JAW SUSPENSION

Jaw suspension means attachment of the lower jaw with the upper jaw or the skull for efficient biting and chewing. There are different ways in which these attachments are attained depending upon the modifications in visceral arches in vertebrates.

AMPHISTYLIC

In primitive elasmobranchs there is no modification of visceral arches and they are made of cartilage. Pterygoqadrate makes the upper jaw and meckel's cartilage makes lower jaw and they are highly flexible. Hyoid arch is also unchanged. Lower jaw is attached to both pterygoqadrate and hyoid arch and hence it is called amphistylic.

AUTODIASTYLIC

Upper jaw is attached with the skull and lower jaw is directly attached to the upper jaw. The second arch is a branchial arch and does not take part in jaw suspension.

HYOSTYLIC

In modern sharks, lower jaw is attached to pterygoquadrate which is in turn attached to hyomandibular cartilage of the 2nd arch. It is the hyoid arch which braces the jaw by ligament attachment and hence it is called hyostylic.

HYOSTYLIC (=METHYSTYLIC)

In bony fishes pterygoquadrate is broken into epipterygoid, metapterygoid and quadrate, which become part of the skull. Meckel's cartilage is modified as articular bone of the lower jaw, through which the lower jaw articulates with quadrate and then with symplectic bone of the hyoid arch to the skull. This is a modified hyostylic jaw suspension that is more advanced.

AUTOSTYLIC (=AUTOSYSTYLIC)

Pterygoquadrate is modified to form epipterygoid and quadrate, the latter braces the lower jaw with the skull. Hyomandibular of the second arch transforms into columella bone of the middle ear cavity and hence not available for jaw suspension.

MONIMOSTYLIC

This type of suspension is a modification of autosystylic suspension in which quadrate is immovable and not flexible as in amphibia and many reptiles. Hyomandibular is modified as columella bone of the middle ear cavity.

STREPTOSTYLIC

This type is found in snakes, lizards and birds, in which quadrate bone is movable and flexible at both ends making the jaw highly flexible. Columella is single bone in the middle ear cavity and is sometimes called stapes.

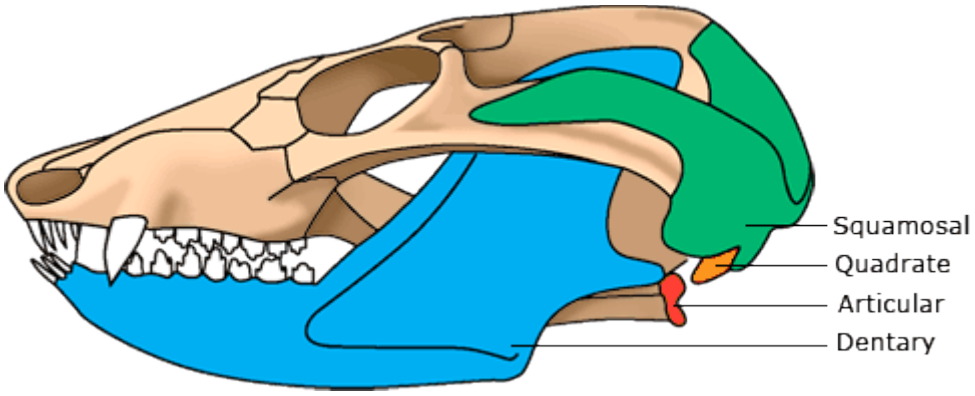
HOLOSTYLIC

This type is found in lung fishes and Holocephali. Upper jaw is fused with the skull and the lower jaw is attached directly with it. Hyoid arch does not participate in jaw suspension and is a typical branchial arch. There is no columella bone.

AUTOSTYLIC (=CRANIOSTYLIC)

Found in **mammals**, in this type of jaw suspension, pterygoquadrate is transformed into alisphenoid and incus, while meckel's cartilage is changed into malleus and not available for jaw suspension. Lower jaw is directly attached to the skull bone called squamosal. Monotremes also possess this type of jaw suspension. Originally the quadrate and articular bones formed the jaw joint, but these synapsids (e.g., *Probainognathus*) evolved a second pair of bones involved in the jaw articulation. The squamosal bone was positioned alongside the quadrate in the upper jaw, and the dentary was positioned alongside the articular in the lower jaw.

In mammals the jaws are made up of the mandible (lower jaw) and the maxilla (upper jaw). In the ape there is a reinforcement to the lower jaw bone called the simian shelf. In the evolution of the mammalian jaw, two of the bones of the jaw structure (the articular bone of the lower jaw, and quadrate) were reduced in size and incorporated into the ear, while many others have been fused together. As a result, mammals show little or no cranial kinesis, and the mandible is attached to the temporal bone by the temporomandibular joints. Temporomandibular joint dysfunction is a common disorder of these joints, characterized by pain, clicking and limitation of mandibular movement.



Skull of *Probainognathus*, an early synapsid.

SPLANCHNOCRANIAL EVOLUTION IN SYNAPSIDA

The story of the transformation of the elements of the mandibular and hyoid components in the lineage leading toward mammals is perhaps one of the best known and most famous of evolutionary transformations taught in vertebrate biology. It is, briefly, the story of: • Consolidation of palatoquadrate elements into the side-wall of the braincase. • Reduction of post-dentary elements of the lower jaw. • Change from the quadrate-articular jaw joint to the DENTARY-SQUAMOSAL JAW JOINT. • Transformation of mandibular and hyoid arch elements into middle ear elements.

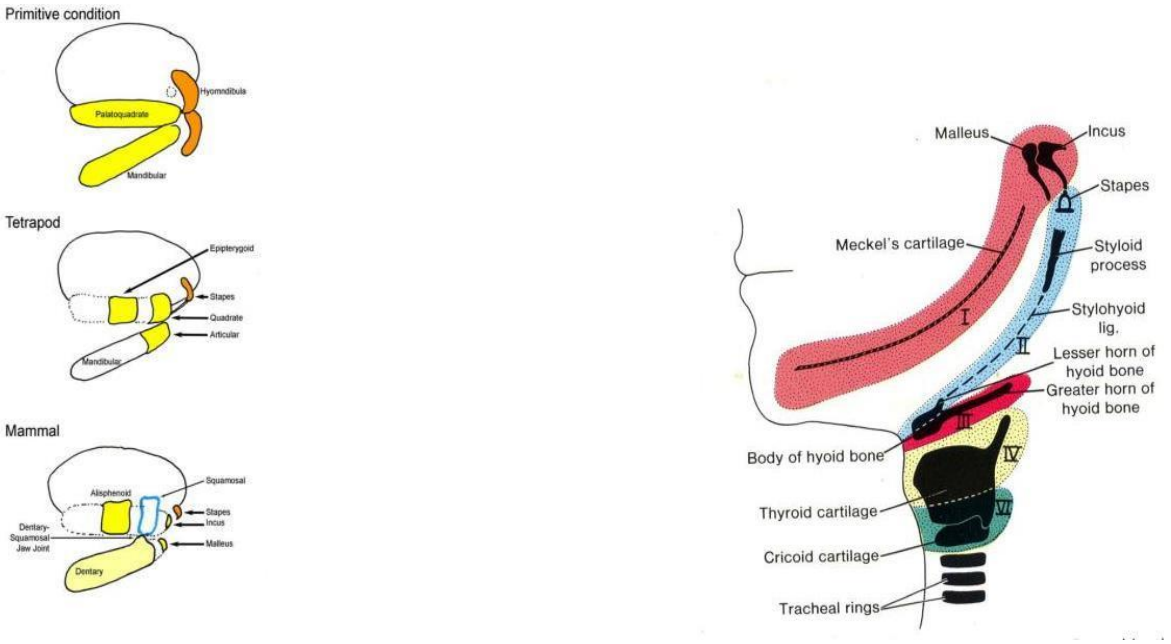
The dentary gradually becomes the dominant, then only bone of the lower jaw. • As it does so, it becomes (by default) the only tooth bearing bone. • The dentary develops a large, dorsally directed CORONOID PROCESS, which will take insertion of the TEMPORALIS muscle. • As this occurs, there is a progressive and proportional reduction in the size of the postdentary bones. • The splenial, coronoid, surangular, and angular are eventually lost. • The quadrate of the upper jaw, comes to be closely associated with the articular of the lower jaw – this is straight-forward, as they had already articulated as the quadrate-articular jaw joint of more primitive taxa.

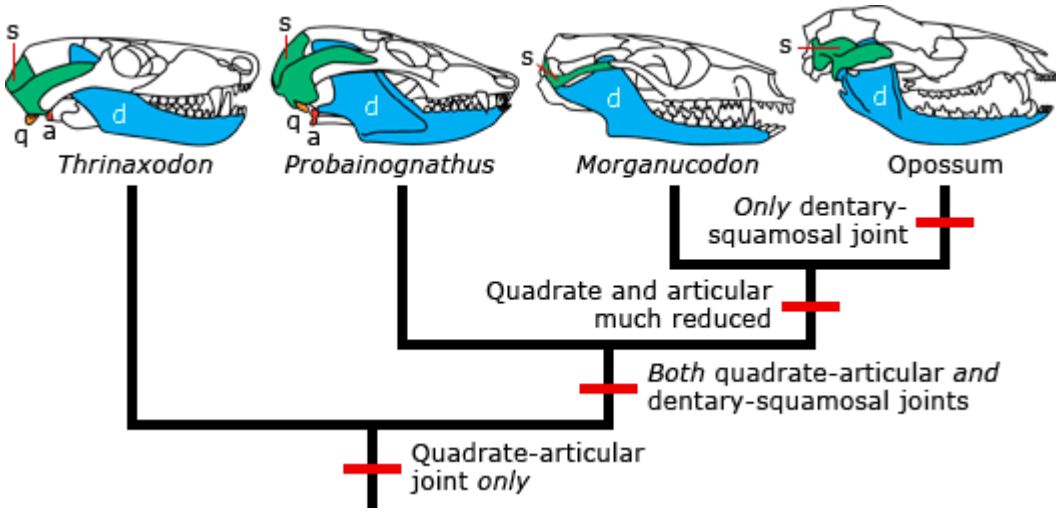
The angular bone is reduced in size, detaches from the back of the jaw, attaches to the otic capsule of the skull, and becomes the circular rim of the EXTERNAL AUDITORY MEATUS of the temporal bone. • The articular is reduced in size. It remains lodged in the membrane that stretches across the articular rim of the external auditory meatus (TYMPANIC MEMBRANE), becoming the MALLEUS bone of the middle ear. • The quadrate is also reduced in size. It remains in articulation with the old quadrate (now the malleus), as the INCUS BONE. • The stapes is already in contact with the otic capsule. It comes to articulate with the incus.

Joint between incus and malleus = old quadrate-articular jaw joint. The angular contributes to the temporal bone, and the articular-quadrate-hyomandibular/stapes series become the MALLEUS-INCUS-STAPES linkage, or MIDDLE EAR OSSICLES.

COMPOSITE BONES OF THE MAMMALIAN SKULL • The bone most clearly explained by this discussion is the TEMPORAL BONE, which has the following components: • PETROUS portion – otic capsule of the chondrocranium • SQUAMOUS portion – squamosal of dermatocranium • ZYGOMATIC PROCESS – squamosal of dermatocranium • ANGULAR RIM of external auditory meatus – angular of mandibular arch of splanchnocranium • STYLOID PROCESS – hyoid arch

COMPOSITE BONES OF THE MAMMALIAN SKULL - II • OCCIPITAL BONE: • OCCIPITAL portion – Supraoccipital, exoccipitals, basioccipital of chondrocranium. • SQUAMOUS portion – postparietals of dermatocranium • Note the alisphenoid is in most mammals a separate ossification. • SPHENOID BONE: • GREATER WING (WHEN FUSED) – alisphenoid (= epipterygoid) of splanchnocranium • BASISPHENOID (including sellaturcica and dorsum sellae) – basisphenoid of chondrocranium • PTERYGOID WINGS – pterygoids of palatal dermatocranium • LESSER WINGS – Optic capsule of the chondrocranium





Evolution of the jaw joint in synapsids. Abbreviations used: a-articular, d-dentary, q-quadrate, s-squamosal.

Only in recent years has it become apparent that several lineages of synapsids, including mammals, replaced their quadrate-articular jaw joint with a dentary-squamosal joint. We don't fully understand why these changes happened. Some evidence suggests that the change in the quadrate-articular complex improved hearing. Other evidence suggests that these changes were a byproduct of early mammals' increasing brain size. These ideas are not mutually exclusive, of course, and more research is needed. Whatever the functional advantages may have been, the pattern of evolution in these features clearly shows another example of exaptation: the incorporation of the dentary and squamosal bones into the jaw joint, originally alongside the quadrate and articular, eventually allowed the latter two bones to acquire a completely different function and to leave the jaw articulation altogether.