Cranial Kinesis

- CRANIAL KINESIS literally means “Movement within the skull”
- Cranial kinesis essentially means movement between the upper jaw and the brain case about joints between them.
- Cranial kinesis includes upward and downward rotation of the upper jaw relative to the brain case.

Kinetic and Akinetic skull

According to kinesis of skull, Vertebrate skull can be of two types

- **KINETIC SKULL**
- **AKINETIC SKULL**

KINETIC SKULL

- Movement occurs between upper jaw and brain case
- The upper jaw and lateral skull bones rotate upon each other, resulting in displacements of these bones during feeding
- Example:

Ancient fishes(Crossopterygeans), Bony fish, very early Amphibians, most Reptiles, birds .

AKINETIC SKULL

- Akinetic skulls have no such movements between upper jaw and brain case
- Upper jaw is incorporated and fused with braincase
- There are no hinge joints through brain case, nor any movable linkages of lateral skull bones.
- Example-Modern Amphibians, Few Reptiles (Turtles, crocodiles), Mammals (Except Rabbit)

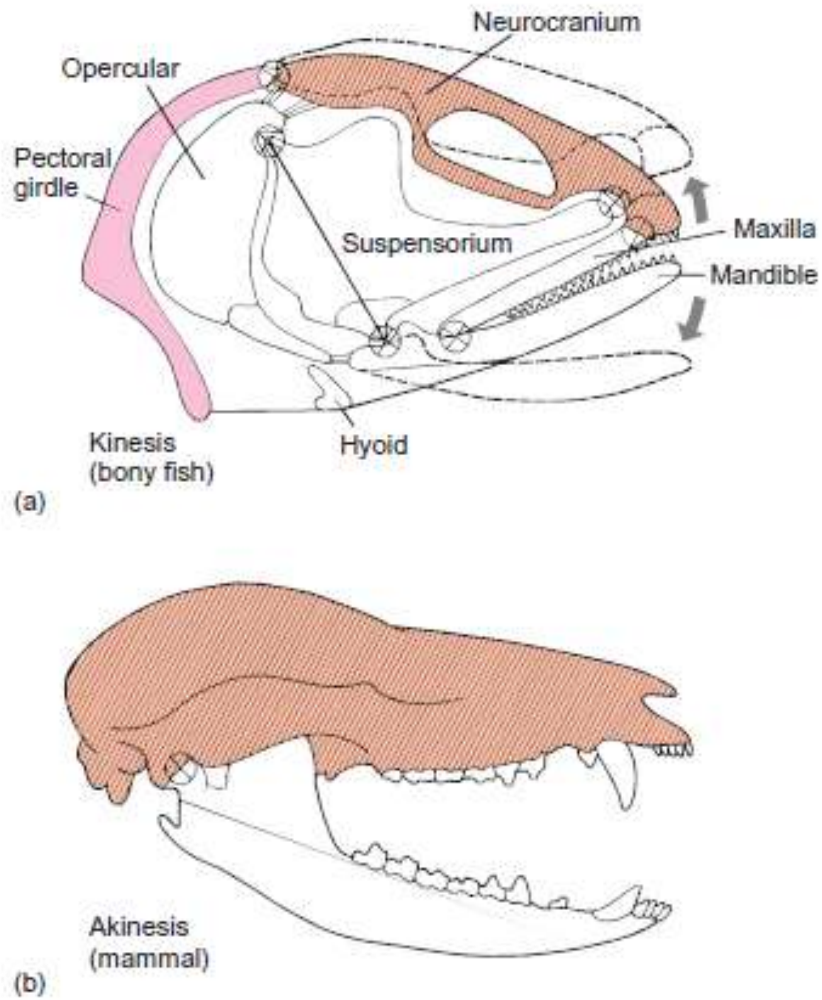


FIGURE 7.12 Mobility of skull bones. (a) The fish skull is kinetic. The upper jaw and other lateral skull bones rotate upon each other in a linked series, resulting in displacements of these bones (dashed outline) during feeding. Circles represent points of relative rotation between articulated elements. (b) The mammal skull is akinetic because no relative movement occurs between the upper jaw and the braincase. In fact, the upper jaw is incorporated into and fused with the braincase. There are no hinge joints through the braincase nor any movable linkages of lateral skull bones.

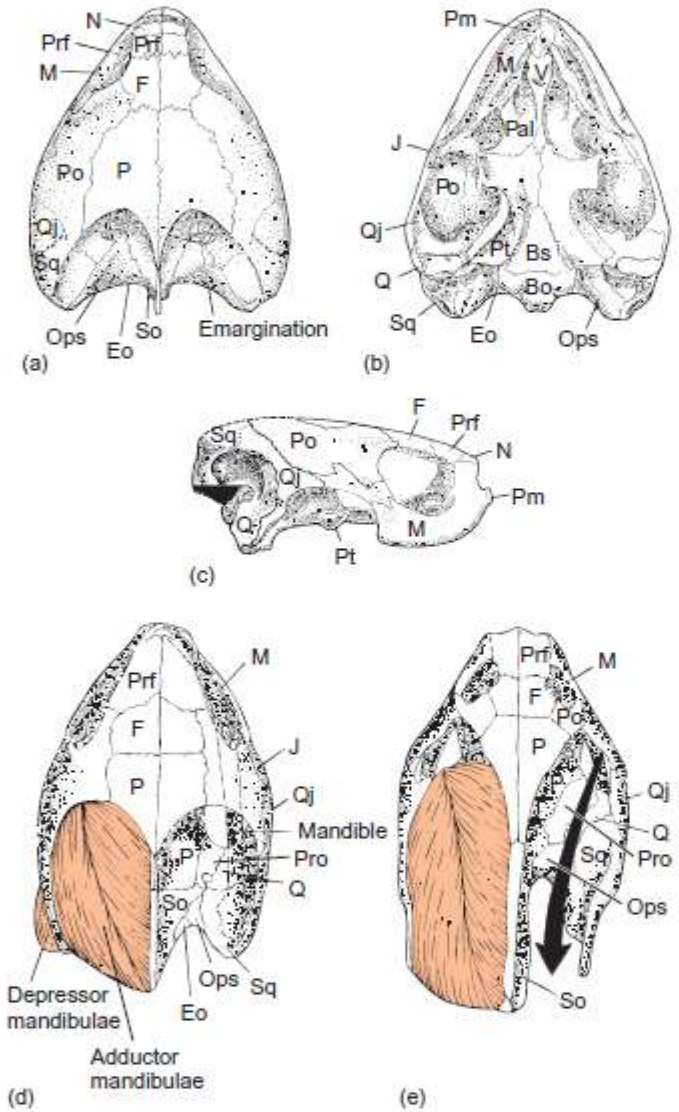


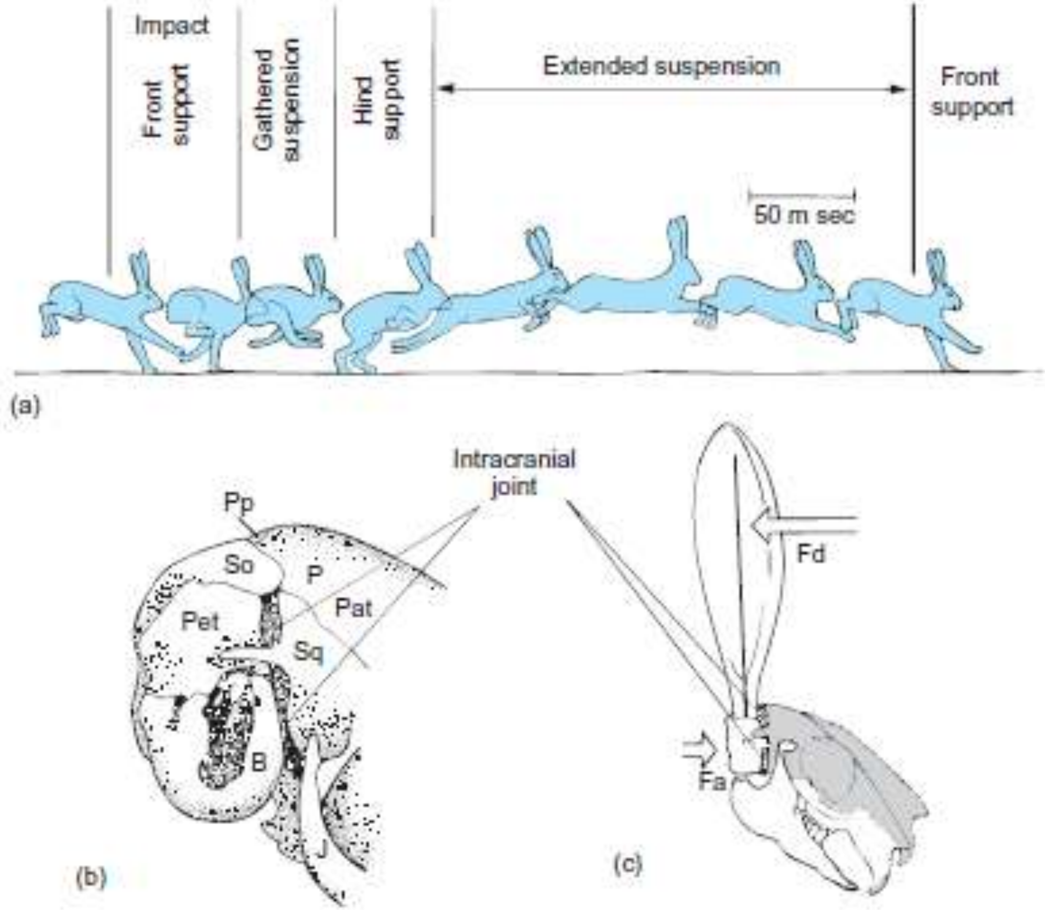
FIGURE 7.37 Turtle skulls. (a–c) Skull of *Pleisochelys,*
from the late Jurassic. *Pleisochelys is the earliest known member* of the cryptodires. Note the **absence of any temporal fenestrae** but the presence of emarginations etched in the dorsal, posterior rim of the skull. Dorsal (a), ventral (b), and lateral (c) views. (d) European pond turtle *Emys, showing site of residence of jaw* opening (depressor mandibulae) and closing (adductor mandibulae) muscles in relation to emargination. (e) Modern softshell turtle *Trionyx, showing line of action of adductor* mandibulae, solid arrow, from lower jaw to skull within enlarged emargination. Abbreviations: basioccipital (Bo), basisphenoid (Bs), exoccipital (Eo), frontal (F), jugal (J), maxilla (M), nasal (N), opisthotic (Ops), parietal (P), palatine (Pal), prefrontal (Prf),
premaxilla (Pm), prootic (Pro), postorbital (Po), pterygoid (Pt), quadrate (Q), quadratojugal (Qj), supraoccipital (So), squamosal (Sq), vomer (V).

Hare(Jack Rabbits)-Mammal with kinetic skull

- **Intracranial joints** are present in skull, that permits relative motion between anterior and posterior parts of braincase.

Hypothesis-

- This joint helps to reabsorb the impact forces sustained as the forelimbs strike the ground when a rabbitt runs. This absorption would reduce the shock sustained by the anterior part of the brain case.
- External ears held erect and attached to the posterior part of the skull help to reposition the posterior part of the skull relative to anterior part during running.
- **Among Mammals rabbit kinesis evolved not for its advantage during feeding but rather for its advantage during rapid locomotion**



BOX FIGURE 1 Possible cranial kinesis in hares. (a) Phases during a running stride are illustrated. Note that the forelimbs receive the initial impact upon landing. (b) Posterior regions of the skull of the jackrabbit *Lepus*. The intracranial joint extends along the sides of the skull between squamosal (Sq) and otic regions and then along the base of the skull. The interparietal bone forms the hinge across the top of the skull. (c) External ears held erect and attached to the posterior part of the skull may help to reposition the posterior part of the skull relative to the anterior part during the extended suspension phase of running. The presumed motion (slightly exaggerated) of the anterior braincase relative to the posterior braincase is indicated. Fa is the force vector due to acceleration resulting from thrust, and Fd is the force vector due to drag of the ears in the oncoming wind. Abbreviations: bulla (B), postparietal (Pp), jugal (J), parietal (P), petrosal (Pet), supraoccipital (So), squamosal (Sq).

Some Important Types

- **Rapid Kinesis**- This creates a sudden reduction of pressure in the buccal cavity which creates sudden vacuum. This method of prey capture is known as suction feeding. Here the animal takes the advantage of the sudden vacuum to gulp in water carrying the intended food. Example-Fish and other Vertebrates feeding in water.
- **Streptostyli**-Quadrate is loosely attached and is movable at both ends. **Here quadrate is free to undergo some degree of independent rotation about its dorsal connection with the braincase**.Example-Snakes, Lizards and birds.
- **Rhyncokinesis**- A form of upper jaw mobility found in some birds, in which the terminal part of the upper jaw may be raised or lowered independandtly of the rest of it by the bending of the nasal or premaxillary bones.

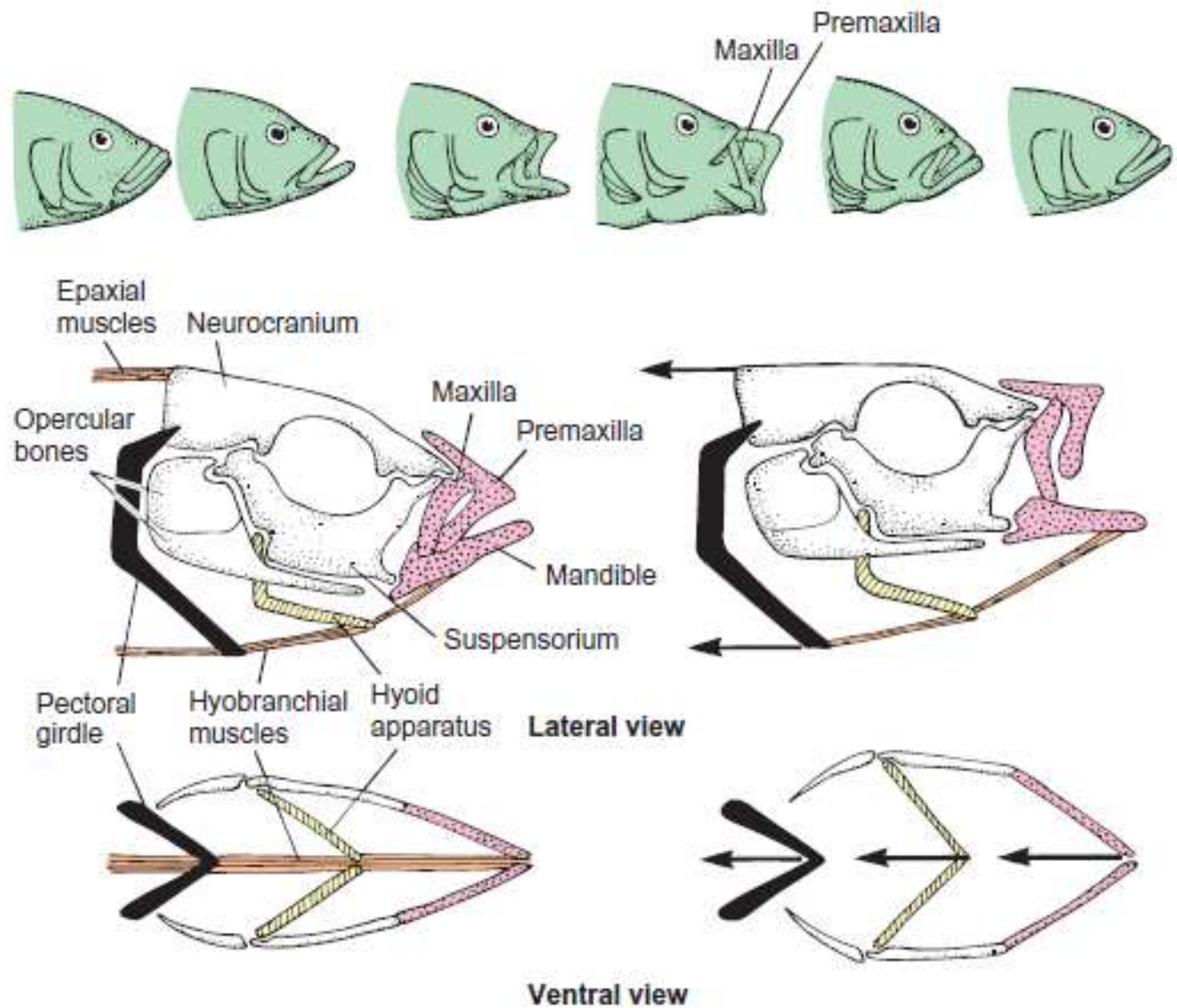


FIGURE 7.25 Suction feeding of a teleost fish. Top series are traces from a high-speed film of jaw opening (food not shown). Note changes in position of the jaws. Lateral and ventral views, respectively, of the major kinetic bones of the skull are shown when jaws are closed (left) and when they are open (right). Note the forward movement of the jaws (stippled areas) and outward expansion of the buccal cavity. Lines of muscle action are shown by arrows.

After Liem.

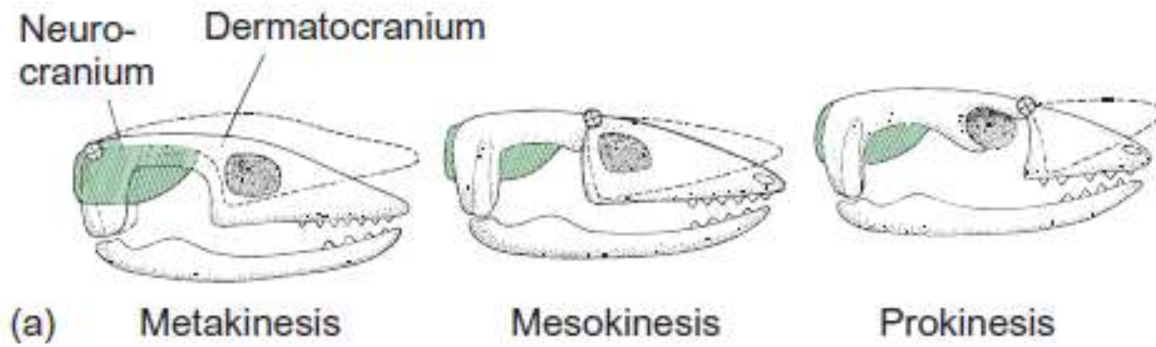
Cranial kinesis in Reptiles

- The most extensive motions are found in the skulls of lizards and especially snakes.
- In these two groups, a transverse hinge extends across the skull roof, a **transcranial joint.**
- Three types are found depending on position of the hinge:

1.**Metakinesis**-Hinge passes across the back of the skull, permitting rotation between the neurocranium and outer dermatocranium

2.**Mesokinesis**-Hinge passes through the dermatocranium behind the eye.

3.**Prokinesis**- Hinge passes through the dermatocranium in front of the orbits.



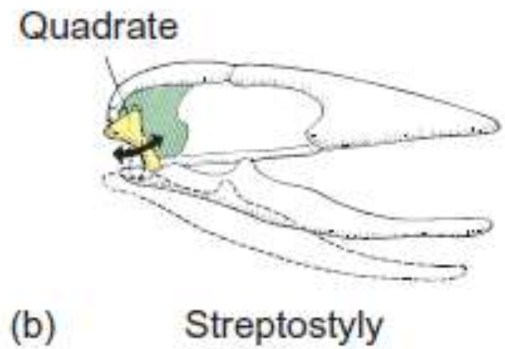


FIGURE 7.36 Cranial kinesis in squamates.
(a) There are three types of cranial kinesis based largely on the position at which the hinge (X) lies across the top of the skull. The hinge may run across the back of the skull roof (metakinesis), behind the orbit (mesokinesis), or in front of the orbit where the snout articulates (prokinesis). (b) The ability of the quadrate to rotate about its dorsal end is called streptostyly.

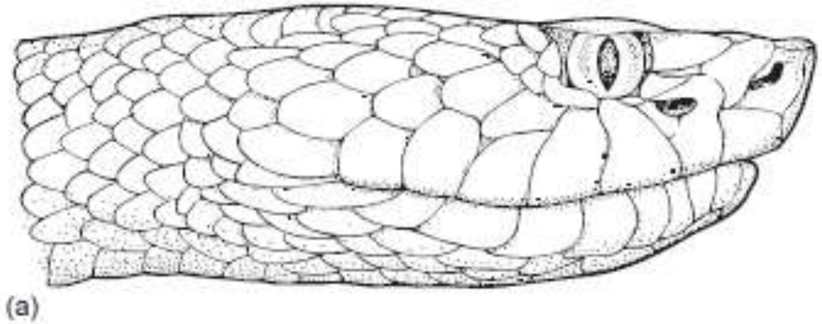
Kinetic Skull in Snakes

- Jaws of snakes are highly kinetic with great freedom of motion
- Streptostyli- The condition in which the quadrate is free to undergo some degree of independent rotation about its dorsal connection with the braincase.
- **Skull bones are joined in snakes into linked chains with extensive motion relative to the brain case**
- The kinetic mechanism of snakes include many units (8 in *Boa*), that are loosely joined together and independent on two sides of the head. **In consequence an infinite variety of relative motion is possible, characteristic of feeding of snakes.**
- **The independent motion and outward spreading of the jaws allows most snakes to swallow large prey**

Kinematic movable bones in Venomous Snakes

- The fangs of most venomous Snakes are longer than other teeth in the mouth.

  Eg- Fangs of Vipers and Pit Vipers are especially long.
- **Extensive rotation of the fang bearing maxilla in such snakes allows this long fang to be folded up and out of the way when it is not in use**.
- The venomous viper erects the maxillary bone bearing the fang and swings it from a folded position along the upper lip to the front of the mouth, from where it delivers venom into prey



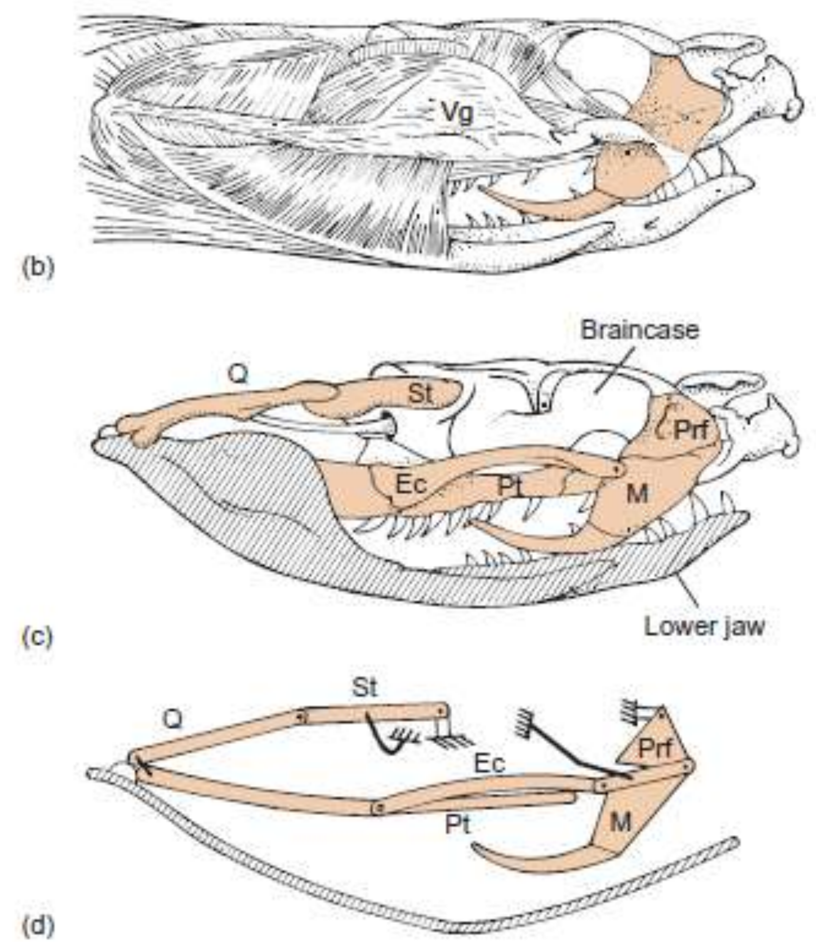
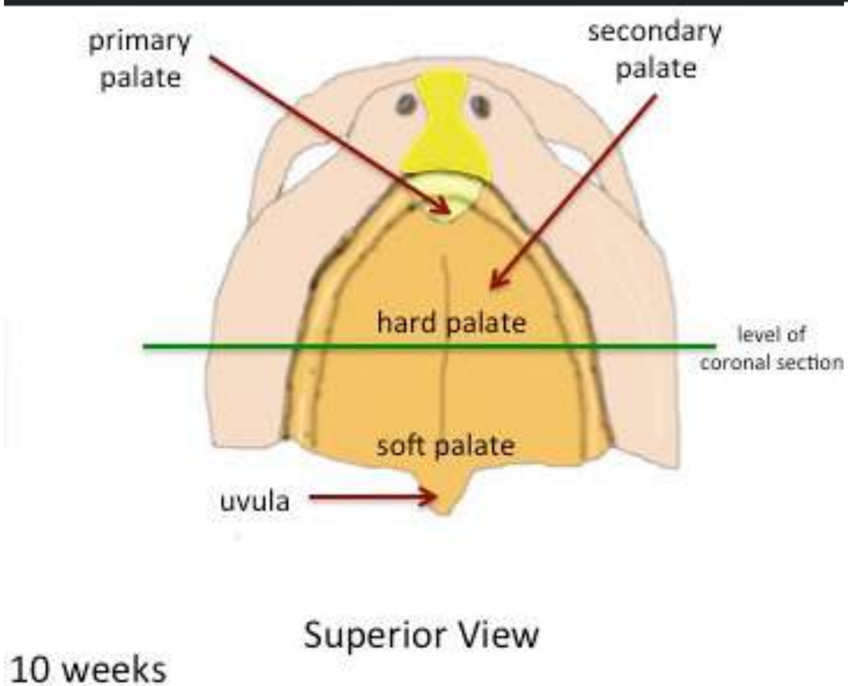


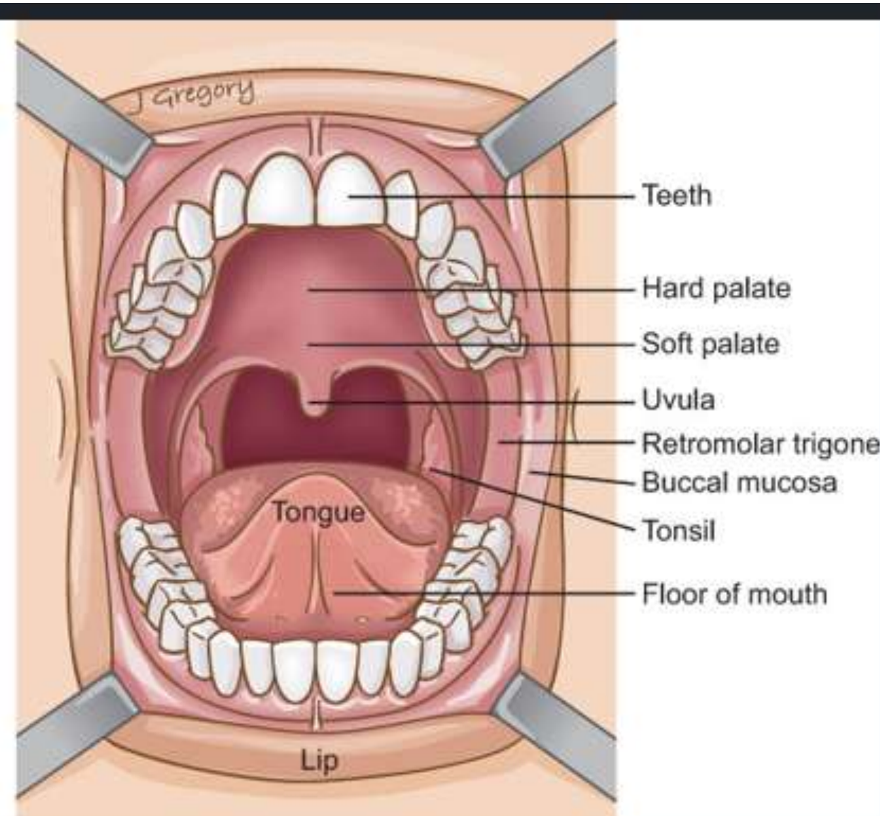
FIGURE 7.43 Kinematic model of movable skull bones in a venomous snake, the water moccasin. Whole head (a) with successive removal of skin and muscles (b) reveals bones of the skull (c). Linkage bones movable relative to the braincase are in color; lower jaw is crosshatched. (d) Biomechanical model of movable bones rotatable about pin connections. Movable bones include the ectopterygoid (Ec), maxilla (M), pterygoid (Pt), prefrontal (Prf), quadrate (Q), supratemporal (St). Location of the main venom gland (Vg) is shown as well.

After Kardong.

Akinesis in Mammals

- In Mammals feeding strategy is based on mastication of food. This **mastication** finds adaptive favour as a result of AKINESIS
- In Mammals set of post dentary bones(angular,articular,coronoid,prearticular,splenial,surangular) are entirely lost and the dentary enlarge to assume the exclusive role of lower jaw function.
- **Secondary palate plays a vital role in mastication.**


primary
palate
secondary
palate
hard palate
level of
coronal section
soft palate
uvula
Superior View
10 weeks


J Gregory
Teeth
Hard palate
Soft palate
Uvula
Retromolar trigone
Buccal mucosa
Tonsil
Tongue
Floor of mouth
Lip

Advantages of Kinetic skull

- Cranial kinesis provides a way to change the size and of the mouth rapidly.
- In fishes and other Vertebrates that feed in water, rapid kinesis creates a sudden reduction of pressure in the buccal cavity so that the animal can suck in a surprised prey.
- Cranial kinesis also allows tooth bearing bones to move quickly into strategic positions during feeding.

Cranial kinesis and feeding- some illustrations

- Some teleost fishes swing their anterior tooth bearing bones forward at the last moment to reach out quickly at the intended prey
- Venomous Snake
- In many fishes and Reptiles with kinetic skull teeth on the upper jaw can be reoriented with respect to the prey in order to assume a most favourable position during prey capture or to align crushing surfaces during swallowing. **Here cranial kinesis brings near simultaneous contact and closure of both upper and lower jaws on the prey.**

Advantages of Akinetic skull

- With loss of kinesis, the skull is firm and ready to serve strong jaw closing muscles.
- Mastication, development of specialized teeth to serve chewing and a muscular tongue (to move food into position between tooth rows) finds adaptive favour as a result of akinesis.
- Although there are other ways of chewing food (some fishes with kinetic skull and teeth also chew food), in Mammals the conditions seem especially favorable for mastication.
- Akinetic skull in Mammals allows infants to suckle easily.

Jaw suspension and evolution of Visceral Arch

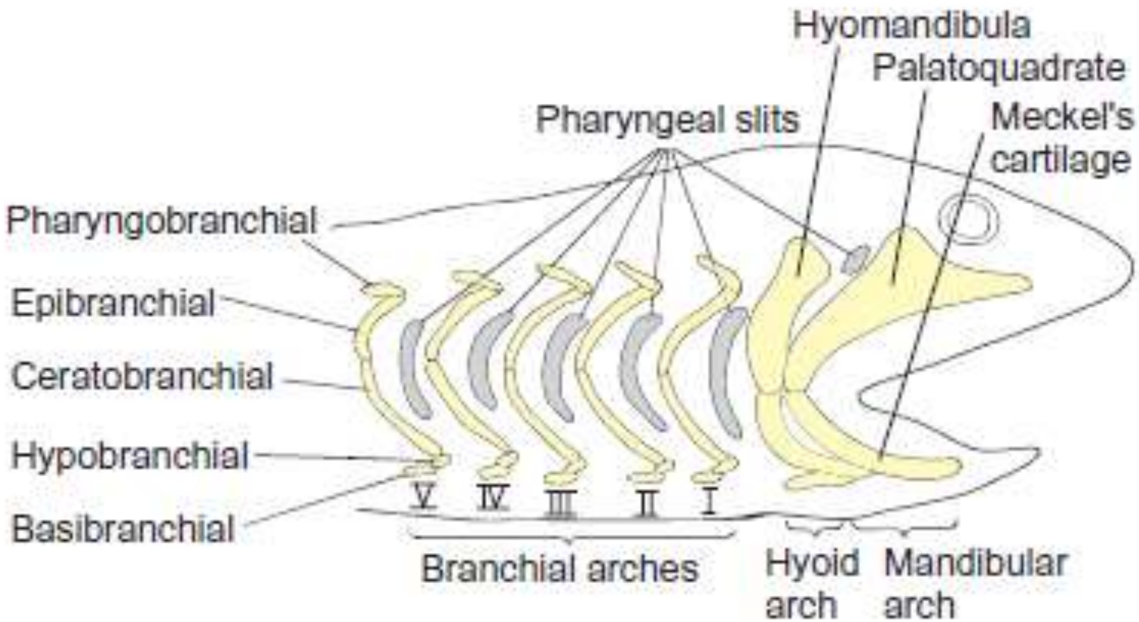


FIGURE 7.5 Primitive splanchnocranium. Seven arches are shown. Up to five elements compose an arch on each side, beginning with the pharyngobranchial dorsally and in sequence to the basibranchials most ventrally. The first two complete arches are named: mandibular arch for the first and hyoid arch for the second that supports it. The characteristic five-arch elements are reduced to just two in the mandibular arch: the palatoquadrate and Meckel's cartilage. The large hyomandibula, derived from an epibranchial element, is the most prominent component of the next arch, the hyoid arch. Behind the hyoid arch are variable numbers of branchial arches I, II, and so on. Labial cartilages are not included.

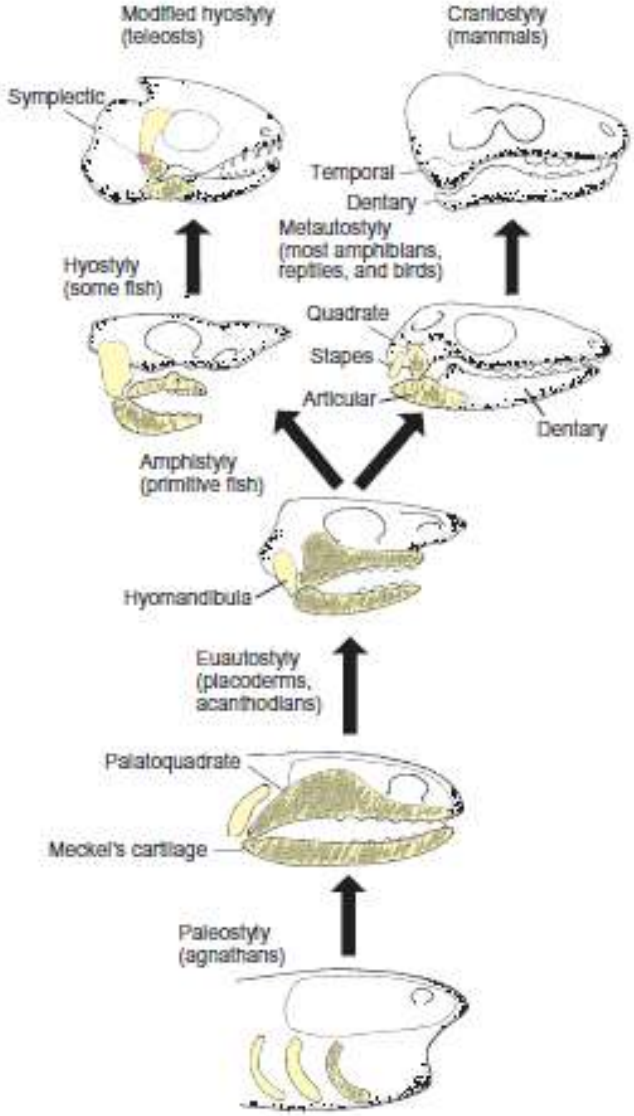


FIGURE 7.8 **Jaw suspension.** The points at which the jaws attach to the rest of the skull define the type of jaw suspension. Note the mandibular arches (yellow, crosshatched areas) and hyoid arches (yellow areas). The dermal bone (white areas) of the lower jaw is the dentary.

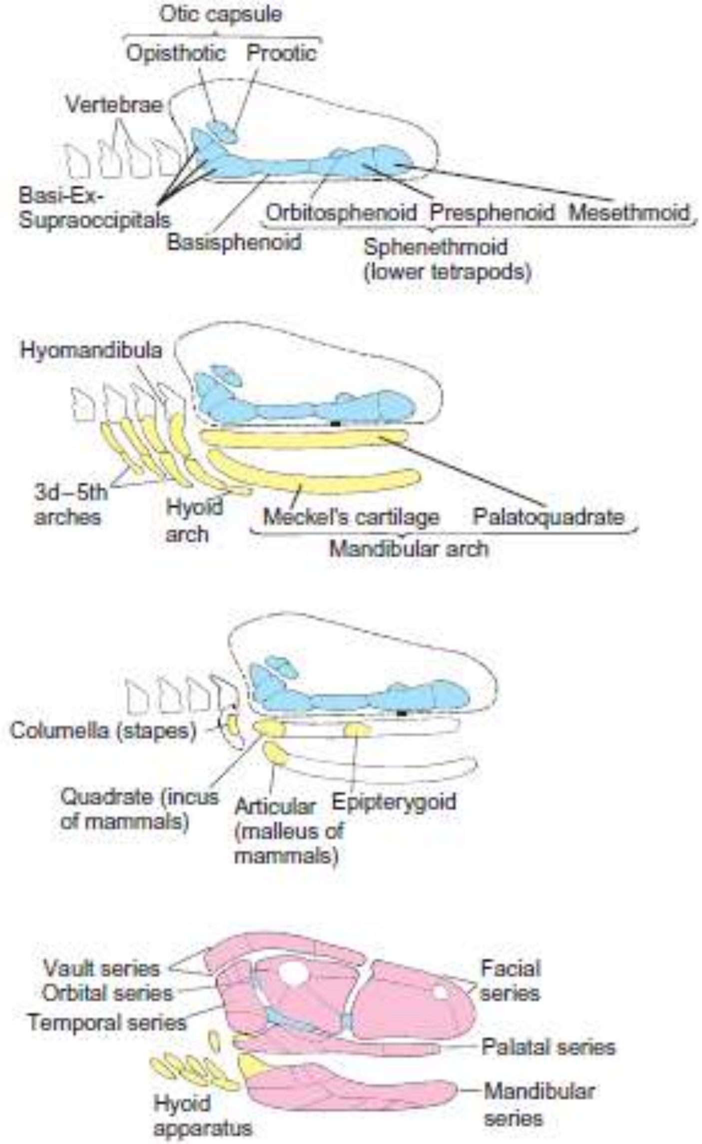
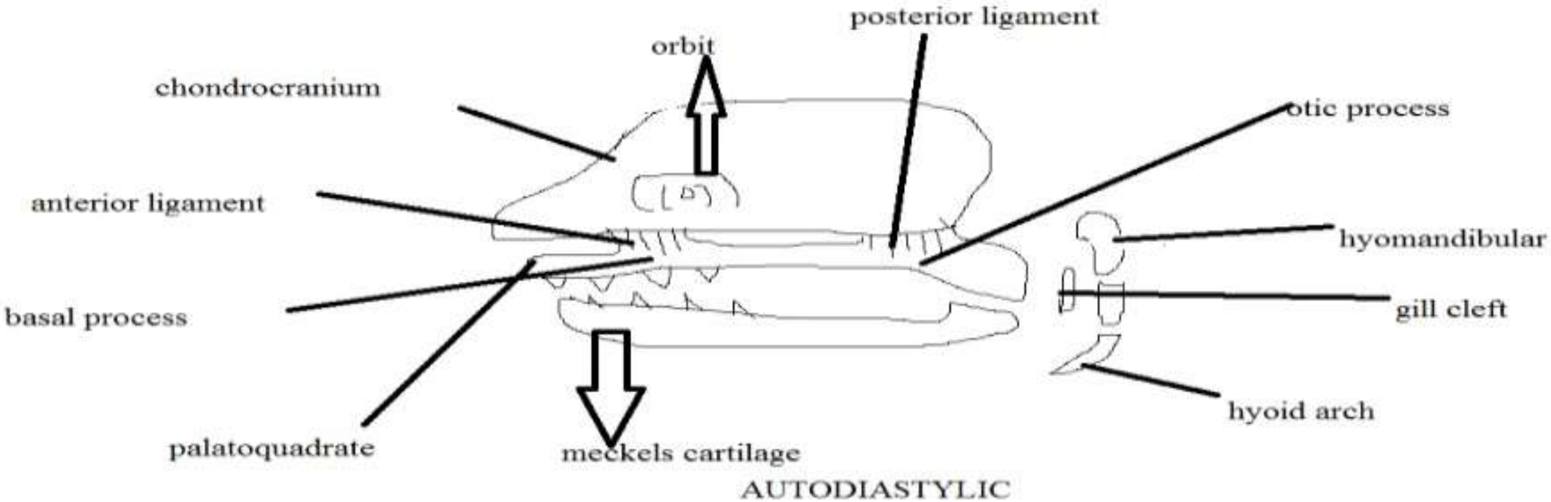


FIGURE 7.11 **Contributions to the skull.** The chondrocranium (blue) establishes a supportive platform that is joined by contributions from the splanchnocranium (yellow), in particular the epipterygoid. Other parts of the splanchnocranium give rise to the articular, quadrate, and hyomandibula, as well as to the hyoid apparatus. The dermatocranium (pink) encases most of the chondrocranium together with contributions from the splanchnocranium.

1)AUTODIASTYLIC

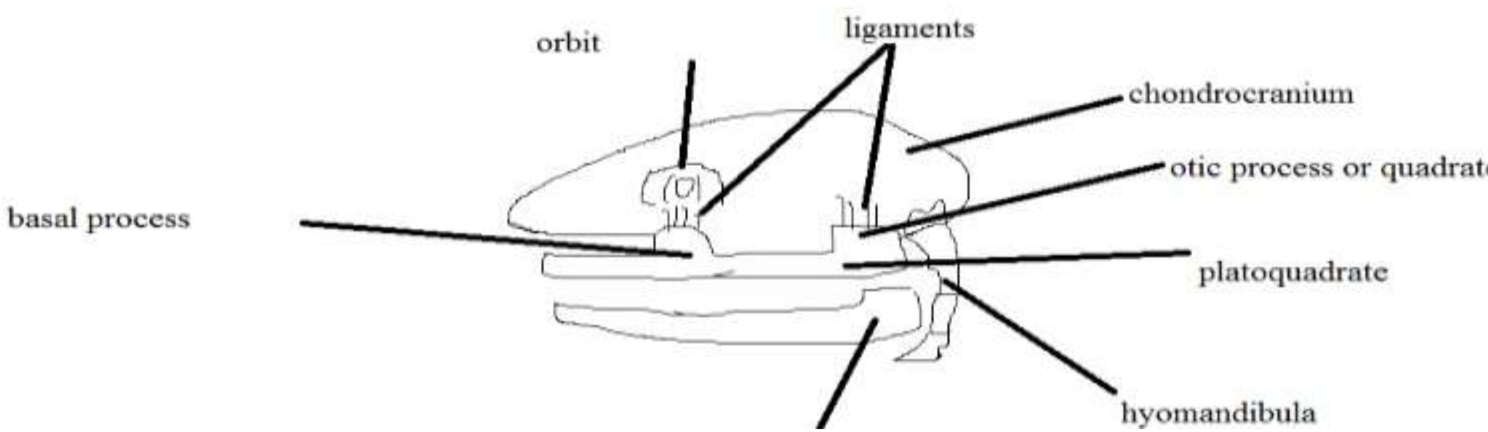
The jaws are attached to the cranium by anterior and posterior ligaments. Hyoid arch remains completely free or independent and does not support the jaws.

Eg:gnathostomes and acanthodians



2)AMPHISTYLIC

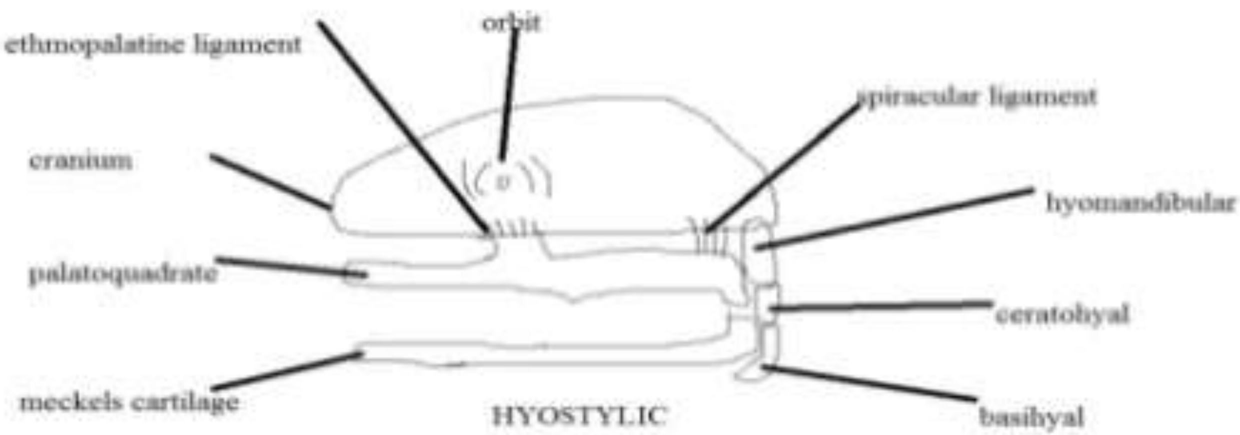
The quadrate or the basal and otic processes of upper jaw(mandibular arch) are attached by ligaments to chondrocranium.similarly,the upper end of hyomandibula(hyoid arch) is also attached to chondrocranium, while the two jaws are suspended from its other end.this arrangment makes double suspension(amphi=both+styly=bracing)since both the first and second arches participate in binding the jaws against the chondrocranium.Eg:primitive shark.



3)HYOSTYLIC

Upper jaw (palatoquqdrate) is loosely attached by anterior ethmopalatine ligament and posteror spiracular ligament to cranium.both the jaws are suspended from the hyomandibular,the upper end of which fits into auditory region of the skull . since only hyoid arch binds the two jaws against cranium ,this jaw suspensionis teremed as hyostylic it provides the jaws a wider movement and helps in swallowing larger preys

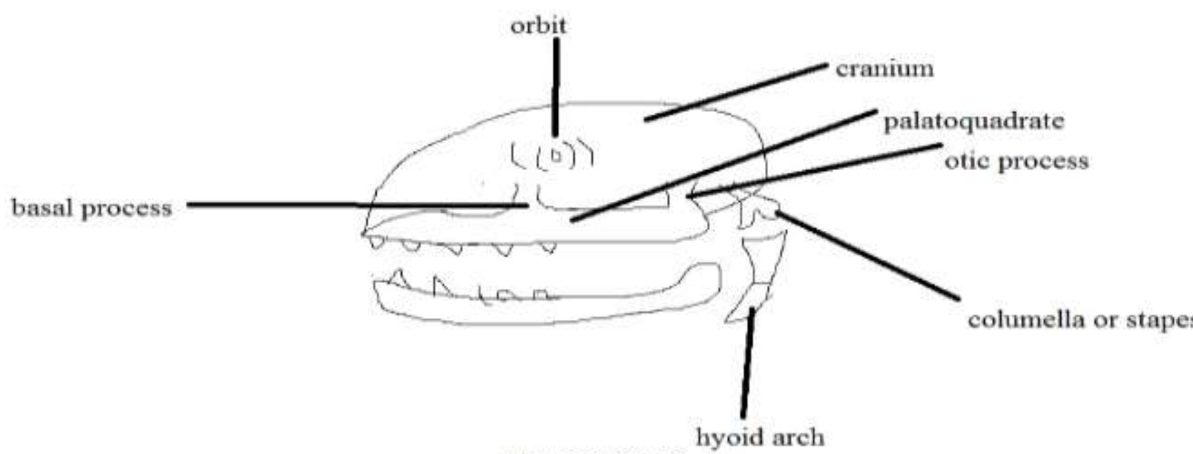
Eg:elasmobranch,bony fishes.



4)AUTOSTYLIC

This condition occurs when hyomandibular does not participate but becomes modified into columella or stapes of middle ear for transmitting sound waves.the upper jaw is completely fused by its processes to the bony skull and the lower jaw is suspended from the upper jaw.thus support from the hyomandibular is not needed,so it enters the middle ear as columella or stapes.

Eg:bony fishes,tetrapoda.



AUTOSTYLIC

5)CRANIOSTYLIC

This type of jaw suspension is characteristic of mammals and some consider it as a modification of autostylic suspension .upper jaw fuses throughout its length with cranium and hyomandibular forms the ear ossicles malleus and incus consequently two dermal bones ,dentary of lower jaw and squamosal of skull provide the articulation between jaws.

Autostylic jaw suspension is divided into 3 subtypes

a)HOLOSTYLIC

In this upper jaw is firmly fused with skull and lower jaw suspended from it.hyoid arch is complete ,independent and not attached to skull;

Eg:chimaeras

b)MONIMOSTYLIC

In many tetrapods , hyomandibular forms columella and articular articulates with quadrate. However ,the quadrate remains immovably attached with skull.

c)STREPTOSTYLIC

Quadrate is loosely attached and is movable at both ends a condition known as streptostylic.Eg:reptiles (lizzard,snakes)and birds.