

CHARACTERS USED TO PLACE VERTEBRATES INTO MAJOR GROUPINGS

BACKGROUND

Vertebrates are in the kingdom Animalia. They belong to Vertebrata, a subphylum of the phylum Chordata. Interestingly, the evolution of vertebrates also involves a water to land transition. The land vertebrates are distinguished, to some degree, by the features that mark this transition. Traditionally, we divided vertebrates into fish (classes of fish include the jawless, cartilaginous, and bony fish), amphibians, birds, reptiles, and mammals. More recently, there has been a reorganization to classify birds as a subgroup of reptiles. Most scientists agree that the reptile clade includes the tuataras, lizards, snakes, turtles, crocodilians, birds, and the extinct dinosaurs. For the purposes of this activity, we will consider the various subgroups of reptiles and their characteristics (crocodilians, birds, lizards/snakes (we will include tuatara in this group keeping in mind that it is usually classified separately), and turtles. Whenever possible, you should base your judgment of the vertebrate class's possession or lack of a character on the more abundant representatives of that vertebrate group. For example, although monotremes (echidna and platypus) lay eggs, most mammals bear live young.

CHARACTERS IN VERTEBRATES

Gait: In a sprawling gait, legs are held out away from the body sideways with elbows and knees permanently locked. In an erect gait, legs are held under the body. Erect gait is considered the advanced condition allowing for longer strides and bipedality. An erect gait also allows for the development of larger animals with large body masses. Think of an elephant trying to move with its belly dragging on the ground. See Figure 1.

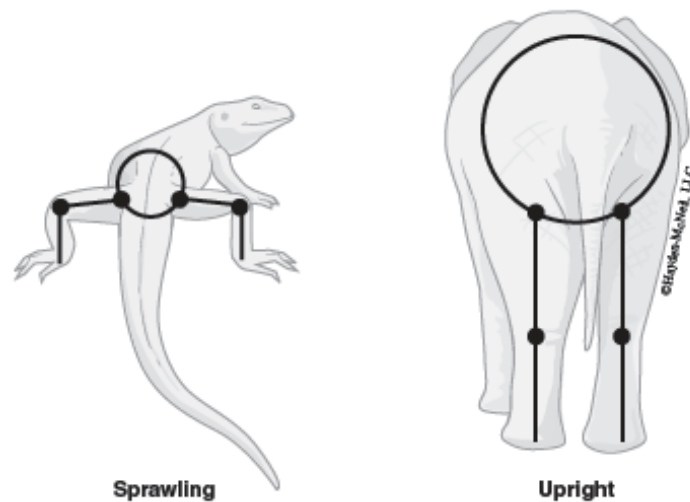


Figure 1. Gait

Reproduction: Most members of the vertebrate group either lay eggs or bear live young.

Amniotes: These groups will have an **amnion** and **extraembryonic membranes** such as allantois and chorion. In mammals it is the chorion and allantois that contribute to the placenta, so humans are amniotes, although these membranes take on different functions in Mammalia than in Reptilia and Aves. Egg A (Figure 2) is the type of vertebrate egg found in aquatic species such as frogs and fish. Egg B (Figure 2) is the type of egg adapted for terrestrial environments having sacs (membranes) for support, respiration, and for storing waste. Organisms such as reptiles and birds that have this type of egg are known as amniotes.

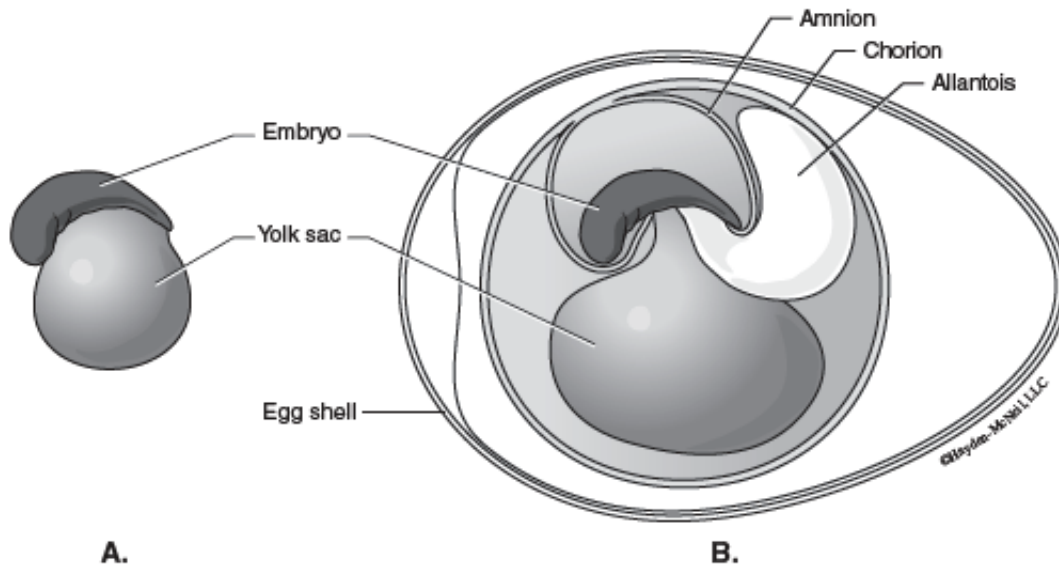


Figure 2. Comparison of a Non-amniote Egg (A) and an Amniote Egg (B)

Skull type: In the vertebrate line, skulls have become less flat, with additional “openings,” or fossae, to allow jaw muscles to pass through before attaching to the top of the skull (see Figure 3). This gives more room for jaw muscles and allows for greater jawbone elaboration. Vertebrate skulls of amniotes are classified as:

- A. **anapsid:** no additional openings right behind eye openings, for example, turtles.
- B. **synapsid:** one additional opening right behind each eye opening, for example, mammals.
- C. **diapsid:** two additional openings right behind each eye opening, for example reptiles.
- D. **modified diapsid:** same as diapsid, but the openings have merged, for example birds.

Refer to images on the lab website and in **Appendix F (the lab photo index)**.

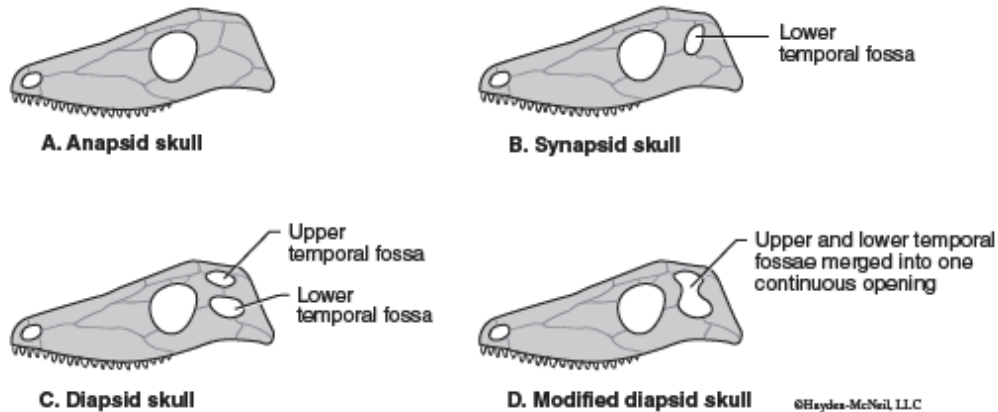


Figure 3. Skull Types

Because skull openings have been modified in many extant species, the number of openings is sometimes difficult to quantify. For example, mammals are descended from synapsid ancestors. The location of the ancestral opening is still visible, but it is no longer a hole in the skull in most.

Temperature regulation: Animals are classified as **ectotherms** or **endotherms**. **Ectotherms** maintain their core body temperature primarily by utilizing environmental heat. We have all seen turtles sun on logs. This behavior enables them to absorb heat and raise their body temperature above ambient temperature. **Endotherms**, in contrast, maintain their core body temperature mainly by regulating their metabolism. Among vertebrates, many endotherms may have higher metabolic rates than ectotherms and may maintain higher body core temperatures.

Body covering—feathers, scales, or hair: Both birds and reptiles have protective overlapping dermal or epidermal structures called scales. Some of the scales found on birds are like those found in reptiles, while others, although they look like reptilian scales, differ on the molecular level. Additionally, birds have feathers used for insulation and flight. Mammals, of course, have hair. An individual hair has two distinct parts: the hair follicle and the hair shaft.

Excretory product: The nitrogenous product excreted by a group may be **ammonia**, **urea**, or **uric acid**. When cells metabolize proteins, the amino acids, if not used to build proteins, are broken down. When broken down, the nitrogen-containing amino portion is a waste product that joins with hydrogen atoms to become ammonia molecules. Ammonia is toxic to cells at low concentrations. Animals may excrete ammonia or convert ammonia to urea or uric acid. The excretion of ammonia, for land animals, requires the most amount of accompanying water. Uric acid, of the three excretory products, is the most insoluble, and so requires the least accompanying water.

Heart Structures: The vertebrate heart has two types of chambers, atria (plural for atrium) and ventricles with interconnecting blood vessels (you will learn more about transport through the animal body during the transport lab unit). The atria are receiving chambers, which receive blood from either the body (oxygen-poor blood) or a respiratory organ like lungs or gills (oxygen-rich blood). The ventricles pump blood from an atrium to either the lungs or gills and to the body. The main role of the heart is to take oxygen-poor blood returning from the body's cells and pump it to a respiratory surface for oxygenation so it can be pumped back to the body as oxygen-rich blood. There are several variations of heart structures in vertebrates. Fish have only two

chambers, one atrium, which receives oxygen-poor blood from the body, and one ventricle, which sends blood to the gills. From the gills, the oxygenated blood circulates to the body and is at very low pressure. This is termed a single circuit circulatory system (see Figure 4). Amphibians and most reptiles have a three-chambered heart, two atria, and one ventricle. The right atrium receives oxygen-poor blood from the body and pushes it to the ventricle, which pumps it to the lungs for oxygenation. The oxygen-rich blood goes to the left atrium and then to the ventricle, which pumps it to the body (see Figure 4). Since the ventricle has both oxygen-poor and oxygen-rich blood, there is some mixing. This mixing may be minimized by the structures of the chambers in some groups of reptiles, for example. In amphibians, the skin is highly vascularized and helps oxygenate blood. Although the three-chambered heart is the start of a double circuit, the three-chambered heart is not as efficient as the four-chambered heart found in mammals, birds, and crocodilians. In these animals, there is a clear double circuit with two atria and two ventricles. The oxygen-poor and oxygen-rich blood supplies are kept separate, and the presence of a second ventricle and associated blood vessels allow for oxygen-rich blood to be pumped efficiently at high pressure long distances in the body (see Figure 4). Note that there are further adaptations in heart and blood vessel structures that are associated with the life history of the vertebrate species.

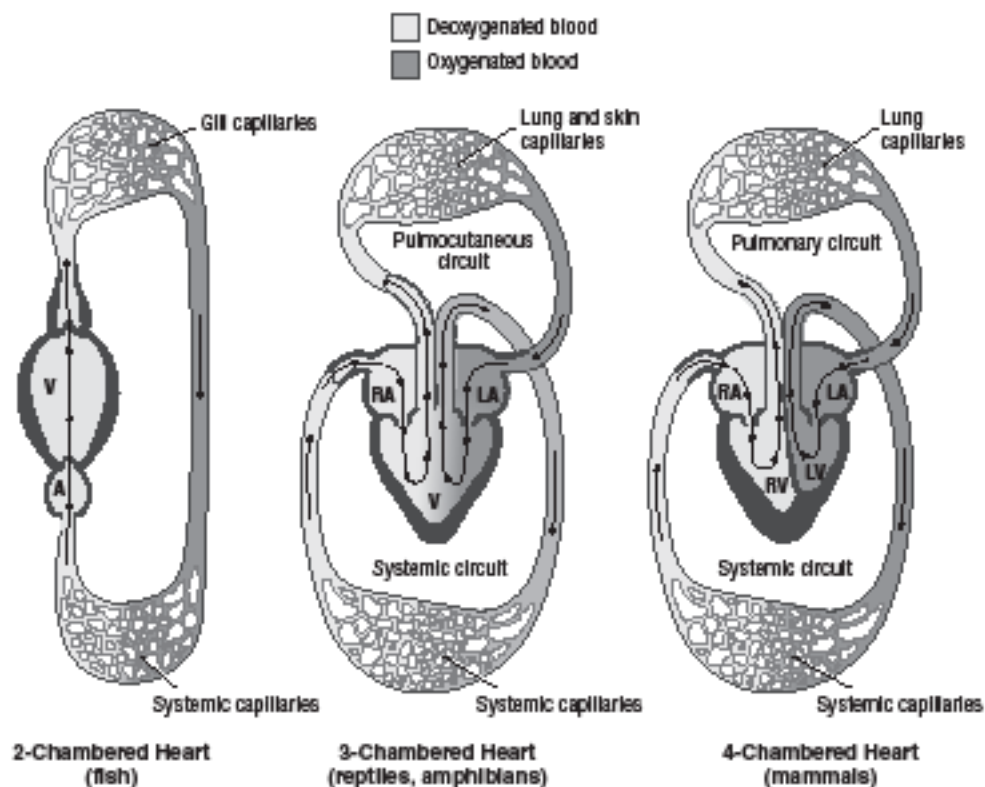


Figure 4. Two-, Three-, and Four-Chambered Hearts