

نموذج أجابة للفرقة الرابعة حيوان / كيمياء نظام قديم.

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اسم الدكتور واضع الأمتحان : ا.د/ سلوى ابراهيم عبد الهادى سعد.

اسم الكلية: كلية العلوم – قسم علم الحيوان.

Benha University
Faculty of Science
Zoology Department

Jan. Session,2014
Comparative Anatomy.
Time Allowed: 2hrs.

Fourth Year Zoology/Chemistry Student

Please illustrate your answers with a clear labeled diagrams whenever possible.

Answer the following questions:-

1. Describe in detail the development of the neurochondrocranium in case of superclass Gnathostomata. (20 marks).

2. Give a brief account on the following:-

- a. The exoskeleton in classes Amphibia and Mammalia. (10 marks).
- b. Types and replacement of teeth. (10 marks).

3. Explain in detail TWO items of the following:-

- a. Modes of jaw suspension. (10 marks).
- b. Different types of reptilian skull. (10 marks).
- c. Vertebral column in classes Amphibia and Reptilia. (10 marks).

4. Explain in detail how the mammalian skull evolved from Therapsidian one. (20 marks).

With my best wishes,
Prof. Dr. Salwa Ibrahim.

أجابة السؤال الأول

There are differences in the details of the development of chondrocranium among different groups of vertebrates. However, the development follows main steps in the embryo of all vertebrates.

The first stage in the development of the chondrocranium represents the appearance of two pairs of elongated cartilages in the mesenchyme of the head, a pair on both sides of the anterior end of the notochord called parachordals, and a pair anterior to these known as trabeculae. Sometimes, a pair of small polar cartilages forms between parachordals and trabeculae. Around the sense organs, cartilaginous sense capsules appear, these are the olfactory, optic and otic or auditory capsules. Then, the parachordals fuse together medially forming a basal plate, which encloses the notochord. This plate unites with the otic capsules on its sides. Usually, the anterior ends of the parachordals become connected by a transverse bar called acrochordal cartilage leaving an opening behind known as basicranial fenestra. The trabeculae fuse with the parachordals behind (and with the polar cartilages if present). Anteriorly, the trabeculae fuse together forming an intertrabecular plate or ethmoid plate, and leaving a hypophyseal fenestra behind, i.e. between the intertrabecular plate and acrochordal cartilage. The intertrabecular plate fuses with the nasal capsules on both sides, while anteriorly it gives rise to a median prolongation between the nasal capsules called internasal septum.

The condition of platybasic and tropibasic skulls are performed as a result of the position of the trabeculae in relation to each other. If the trabeculae are widely separated and hence a large hypophyseal fenestra exists, and a primitive platybasic skull is formed without an interorbital septum, as found in lower fishes and Amphibia. If the trabeculae are

closely placed, there is a small hypophyseal fenestra and an interorbital septum, and a tropybasic skull is formed, as in higher fishes and most tetrapods.

Certain vertebrae fuse together into the posterior region of the parachordals.

As a result of these fusions, a cartilaginous floor is formed below the brain.

The formation of the side walls of the chondrocranium takes place firstly in the orbital region by arising two orbital cartilages. These grow ventrally to fuse with the trabeculae and posteriorly to fuse with the auditory capsules. Secondly, in case of the auditory region, the otic capsules perform the side walls for the chondrocranium.

Finally the roof of the chondrocranium is formed in the orbital region by growing two plates of cartilage from the orbital cartilages towards the middle line, until they fuse together to form the roof for the chondrocranium. In the otic region, two plates of cartilage grow from the dorsal edges of the auditory capsules towards the middle line, and fuse together into a tectum synoticum. In relation to the olfactory region no roof is formed and a large anterior fontanelle is left between the two olfactory capsules.

Posterior to the auditory capsules, the region of the parachordals is segmental in nature. The segments in this region form upward projections on both sides. The last segment may be called occipital arch and the segments in front are the preoccipital arches. Certain vertebrae may be added from behind, and these are called occipitospinal arches. From some of these arches a roof develops above. The preoccipital, occipital and occipitospinal arches, together with their roof and the tectum synoticum perform the occipital arch of the skull bounding a large foramen magnum through which the spinal cord passes.

اجابة السؤال الثانى (أ)

Exoskeleton of Amphibia :

Amphibia possess naked skin without exoskeleton. The extinct order "**Stegocephalia**" had bony dermal plates, which probably evolved from the cosmoid scales of extinct fishes. Claws of the vertebrates, first appear in Amphibia, and occur on the posterior extremities of a few genera, especially in the south american toad "**Xenopus**". The claws are cornifications of the corneal epidermal layer, just as the hoof and nail.

Exoskeleton of mammals : ,

Mammals possess different kinds of exoskeleton. these kinds are :

1- Hairs : These comprise the chief exoskeleton of mammals, and they are not found in any other vertebrate. However, a number of mammals are devoid of hair, as **Cetacea, Sirenia** (aquatic mammals), elephants, **Hippopotamus and Rhinoceros**, although the embryos of some of these are entirely covered with hairs. Hairs vary in shape, size and color. Hairs may be shed seasonally as in most mammals.

2- Scales : Some mammals possess horny epidermal scales which resemble those of reptiles. These scales may cover the body as in the scaly anteater, or occur only on the tail as in rats, or on the feet as in kangaroos. The scaly parts are provided with few hairs. The armadillos are the only living mammals which possess an armour composed of both epidennal scales and dennal bony plates an in the turtles.

3- Claws, nails and hoofs : These are found in mammals at the end of toes and fingers, and are epidennal in origin. Claws resemble those of reptiles and birds, being composed of a dorsal convex unguis covering the last phalanx of the digit, and a ventral concave subunguis (sole). Nails are found in primates and man, and consist of a broad flattened unguis and usually no subunguis. Hoofs, found in ungulates, consist also of unguis

which surrounds the front of the toe and a subunguis which is greatly enlarged and thickened and covers the ventral side of the toe.

4- Horns and antlers : These are structures of different origin and composition. There are keratin fiber horns or horns consisting of a core of bone from the frontal of the skull, covered with keratin. These are the hollow horns of ruminants, as in cattle, sheep and goats and in antelope. Also there are the antlers of the deer which belong to another type. They consist of bone and are connected with the frontal. During their growth, the antlers are covered with skin called velvet, which carries short hairs. This velvet is shed when the antlers attain their full size. Fighting between animals causes breaking of antlers at a weak zone close to the skull, as for example in the mating season. A new larger set of antlers grows under the influence of sex hormones. Such weapons of antlers are usually restricted to the males, although in the reindeer (of the northern regions) they are found in both sexes. Antlers of the giraffe are short, unbranched and covered with permanent skin. The horns are permanent and unbranched, and continue to grow from the malpighian layer between them and the bony core. Usually, there are sexual differences in size and shape of horns, especially in sheep and cattle.

أجابة السؤال الثانى (ب)

Replacement of teeth :

There are three kinds of replacement of teeth :

a- Polyphyodont, where there is a series of developing teeth beneath the functioning tooth. When the latter falls, it is replaced by a new tooth just below. This kind of replacement is found in many fishes, amphibians and some reptiles (lizards and snakes).

b- Diphyodont, where there are only two sets of teeth, the deciduous or milk teeth and the permanent ones. This is found in mammals generally.

c- Monophyodont, where there is one set of teeth. This is found in few mammals, e.g. moles, some rodents and toothed whales.

Types of teeth :

Teeth are of several types among different vertebrates. Sharks have sharp conical teeth resembling placoid scales. Rays have grinding teeth with flat or rounded surfaces for crushing molluscs.

Most bony fishes have conical teeth, found in single row or several rows or in patches. Some bony fishes lack teeth.

Among **Amphibia**, the limbless **Apoda and Salamander** have two rows of teeth in upper jaw and in the lower. Most frogs have a single row of small teeth in the upper jaw and none in the lower. Toads are toothless. Tadpoles have rows of horny nibbling teeth on the skin outside the mouth not to be considered as true teeth.

In Reptilia, the primitive groups as well as **Rhynchocephalia and Squamata** have a palatal and marginal teeth above. Poisonous fangs are found in certain snakes and in vipers. In **Chelonia** teeth are lacking. Birds have no teeth, although found in ancestral ones where the dentition was thecodont, i.e. teeth with sockets. **Thecodont** dentition was also found in mammal-like reptiles " Therapsida", as the case in mammals. **Therapsida** had also adaptive forms of teeth as in mammals, i.e. incisors, canines, molars, the so-called heterodont condition which is of a high degree of specialization in mammals.

Among mammals, monotremes are toothless, except the duckbill which has temporary teeth. Marsupials have about 50 teeth as in **Opossum**. This is the primitive number. Placental mammals have started with forty four teeth. In advanced types, the number is reduced, for example in apes and man, the dental formula becomes : 2-1-2-3/2-1-2-3.

Rodents have lost the more lateral incisors, the canines and more anterior premolars, having a wide gap called diastema between the single enlarged pair of incisors and the cheek teeth-formula is 1-0-1-3/1-0-1-3. In toothed whales, the teeth become secondarily increased in number, and lost their differentiation.

اجابة السؤال الثالث(ا)

Modes of jaw suspension :

The most important types of jaw suspensions in superclass **Gnathostomata** are the following.

1- Amphistylic:

This type is found in primitive **Elasmobranchi**, since the palatoquadrate is attached to the neurocranium by ligaments through two processes; an orbital and an otic processes. The hyoid arch contributes to the jaw suspension, since it is attached to the cranium and lower jaw by ligaments.

2- Hyostylic :

Jaws are suspended by the hyomandibular, which in turn is attached to the otic region, as in most modern **Elasmobranchi**

3- Autostylic :

Palatoquadrate articulates to the neurocranium or is fused with it and there is role for the hyomandibular in jaw suspension. This is found in most vertebrates. The palatoquadrate may be suspended by four processes, ethmoid, basal, ascending and otic processes.

a- Ethmoid process (pterygoid process) :

It originates from the anterior end of the palatoquadrate. It comes

into contact or fuses with the ethmoid region of the skull, as in fishes and amphibians.

b- Basal process :

It articulates with a process from the neurocranium called basi-trabecular process. This attachment is very important and found in **Elasmobranchi, Dipnoi**, primitive teleostomes and **Tetrapoda**.

c- Ascending process :

It is found in **Dipnoi** and **Tetrapoda**. It becomes finally the epipterygoid bone.

d- Otic process :

It attaches with the otic region. It becomes the quadrate bone in Tetrapoda. ;

أجابة السؤال الثالث (ب)

Skull of Reptilia :

The skull of primitive reptiles resembles that of primitive amphibians. The openings in the primitive reptilian skull were also the nostrils, the orbits and the parietal foramen. Such a skull is known as anapsidian skull, found in extinct reptiles and still present in the case of **Chelonia**.

During the evolution of the reptilian skull, fenestration occurred in the temporal region, forms were found with an upper fossa (parapsida), other with a lower or infratemporal fossa (synapsida) and still other forms with two temporal fossae (diapsida). Therefore, these three types of skulls evolved from the anapsid type.

1- Parapsid skull :

It was found in extinct reptiles, an upper temporal fossa existed.

This fossa is bounded laterally by the postorbital and squamosal.

2- Synapsid skull:

It was found in extinct reptiles and in mammal-like reptiles (**Therapsida**). The temporal region is fenestrated by a single fossa, but the fossa lies more ventral, i.e. lateral. It is bounded laterally by the jugal and quadratojugal bones.

3-Diapsid skull :

This type of skull is existed in extinct reptiles and three orders of the living reptiles. These orders are **Crocodylia, Squamata and Rhynchocephalia**. In fourth living order (**Chelonia**) the skull is anapsidian type.

Between the upper and lower temporal fossae, there are the postorbital and squamosal bones forming an arch known as upper temporal arcade, while the arch lateral or ventral to the lower temporal fossa is called the lower temporal arcade formed by the jugal and quadratojugal.

In Squamata (Lacertilia and Ophidia), the skull is modified from the diapsid type. But in **Lacertilia**, the lower temporal arcade is lost and the quadrate bone is movable, hence a streptostylic skull is established. Also in **Ophidia**, both the lower and upper temporal arcades are lost, and thus the upper and lower temporal fossae are confluent. This leads to a more mobile quadrate and a more streptostylic of the skull.

أجابة السؤال الثالث (ج)

Tetrapods:

In tetrapods, the vertebral column is differentiated into several regions especially in Aves and mammals. The vertebrae are characterized by complete bony centra and presence of pre-and post-zygapophyses for articulation between successive vertebrae.

Modern Amphibia: More primitive amphibians and salamanders (Caudata) have a continuous notochord surrounded by ossified centra. The centra carry neural arches dorsally, while ventrally they carry haemal arches in the tail. Between the successive centra, there are intervertebral discs of cartilage which may develop from the interdorsals and interventrals. The sacrum in Caudata and Salientia consists of one or two modified trunk vertebrae carrying sacral ribs, which meet the ilium laterally on each side. In Salientia, the vertebrae are nine in number or even lesser. Sometimes, the number is reduced to six which is the least number among all vertebrates owing to fusion or loss.

In Anura, the vertebrae are procoelous. Few forms have opisthocoelous vertebrae. The vertebrae are eight trunk, one sacral and an urostyle of fused caudal vertebrae. Apoda have a very large number of amphicoelous vertebrae.

Reptiles: In the vertebral column of reptiles. The first two vertebrae are the atlas and axis. Centrum of atlas separates from its neural arch and fuses with the centrum of the axis to form the odontoid process of the latter vertebra. Around the odontoid process of the axis the ring-shaped atlas can rotate. Up and down movements of the skull take place at the joint between it and the atlas, i.e. at the condyles.

The vertebral column is characterized by the following :

1. Presence of ribs in most reptiles from the third vertebra until the sacrum, without capitulum and tuberculum. Usually, the cervical ribs are reduced to short spines which may be fused with their vertebrae leaving a vertebral canal between the rib articulations and the centra.
2. Sacrum consists mainly of two vertebrae, each carrying a pair of neural ribs. Reptiles, without hind limbs and accordingly without pelvis, lack

a sacral region. In turtles, the carapace is fused with all the trunk vertebrae.

أجابة السؤال الرابع

Mammal-like reptiles (Therapsida) :The structure of the skull in **Therapsida** changed from that of reptiles. From the therapsidian skull, that of mammals evolved. The changes which occurred in the reptilian skull to give rise to the skull of **Therapsida**, are of great evolutionary importance in the history of vertebrates. The characteristics of the skull of

Therapsida are

- 1- Dentition is heterodont.
- 2- The skull is of the synapsid type, i.e. a single lower fossa is present in the temporal region arched laterally by the jugal bone. This is in the case found in mammals.
- 3-Occipital condyle is double as in mammals.
- 4- Presence of secondary palate as inward extensions of the premaxillae and maxillae.
- 5- Prevomeres are fused together among some therapsids into a single bone as in mammals.
- 6- In advanced therapsidians, the mandibular fossa for articulation with the lower jaw is composed of two bones, the quadrate and the squamosal bones. Also, the articular facet on the lower jaw is composed of both dentary and articular bones. Through the line of evolution towards the mammals, the quadrate and articular became ossicles in the middle ear. Thus, they no longer took part in jaw articulation. Instead, the lower jaw articulates with the skull through the dentary and squamosal bones.

7- Angular bone of the reptilian lower jaw became a tympanic which supports the ear drum.

Mammalian skull :

The skull of mammals evolved from **Therapsida** by reduction, fusion and translocation of certain bones. Hence, prefrontal, postfrontal, postorbital, quadrate, jugal and supratemporal are generally absent. Concerning the translocation of bones, the quadrate and articular bones no longer carry out articulation between the jaws, but they are found in the middle ear as sound transmitting bones.

Brain-case in mammals is very large owing to the large size of the brain. A zygomatic arch is present formed by the jugal and squamosal bones. A tympanic bulla lodges the bony ossicles of the middle ear. The lower jaw consists of a single dentary with a large dorsal coronoid process for the attachment of muscles.

A well developed secondary palate is present, formed by processes from the maxillae and palatines. This secondary palate forms the roof of the mouth and shifting the internal nares posteriorly. The nasal passages lie dorsal to the secondary palate. The secondary palate hides the single vomer bone, the posterior end of which only can be seen from the palatal view.

Fate of mandibular and hyoid arches in tetrapods (middle ear) :

It is quite known that the mandibular arch or first gill arch found in **Agnatha**, migrated anteriorly towards the margins of the mouth to form the upper and lower jaws in **Gnathostomata**. On the other hand, the hyomandibular cartilage which is the dorsal part of the hyoid or secondary gill arch-functions as a suspensory apparatus for the jaws in fishes (hyostylic skull). Thus, the hyomandibular cartilage attaches by one end to the auditory capsule in the skull, while it is connected to the jaws by its other end.

In case of **Tetrapoda**, the upper and lower portions of the mandibular arch, i.e. the palatoquadrate and Meckel's cartilage which form the upper and lower jaws of the embryo, ossify at their posterior ends to form the quadrate and articular which articulate together, thus constituting the hinge between the jaws. On the other hand, the hyomandibular or the former jaw suspensory apparatus shares no more in jaw suspension, since the skull is an autostylic one. Consequently, the hyomandibular should take another function. It has been found, by investigating the developmental stages of tetrapod embryos, that the hyomandibular-already 'attached' by one end to the auditory capsule in case of fishes-remains also attached to the capsule in case of tetrapods. However, the hyomandibular played a quite different role than suspending the jaws. Instead, the hyomandibular functions as a sound transmitting bone known as the columella auris or stapes, at one end attached to the auditory capsule where the inner ear is located and the other end fits into the newly formed ear drum in **Amphibia**, **Reptilia**, and **Aves**. The hyomandibular, now referred to as columella auris, crosses a cavity known as tympanic cavity which was the spiracle in fishes. A canal connects the tympanic cavity with the pharynx called eustachian tube. The tympanic cavity with its columella auris constitute the middle ear. This is the condition found in **Amphibia**, **Reptilia** and **Aves**. In case of **Mammalia**, however, the condition does not remain as such. The quadrate and articular bones, which were replacing bones of the palatoquadrate and Meckel's cartilage and earned out jaw-articulation, were found to be lacking in the adult skull of mammals. Indeed, these bones are not totally absent, since they only changed their position and function. This fact has been clarified through the study of development of the skull in mammalian embryos. It has been found that the quadrate and articular migrated towards, the tympanic cavity and became attached to

the columella auris (hyomandibular), their former adjoining bone in jaw suspension. The quadrate and articular took the function of sound transmission like the columella auris. Therefore a chain of these bones arises, the columella auris (hyomandibular), the quadrate (palatoquadrate) and the articular (Meckel's cartilage). The quadrate and articular no more carry their old names. Instead, they are known as incus and malleus respectively. Therefore, the incus in the mammalian skull is homologous to the quadrate and the malleus to the articular bones of other tetrapods. The stapes, incus and malleus are collectively known as middle ear ossicles, and found inside the tympanic bulla which represents the angular bone of the lower jaw or is homologous to it. The stapes is fixed by its inner expanded end into an opening inside the walls of the auditory capsule known as fenestra ovalis, while its outer end is attached to the incus. The latter is the middle ossicle transmitting the sound waves from the malleus to the stapes. The malleus receives these waves from the ear drum or tympanic membrane to which it is fixed. Accordingly, by the absence of the quadrate and articular bones from the jaws of mammalian skull, the articulation between the jaws occurs by the dentary of the lower jaw and squamosal bone of the skull.

أنتهت الأسنان والأجوبة النموذجية

انتهت الأجابة النموذجية للامتحان