

# ZOO 430: COMPARATIVE ANATOMY Taxonomy Exhibit Handout OF THE VERTEBRATES

## Tokay Gecko

- K Animalia
- P Chordate
- C Reptilia
- O Squamata
- F Gekkonidae
- G Gekko
- S Gekko gecko



## Key terms and concepts for understanding vertebrate evolution

---

**Analogy** - Features of two or more organisms that are similar because they perform a similar function.

**Ancestral** - A characteristic that is present in both the outgroups and in the ancestors.

**Clade** - A natural evolutionary group in which the ancestor and all and only its descendants are included. Defined by one or more shared derived characters.

**Derived** - A characteristic that occurs only in later descendants.

**Evolutionary convergence** - The process by which unrelated organisms evolve similar characteristics from dissimilar ancestors.

**Extant** - Organisms that are still in existence; not yet extinct or destroyed or lost.

**Extinct** - Organisms that are no longer in existence; lost or especially having died out leaving no living representatives.

**Homology** - Features in two or more organisms derived from common ancestors.

**Informal Assemblage** - A paraphyletic or polyphyletic (a group of unrelated organisms) taxon. Not a natural group.

**Monophyletic** - Used to describe a group of organisms that fit the definition of a clade, therefore, a group or taxon that includes the ancestor and all its descendants.

**Natural Group** - A clade. Also, a monophyletic group or taxon.

**Paraphyletic** - A group or taxon that does not include all descendants of the ancestors.

**Phylogeny** - The course of evolutionary change within a related group of organisms. Also, a graphical representation or evolutionary tree of that change. Often represented by a diagram of bifurcating branches (see station 3).

**Serial homology** - Used to refer to different elements in a repeating morphological array within a single individual. For example, different vertebrae along the spinal column are serially homologous.

**Taxon** - A related group of organisms that comprise a unit of classification.

**Taxonomy** - The science of classifying organisms, or, the classification itself.

**Vestigial** - Adjective which describes a remnant structure that was better-developed in the ancestor.

## Station 1

Vertebrates are members of the subphylum Vertebrata, in the phylum Chordata, which includes two additional subphyla that are collectively referred to as **protochordates**.

**Phylum:** Chordata

**Subphylum:** Urochordata

**Subphylum:** Cephalochordata

**Subphylum:** Vertebrata (or Craniata)

Protochordates are of special interest because they probably share a more recent common ancestor with vertebrates than any other organisms. Adult protochordates can look very different from vertebrates, but the special relationship between protochordates and vertebrates is indicated because all three subphyla share the three defining characteristics of chordates either as larvae or adults:

1. **Notochord.** Present at least embryologically in all chordates. It is a stiffened band of specialized cells located along the dorsal side of the animal. It provides support and prevents compression of the body when the muscles contract.
2. **Dorsal Hollow Nerve Cord.** An unpaired dorsal hollow tube that integrates the action of the longitudinal muscles of the body wall.
3. **Pharynx.** An expanded portion of the gut with pouches and **pharyngeal slits** through which water passes out of the animal. In ancestral protochordates these slits are used for filter feeding. In vertebrates, the pharynx is associated with respiration.

**NOTE:** Although not a defining characteristic, many chordates also have a **post-anal tail**.

## Station 2

**Phylum:** Hemichordata

**Hemichordates are sometimes considered protochordates** (your text is noncommittal on this point). All recent taxonomic treatments exclude them from the phylum Chordata, however.

Hemichordates are present in several forms, including the **enteropneusts** or acorn worms. A microscope is available to view a preserved specimen of one such worm. Note the three body regions: **proboscis**, **collar**, and **trunk**. The mouth is located between the proboscis and the collar. **Pharyngeal slits** are present along the trunk of the animal; they may be visible only under high magnification.

Hemichordates are believed to be related to chordates and share some features with them, for example, the pharynx. However, current thinking places hemichordates in their **own phylum** for two reasons:

1. A stiffened section in the proboscis, called a stomochord, resembles the notochord but the two structures probably are not homologous.
2. Instead of a dorsal hollow nerve cord, hemichordates have dorsal and ventral nerve strands. As these structures are internal; neither is visible in this specimen.

\*\*Thus, Hemichordata can be said to have only one of the three defining characteristics of chordates.

### Station 3

All chordates possess three defining characteristics: **notochord**, **dorsal hollow nerve cord**, and **pharyngeal slits**. However, the protochordates do not comprise either a monophyletic group or a formal taxonomic category. Based on the definitions of these terms and the phylogeny indicated, can you explain why?

## Station 4

**Phylum:** Chordata

**Subphylum:** Urochordata

The urochordates are marine animals. The most well-known members of the subphylum are called tunicates (see whole mount and model) in reference to the adult's tough outer skin, called a **tunic**; these particular urochordates are also sometimes called "sea-squirts" because they can expel fluid from a **siphon**, especially when disturbed by curious marine biologists who often encounter them on rocks in the intertidal zone. The tunic and (incurrent and excurrent) siphons can be seen in the thin section and model of an adult tunicate.

Urochordates are defined by **restriction of the notochord to the tail**. Membership of tunicates in Chordata is based on features of the larval forms (see slide and model), which develop all three chordate characteristics. Superficially, these larvae resemble the free-swimming tadpoles of anurans (frogs), and are called ascidian tadpoles. The **dorsal hollow nerve chord** and **pharynx** are also present in the larvae.

Although larval tunicates are free-swimming, adults are sessile and retain only one of the three chordate characteristics, the pharynx. This feature is difficult to see on the mounted specimens but the model shows where the pharyngeal slits are located on the adult. Other members of Urochordata may retain all three features as adults.

## Station 5

**Phylum:** Chordata

**Subphylum:** Cephalochordata

The cephalochordates include the filter-feeding **lancelet** or **amphioxus**. The name comes from the extension of the **notochord into the head** of the animal; the notochord remains the **sole support** for the animal's body.

Cephalochordates retain all three chordate characteristics into adulthood. The pharynx is well-developed and pharyngeal slits occur along much of the body. The dorsal hollow nerve cord may be located by looking for pigmented photoreceptors along its ventral edge. These **sensory receptors** are part of the nerve cord. There also is **incipient cephalization** because the dorsal hollow nerve chord runs anterior to the pharynx. However, there is no swelling of the nerve cord in the head region. Generous morphologists say that amphioxus has a brain. What do you think?

There is obvious segmentation or **metamerism** of muscles (myomeres) along the body.

## Station 6

**Phylum:** Chordata

**Subphylum:** Vertebrata (Craniata)

Vertebrates retain the three defining structures of chordates, but there are several derived characters unique to them.

The notochord is still present, at least in the embryo, but with few exceptions, the function has been replaced in adults by **vertebrae**, which define this subphylum.

The dorsal hollow nerve cord has expanded in the head region to form the anterior swelling, the **brain**. Sensory organs are concentrated in the head (**cephalization**), improving the animal's ability to move around in and respond to the environment. Vertebrates comprise the most diverse subphylum among chordates.

The brain is protected by a cartilaginous or bony case called the **cranium**, hence the alternate name, Craniata. This structure supports the brain and may serve as a platform for some sensory structures.

## Station 7

**Phylum:** Chordata

**Subphylum:** Vertebrata

Agnatha (**informal assemblage**)

Agnatha comprises all **jawless vertebrates**, hence the name. Agnathans also **lack paired appendages** and have **poorly formed vertebrae**. Instead, the **notochord is the primary means of axial support**. The **chondrocranium lacks a roof**.

The group includes two informal assemblages: the **Ostracoderms** and the **Cyclostomes**. **Ostracoderms are extinct ancient fish-like forms whose bodies were covered with dermal armor**. The cyclostomes are an informal assemblage of living eel-like agnathans that include the lampreys and hagfish. Despite their superficial similarity, lamprey and hagfish probably are not each others' closest relatives; current evidence suggests that lamprey are closer to some extinct Ostracoderms. Consequently, hagfish are sometimes placed in their own Class (Myxini, as in your text, see also Station 11).

## Station 8

**Phylum:** Chordata

**Subphylum:** Vertebrata

Agnatha (**informal assemblage**)

Ostracodermata (**informal assemblage of extinct agnathans**)

**Ostracoderms** include several orders of **extinct** fish-like vertebrates that lived from the **Cambrian** to the **Devonian**. Most were small, bottom-dwelling forms covered with a **heavy armor of bony plates**. It is believed that they were mainly filter-feeders. Some species had paired spines or lobes in the pectoral region, but these were not true fins, as they were unsupported by bone or muscle.

The two classes of ostracoderms were Cephalaspidomorpha (represented by the model labelled 'A' on left) and Pteraspidomorpha (represented by the model labelled 'B' on right). The lamprey is believed to have evolved from an ancestral Cephalaspidomorpha and thus, is often placed in an order (Petromyzontiformes, see Station 10) within that class.

## Station 9

**Phylum:** Chordata

**Subphylum:** Vertebrata

Agnatha (**informal assemblage**)

Cyclostomata (**informal assemblage of extant agnathans**)

Cyclostomes include the lampreys and hagfish. "**Cyclo-**" refers to their **round, sucking mouth**. The **skeleton is completely cartilaginous** and the **notochord** functions as the main axial support. **Lateral neural cartilages** along the dorsal hollow nerve cord may correspond to vestigial vertebrae.

The specimen in front of you is that of an adult lamprey, which shows the round mouth particularly well.

The fossil record for cyclostomes is poor, but it is believed that they arose early in the **Paleozoic** era. Their long independent evolution has led to extreme modifications among living descendants, which are similar in appearance because of similar ecological habits.

## Station 10

**Phylum:** Chordata

**Subphylum:** Vertebrata

Agnatha (**informal assemblage**)

**Order:** Petromyzontiformes (**lampreys**)

Several adult characters place lampreys in a separate order from hagfish:

1. **Fewer (often seven) pairs of external gill slits.** As these are not covered by an **operculum**, they are easily visible in the preserved specimen.
2. **Well-developed horny teeth.** Many lampreys are parasitic on other fish, and use these teeth to cut into the body walls of their hosts. However, brook lamprey are not parasitic, and don't feed at all as adults.
3. Inner ears with only **two semicircular canals.**

Larval lampreys, or **ammocoetes**, are very different from the adult and were originally thought to be a different species. On the mounted specimen in sagittal view note the superficial resemblance to amphioxus, providing compelling support that vertebrates share a common ancestor with protochordates: like protochordates, ammocoetes expresses all three chordate features and is a filter feeder.

## Station 11

**Phylum:** Chordata

**Subphylum:** Vertebrata

Agnatha (**informal assemblage**)

**Order:** Myxiniiformes (**hagfish**)

The hagfish are superficially similar to the lampreys but there are important differences.

1. **More (six to fifteen) pairs of external gill slits.** As these are not covered by an operculum, they are easily visible in the preserved specimen.
2. **Few teeth.** Most hagfish are scavengers rather than parasites.
3. Inner ears with only **one semicircular canal.**

## Station 12

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Placodermii

Placoderms were the **first jawed vertebrates**. These fish evolved well after the ostracoderms, in the late Silurian, but went extinct shortly after ostracoderms, in the latest Devonian or earliest Carboniferous. In general, they were either **fusiform** (spindle-shaped, tapering at both ends but wide in the middle) or flat bodied. Although many were small, others were large fierce predators and the "top dogs" of their day.

Placoderm jaws were **derived from the ancestral first visceral arch**. Like subsequent jawed fishes, placoderms had **paired pectoral and pelvic appendages**. The head and thorax were covered with **bony plates**.

## Station 13

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Chondrichthyes

Chondrichthyes means literally "**cartilaginous fish**". This group includes sharks, skates, rays, and chimaeras.

The endoskeleton is **entirely cartilaginous**, although some of it may be **highly calcified**. The **notochord is continuous but surrounded by vertebrae**. The bony armor of early fishes has been replaced by scales. There is **no swim bladder** and the **gills are exposed** (not covered by a bony operculum).

The jaw is derived from the ancestral first visceral arch, and part of the **ancestral second visceral arch** helps suspend the jaw.

## Station 14

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Chondrichthyes

**Subclass:** Elasmobranchii

**Order:** Selachii

Order Selachii includes the marine **sharks and dogfishes**. These are generally **fusiform** fishes with either pelagic, predatory lifestyles or slower, bottom-dwellers.

Except in highly mobile forms, a **spiracle** is generally present (although it is not visible in the hammerhead specimen). It evolved from the ancestral first gill slit and appears as a small round opening that serves as a one-way valve that takes in water for respiration. However, the mouth is the primary source of water for the gills. The **gill slits are lateral in position and exposed**. The **pectoral fins are distinct** and the **heterocercal tail** is used for locomotion.

## Station 15

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Chondrichthyes

**Subclass:** Elasmobranchii

**Order:** Batoidea

Order Batoidea includes the **skates and rays**. They are predominantly marine fishes adapted to a bottom-dwelling lifestyle. The **dorso-ventral flattened bodies** are usually hidden in sand or mud or disguised with cryptic coloration.

Locomotion is provided by **greatly enlarged pectoral fins**. The **gill slits are located ventrally** and oxygen-rich water is taken in through the **dorsal spiracle** rather than through the mouth. This keeps sand from being trapped in the delicate gill tissues while the animal is buried.

## Station 16

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Chondrichthyes

**Subclass:** Holocephali

Holocephalans include the **chimaeras**, ratfish, and elephant fish. They are deep-sea fishes and thus, very little is known about them.

The gill slits are covered by a **fleshy operculum** and the **spiracle is lacking**. The **head region is enlarged**. Unlike sharks, the **notochord is large** and **vertebrae are poorly developed**. Chimaeras have **naked skin** (that is, it is not covered with scales or other dermal armor). A **diphycercal tail** is used for locomotion.

## Station 17

Phylum Chordata

Subphylum Vertebrata

Class Osteichthyes

Osteichthyes literally means "**bony fish**". Most vertebrate species and individuals belong to this class. Although an amazing variety of forms have evolved in Osteichthyes, all possess a **bony operculum** covering the external gill slits, a partially or completely **ossified skeleton** and either **lungs or a swim bladder**. Bony fishes usually have obvious **scales** that are of dermal origin.

## Station 18

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Osteichthyes

**Subclass:** Acanthodii

These **extinct jawed fishes** were generally small, **fusiform**, and **unarmored** except for **small scales**. They are sometimes called "**spiny sharks**" because many had several pairs of ventral spines. The evolutionary relationships of Acanthodii and even of Placodermii to later jawed fishes is uncertain. Acanthodii may have been ancestral to the later jawed fishes, and they are sometimes placed in Osteichthyes because they both have a bony operculum.

## Station 19

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Osteichthyes

**Subclass:** Actinopterygii

**Ray-finned fish** are the larger and more diverse group of bony fishes. Their name comes from their fan-shaped paired fins, whose delicate **fin rays are supported by basal skeletal elements in the body wall**. Ray-finned fish are also characterized by **external nares** that end in closed olfactory sacs rather than leading into the pharynx.

The **swim bladder** is present and functions in buoyancy and balance.

## Station 20

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Osteichthyes

**Subclass:** Actinopterygii

**Order:** Chondrostei

These fish are thought to retain many features of **ancestral bony fish**. Most are extinct except for the **bichirs** (Family Polypteridae), **sturgeon** (Acerpenseridae) and **paddlefish** (Polydontidae). All have a spiral valve in the intestine and a **heterocercal tail**.

Bichirs have retained the **spiracle, lungs, and a bony skeleton**.

Sturgeon and paddlefishes have **lost or reduced dermal scales** and the skeleton is cartilaginous. Note they are derived from bony fishes so the cartilaginous skeleton is a derived, not an ancestral, condition.

## Station 21

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Osteichthyes

**Subclass:** Actinopterygii

**Order:** Holostei

Holostean fishes were most diverse in the Mesozoic but only two genera remain in North America. The **gar pikes** (*Lepisosteus*) and the **bowfin** (*Amia*) have a **bony skeleton** and a **skull that retains many ancestral features**. In addition, *Lepisosteus* has retained well-formed primitive **ganoid scales**.

## Station 22

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Osteichthyes

**Subclass:** Actinopterygii

**Order:** Teleostei

These are the "modern" fishes, which are the most common fishes in nearly every aquatic environment. Their anatomy is extensively derived compared to the preceding groups of Actinopterygii.

The skeleton is mostly or completely **ossified** and the **tail is homocercal**.

## Station 23

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Osteichthyes

**Subclass:** Sarcopterygii

These are the **lobe-finned fishes**. Two orders still exist today: the Crossopterygii (coelacanth) and the Dipnoi (lungfish).

Sarcopterygii are characterized by the **prominent fleshy lobes that extend into the paired fins** and **contain part of the fin skeleton**. The **nostrils open into the pharynx**. A swim bladder is present, but is bi-lobed and functions in respiration. Lobe-finned fish also have **clavicles**, a bone that was retained in most tetrapods, which descended from this group of fish.

## Station 24

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Osteichthyes

**Subclass:** Sarcopterygii

**Order:** Dipnoi

Although once a structurally and taxonomically diverse order, living **lungfish** are divided into just **three genera**. The Dipnoi were named for their **lungs**, which they use to respire in air. Although living lungfish retain many ancestral features (such as lungs for air-breathing, an **intestine** with a **spiral valve**, and **nasal cavities** that communicate with the mouth cavity), they have changed greatly in form since their origins and resemble amphibians to some extent.

## Station 25

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Osteichthyes

**Subclass:** Sarcopterygii

**Order:** Crossopterygii

Believed extinct since the Mesozoic, the discovery in 1939 of a crossopterygian living in the depths of the Indian ocean, the **coelacanth**, *Latimeria*, was among the most remarkable scientific finds of the century. The order contains the suborders Coelacanthiformes and **Rhipidistia**. The latter group **gave rise to the tetrapods** and for that reason, it is important in our own evolutionary history.

## Station 26

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Amphibia

Amphibians develop from an egg to an adult by one or several steps. All species except for neotenic species such as the axolotls and mudpuppies **metamorphose** from the larval form to the adult. **Neotenic** species retain larval characteristics for life, but are able to reproduce without ever metamorphosing to the adult form.

Amphibian skin is designed for life in a moist or aquatic environment. It is covered with **mucoïd secretions** to slow evaporation and also to help the **skin respire**. Any **scales present are dermal** in origin.

The skeletal system shows a variety of modifications, from the enlarged skulls and hind limbs of the frogs, to a complete lack of limbs in the caecilians. All amphibians have only **one cervical and one sacral vertebra**.

## Station 27

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Amphibia

**Subclass:** Labyrinthodontia

Labyrinthodonts were the **first terrestrial tetrapods but are now extinct**. They were often large, heavily-built animals with **pelvic and pectoral girdles modified for life on land**. The **ribs** were also strengthened to **support the thorax**, which now functions in respiration. The exhibit shows a cast of a fossilized labyrinthodont skull with **bony dermal plates**, which, along with **ventral plates, served as armor**.

## Station 28

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Amphibia

**Subclass:** Lissamphibia

**Order:** Anura

The **lissamphibians** are the living amphibians.

Order Anura includes the **frogs and toads**. **Adults lack tails and external gills**. The **mouth is large and extremely wide**. **Hind-limbs are adapted** for jumping, swimming or climbing.

## Station 29

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Amphibia

**Subclass:** Lissamphibia

**Order:** Urodela

This order includes the **salamanders and newts**. They are characterized by their **small, weak limbs**, and by the presence of a **tail**. Tadpoles have **external gills**, which may be retained in neotenic forms, such as the **mudpuppy** (*Necturus*).

## Station 30

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Amphibia

**Subclass:** Lissamphibia

**Order:** Apoda

Order Apoda includes the **caecilians**. These are legless amphibians, superficially resembling large worms. **Limbs and limb girdles have been lost** and the **eyes are small and embedded in the skin**. These are adaptations for a life spent almost entirely underground.

## Station 31

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Reptilia

**Reptiles** are distinguished from amphibians by several characters. They have **at least two cervical vertebrae**. Modern forms also have **two sacral vertebrae**. In the skull, a **secondary palate** has formed, separating the nasal cavities from the mouth. This lets the animal chew without suffocating and expands the dietary range beyond small and easy-to-swallow prey.

The skin is dry and covered with **epidermal scales**. Unlike the scales of a fish, reptilian scales are formed by folds in the skin and cannot be lifted off without tearing the skin. Crocodilians and turtles use plates of dermal bone beneath the skin to provide extra protection.

Another key to the success of reptiles is the evolution of an **amniotic or cleidoic egg**. Reptiles and their descendants are therefore called **amniotes**.

Together with their tougher skin, the amniotic egg freed reptiles and their descendants from a strict dependency on water, allowing them to exploit a wider variety of niches.

## Station 32

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Reptilia

**Subclass:** Anapsida

**Order:** Captorhinida

The first reptiles are referred to as **stem reptiles**. They were very similar to **extinct ancestral amphibians** and had only a few derived characters. During their relatively brief existence, the stem reptiles gave rise to six different subclasses or superorders, including all of the reptiles alive today. The Subclass **Synapsida** (mammal-like reptiles) **gave rise to modern mammals** and the Superorder Archosauria, which includes dinosaurs, **gave rise to modern birds**.

## Station 33

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Reptilia

**Subclass:** Anapsida

**Order:** Chelonia (**Testudines**)

The chelonians are the **turtles and tortoises**. Their heavy skull lacks any temporal fenestra. Turtles and tortoises have strong jaws **lacking teeth**. The characteristic shell, or **carapace**, is made of **plates of dermal bone**, overlaid with **keratinized epidermal scutes**. The skeletal system is partially fused to the carapace, and the organ systems are modified as well.

## Station 34

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Reptilia

**Subclass:** Diapsida

**Order:** Rhynchocephalia

Only **one genus** from this order survives today. The **tuataras** (*Sphenodon spp.*) of New Zealand are endangered **ancestral, lizard-like** reptiles. Like their ancestors, tuataras retain a **pineal eye**. **Gastralia** (abdominal ribs that do not articulate with the vertebrae) are present.

## Station 35

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Reptilia

**Subclass:** Diapsida

**Order:** Squamata

This order is the dominant group of reptiles living today. Their anatomy is often highly derived and allows for adaptation to a wide variety of terrestrial and aquatic environments. However, **gastralia (ventral abdominal ribs) are lacking** in this group.

Suborder Serpentes (a.k.a. Ophidia) - **snakes**

Suborder Sauria (a.k.a. Lacertilia) - **lizards**

Suborder Amphisbaenia - **worm lizards**

## Station 36

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Reptilia

**Subclass:** Diapsida

**Order:** Crocodylia

The **crocodilians** are a successful group of generally large reptiles, most closely related to dinosaurs and birds. The **brain is well-developed** and allows for **complex parental care**.

**Gastralia are present** in this group. The thick, rough skin is reinforced with internal **plates of dermal bone**.

## Station 37

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Aves

**Birds** are a highly successful group of vertebrates. Unlike the reptiles and amphibians, birds have developed **homeothermy**, the ability to maintain a constant elevated body temperature, which allowed them to adapt to colder environments.

Birds are characterized by the presence of **feathers**, a **syrix**, epidermal **scales on their legs** and a **horny beak** lacking teeth. Like reptiles, birds lay **amniotic eggs**.

There are two major groups of birds. **Palaeognathae**, the flightless birds, such as **ostriches, emus and kiwis** possess a **sternum that lacks a keel** for the attachment of flight muscles. **Neognathae** include all flying birds and penguins. The **sternum has a ridge-like keel** to provide support for flight muscles.

## Station 38

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Mammalia

**Mammals** are characterized by **hair**, **mammary glands**, a **four-chambered heart**, and a **diaphragm**. Moreover, the evolution of a **secondary palate**, muscular **tongue**, and **heterodont dentition** with limited tooth replacement permitted the mastication of food and thereby the exploitation of fibrous vegetarian or very large food or prey items. Like birds, mammals are **homothermous**.

## Station 39

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Mammalia

**Subclass:** Prototheria

**Order:** Monotremata

The **monotremes** include the **duck-billed platypus** and the **spiny anteaters (echidna)**. They retain several reptilian characteristics such as shelled, **amniotic eggs** and a **cloaca**. Males have **spurs** on the hind feet; the spur is non-functional in echidnas but contains a powerful **venom** in the male platypus. The **mammary glands** are little more than pores that secrete milk, unlike the specialized teats or nipples of other mammals. Additionally, monotremes express extra bones in the pectoral girdle, including an **interclavicle**, which are not found in other mammals.

## Station 40

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Mammalia

**Subclass:** Theria

Therians are **viviparous (livebearers)**. The mammary glands have either **nipples or teats**. Therian mammals (marsupials and placentals) are the only tetrapods which never have an **interclavicle**. Unlike the monotremes, whose basal temperature can fluctuate widely, therians have well-developed **homeothermy**.

## Station 41

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Mammalia

**Subclass:** Theria

**Infraclass:** Metatheria

These are the **marsupials**, such as kangaroos, koalas and opossums. A **prepubis** (or marsupial bone) supports the **marsupium**, in which the young develop after being **born at an extremely early stage of development**.

The **mandibles** of marsupials have an **inflected lower angle**, as well as up to 50 teeth, including a **maximum of 18 incisors**.

## Station 42

**Phylum:** Chordata

**Subphylum:** Vertebrata

**Class:** Mammalia

**Subclass:** Theria

**Infraclass:** Eutheria

These are the **placental** mammals. A **true placenta**, developed from embryonic and maternal tissues is present. Placentals have 44 teeth at most, with **no more than 12 incisors** total. The **coracoid is retained only as a process on the scapula** (see handout 4) - as in marsupials but not as in monotremes.