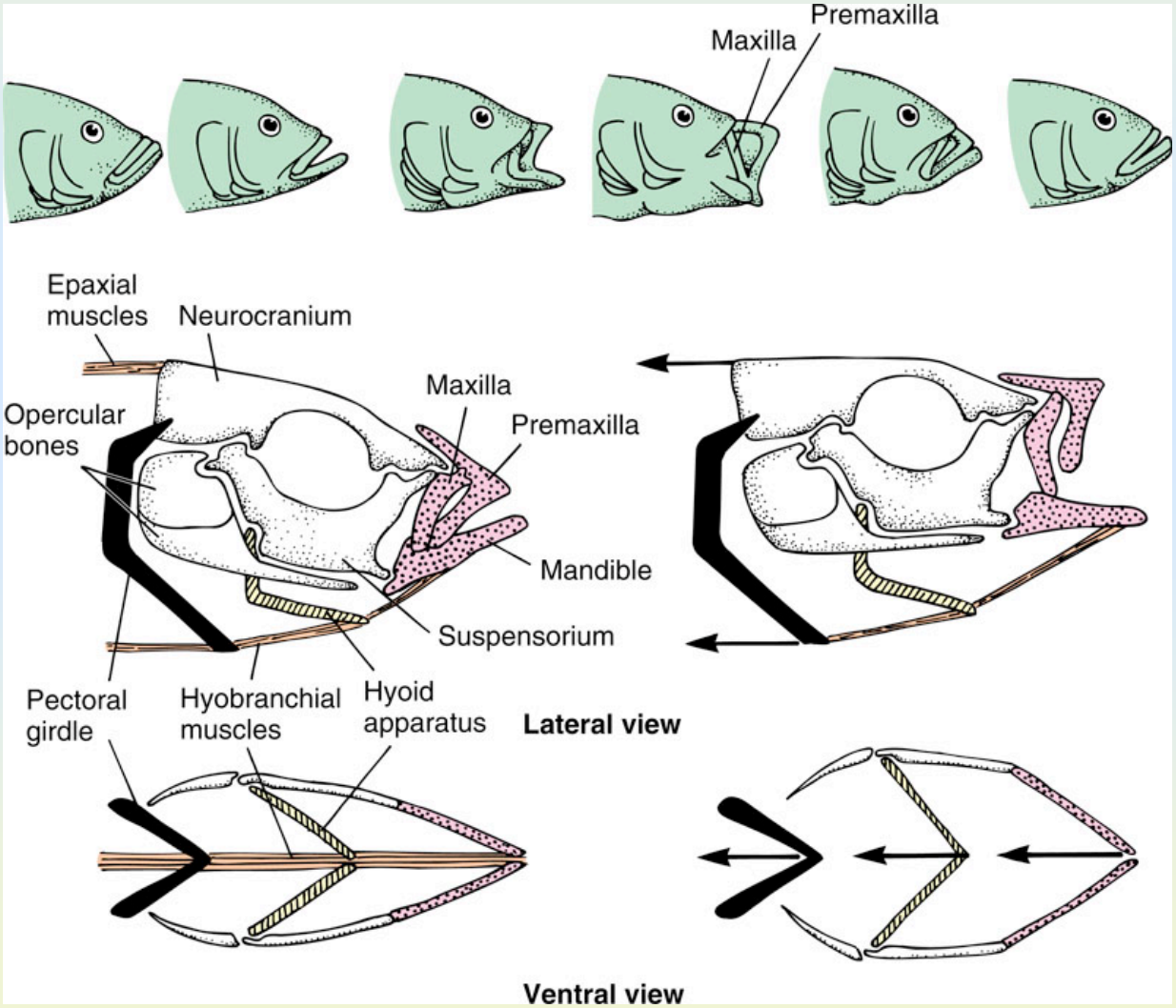
Movement between upper jaw and braincase via joints

Present in:
fishes, early amphibians, reptiles, birds, therapsids

Absent in:
modern amphibians, turtles, crocodiles, mammals

Cranial Kinesis

Functional Aspects in Fish



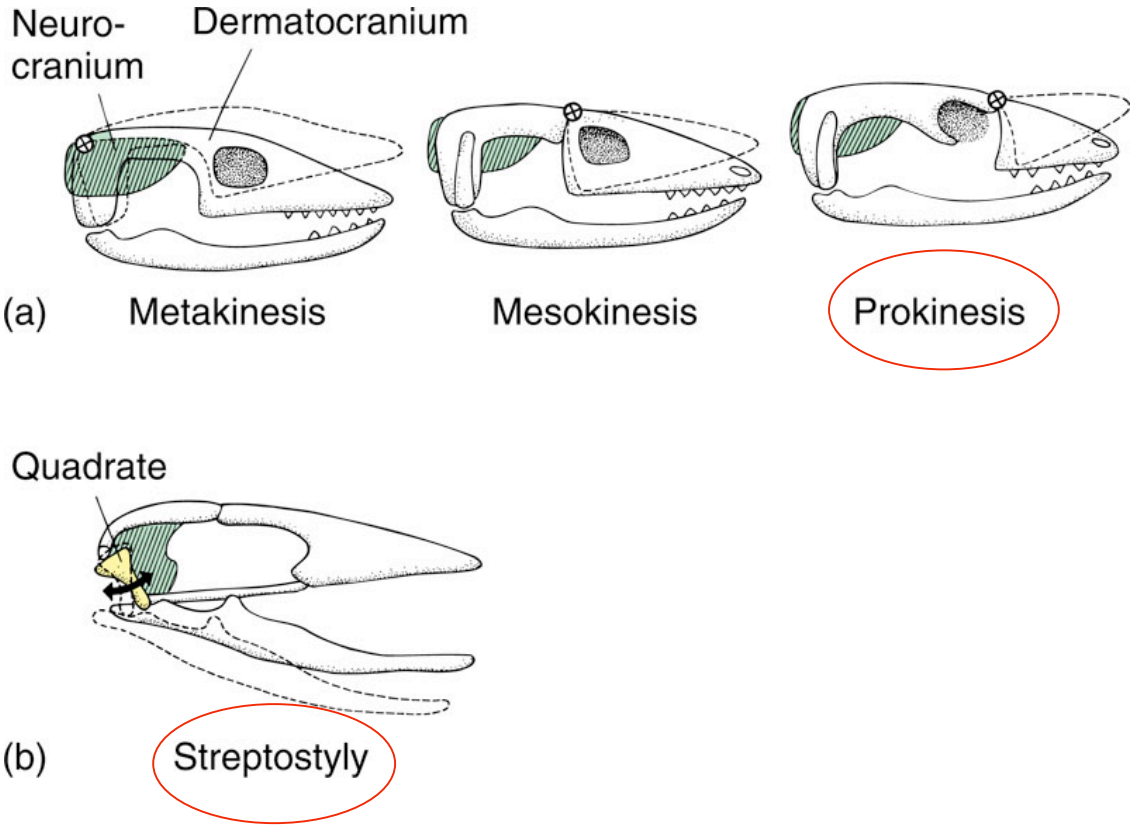
* Rapid kinesis involving separation of upper jaw from braincase
* Kinesis reduces pressure in buccal cavity
* Negative pressure (relative to ambient) creates vacuum
* Vacuum sucks water/prey into the mouth
* Prey capture completed within 1/40 seconds

Fish jaw mechanics #1
Fish jaw mechanics #2
Fish jaw mechanics #3

Cranial Kinesis

Functional Aspects in Reptiles

Varied kinesis based on transcranial joint position

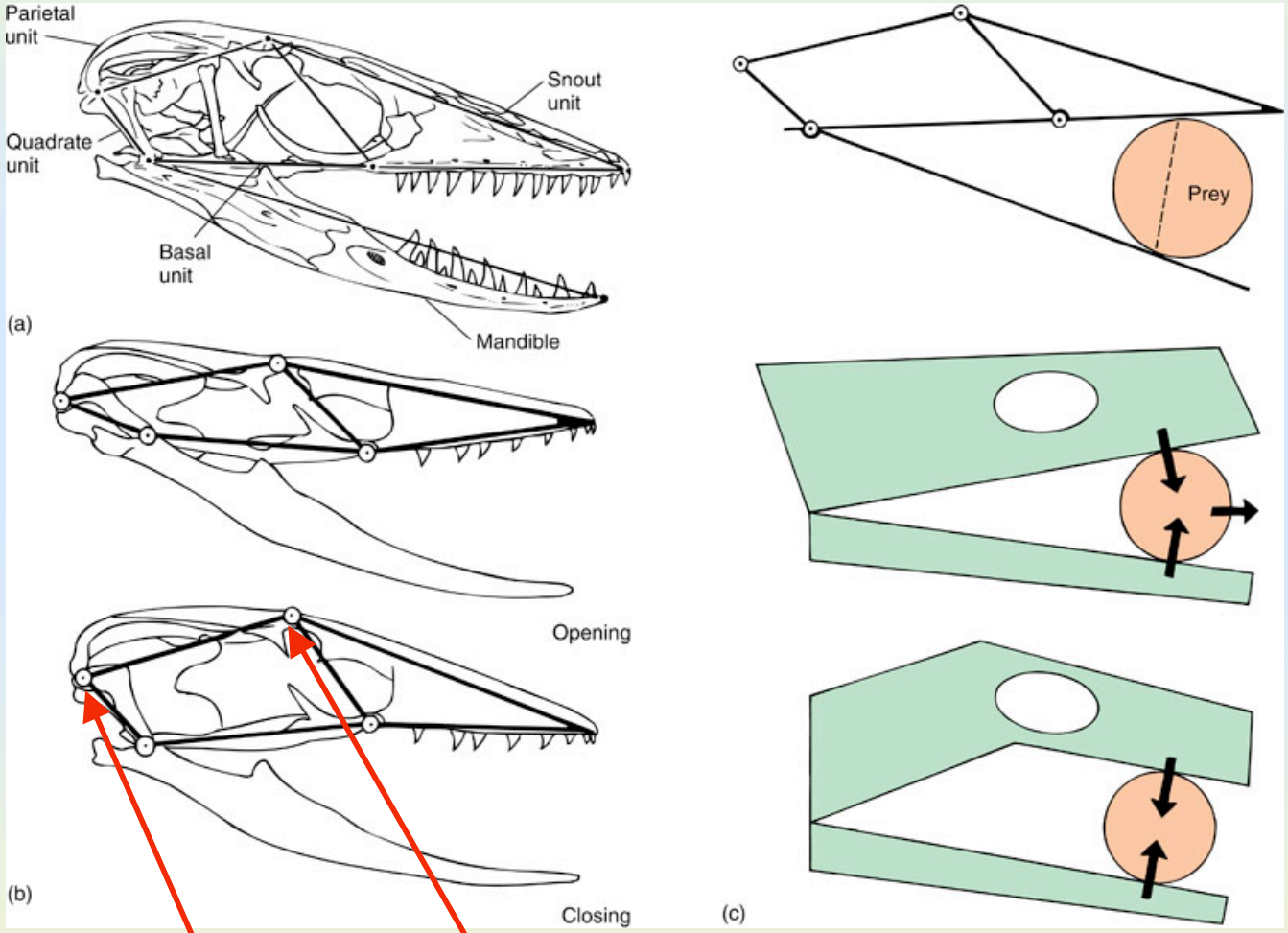


Monokinetic: one joint

Dikinetic: two joints

Cranial Kinesis

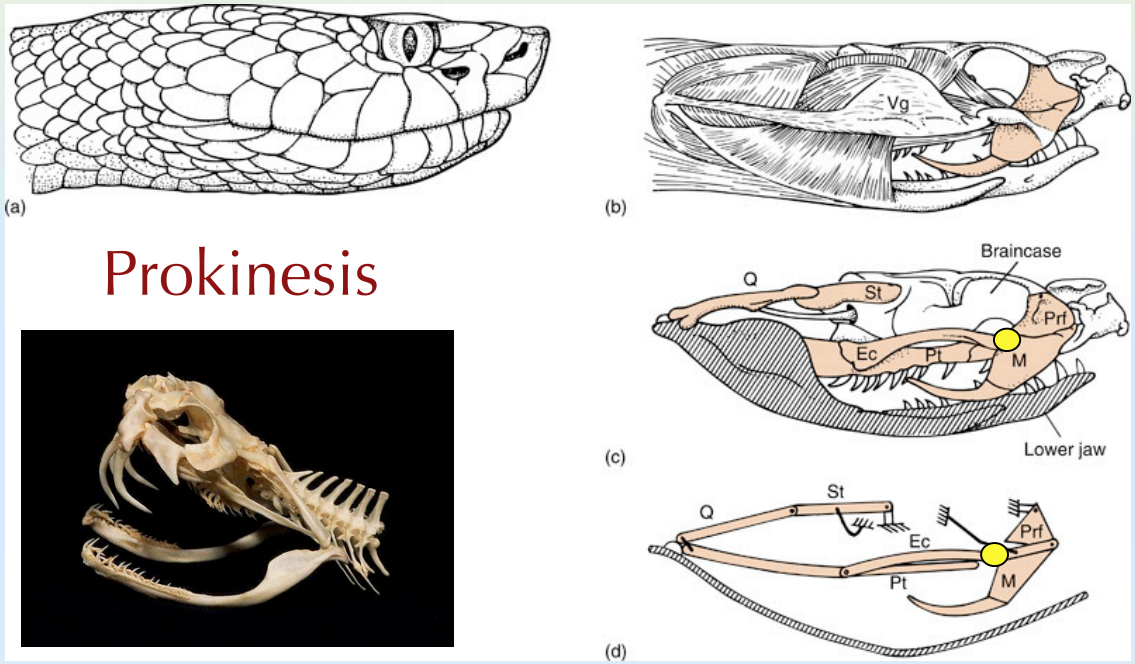
Functional Aspects in Reptiles



Meta- and Mesokinetic articulations

Cranial Kinesis

Special Case of Snakes



Prokinesis

"unhinging" is a myth

* No connections between left and right skull elements

* Ultrahinging with two connections to braincase (prefrontal and supratemporal)
  - linkage chains

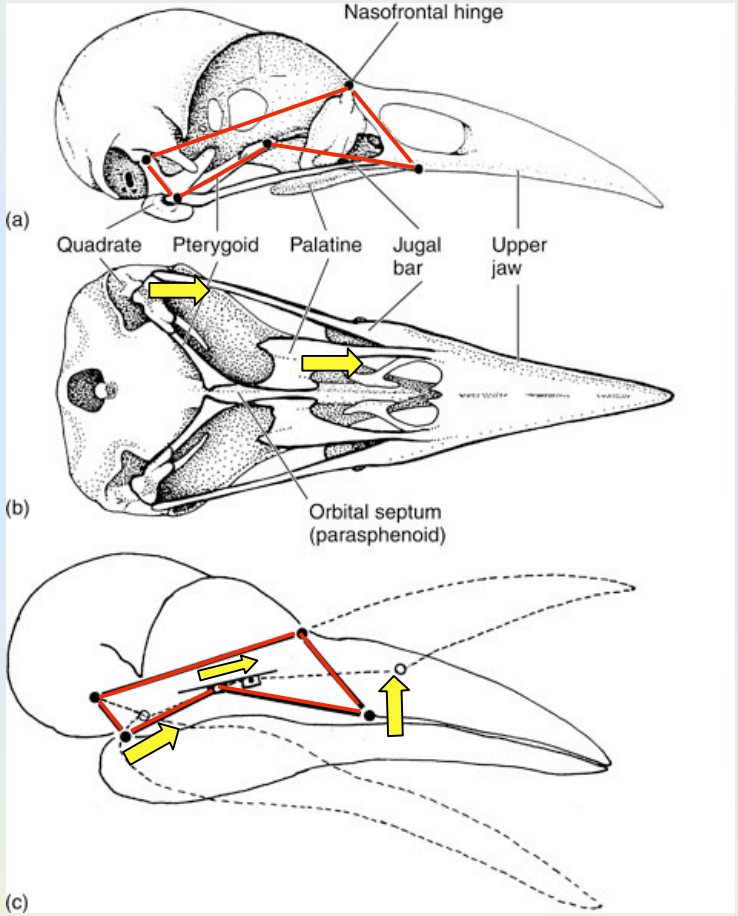
RESULTS

- alternate jaw 'walking' over sometimes large prey items

- extension of fangs during offense, defense, and predation

Cranial Kinesis

Prokinesis in Birds



Slider-Crank Mechanism

- Quadrate + Palatine pulled forward by muscles

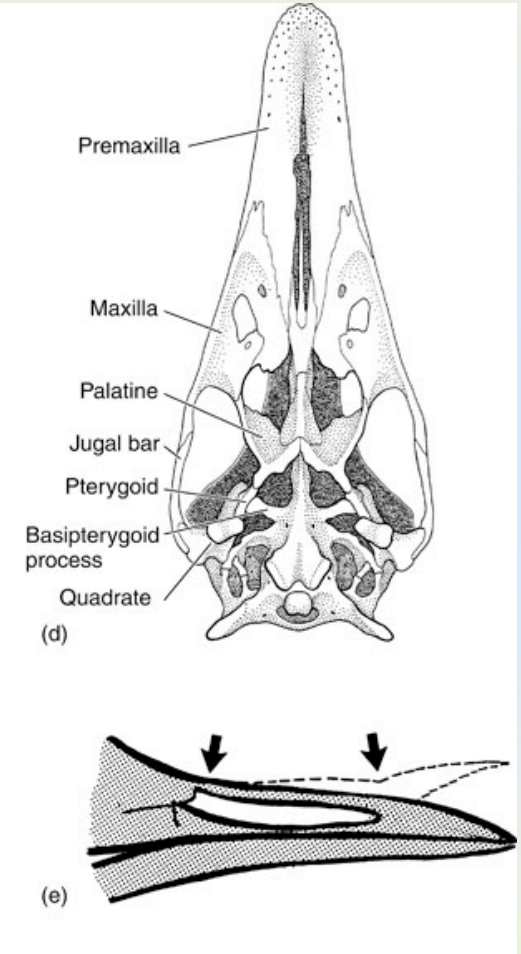
-Palatine slides along orbital septum (parasphenoid)

-Sliding palatine pushes against beak base

-Beak rotates about nasofrontal hinge to open

Cranial Kinesis

Rhynchokinesis in Birds



Unique adaptation for ‘probing’ birds