Patterns in Time: Vertebrate Patterns

WHAT ARE THEY? You probably know that most animals familiar to you are **vertebrates**, and they can be divided into five classes: fishes, amphibians, reptiles, birds, and mammals. It's helpful to know what they have in **common** (vertebrate traits), and what makes them **different**. Your teacher may show you pictures and models or living examples of each group:

They all have a head and tail ends, vertebrae (spinal bones), dorsal nerve cord (spinal cord), and gill arches in their embryos (common to all vertebrates). **In addition**...

Fishes: have fins, gills and scales;

Amphibians: have four limbs, + lungs, and smooth moist skin, all teeth the same type, lower jaw with 3 bones, 1 ear bone;

Pre-Mammals: have four limbs, lungs, eggs with special membranes, different teeth types, lower jaw with decreasing number of bones, and increasing number of ear bones;

Mammals: have four limbs, lungs, + fur, eggs with special membranes, different teeth types, lower jaw with only one bone, 3 ear bones, and mammary glands;

Reptiles: have four limbs, lungs, + scaly skin, and produce eggs with special membranes; all teeth the same type, lower jaw with 3 bones, one ear bone.

Birds: have four limbs, lungs, + feathers, eggs with special membranes, and hollow bones.

ACCUMULATING TRAITS: A chart of these major vertebrate groups "**Accumulating Traits in the Vertebrate Fossil Record**" is provided, summarizing the general vertebrate traits plus the particular traits that distinguish each group. Be sure that you notice how each successive group (more recent in time) possesses the same traits as the previous group, PLUS a few modifications. In other words, in general, the different vertebrate groups appear to have *accumulated* their traits from previously existing groups over long periods of time.

It would be useful to find out how far back in time each group lived... in other words, can we say when each group first appeared in the fossil record? This can be tricky, but paleontologists have found features that are fairly unique to each group, and appear in their teeth and bones, and therefore in their fossils. For example, there are certain bones in certain patterns that are found in the skulls of mammals, but they are different in amphibians or reptiles.

Using those diagnostic features, paleontologists have found that the earliest **fish** fossils appear around **500 mya** (million years ago). Those fishes had no jaws and no bones, and certain ones live today in the form of lampreys and hagfishes. These are the agnaths, or "**jawless fishes**."

The first **jawed fishes**, appeared about 60 my later, about **440 mya**. That means that, for about 60 my, there were *no* fishes with jaws. Most of today's fishes have jaws: most have bones (teleosts, like salmon and perch) but many have cartilage instead (sharks and rays)

The oldest **amphibian** fossils begin to appear about **365 mya**, about 75 my after those first jawed fishes appeared.

Then, about 45 my later, we find fossils of the earliest **pre-mammals** (stem-mammals or synapsids) that began to appear, about **320 mya**. About 100 my later, these pre-mammals accumulated more and more mammal-like features, (passing through stages known as pelycosaurs, therapsids, then cynodonts). Eventually, true **mammals** appeared (about **220 mya**). The pre-mammals all became extinct. Note there are no true mammals prior to 220 mya, so there were **no true mammals** during the 280 million years when fishes, amphibians, and reptiles gradually emerged.

A little after the pre-mammals appeared, another group known popularly as the "**reptiles**" first appeared (**310 mya**). This entire group is more accurately known as "**sauropsids**." The earliest sauropsids to appear were anapsids, with some traits like modern day turtles and tortoises. Then, two other groups of sauropsids appeared: one with traits closest to lizards and snakes of today, and the other a widely diverse group that included the pterodactyls, crocodiles, and **dinosaurs**. About 226 mya, **therapsid dinosaurs** first appeared and many became increasingly bird-like. The earliest therapsid fossils showing feathers (now called **birds**) date back to about **150 mya**.

This is what the fossil record tells us quite clearly today. In addition, the earliest fossils in each group are preceded by fossils with intermediate traits (between the previous group and the newly-formed group), strongly suggesting that each group must have formed gradually from a previous group by gradual changes and modifications of some of the earlier traits. This pattern is repeated many times. You can see this in the **Animals of the Past** diagram displayed for you, and how connecting lines reflect those likely connections (see **Animals of the Past 2)**. The branches between reptiles and mammals represent the pre-mammal groups (pelycosaurs, therapsids, and cynodonts. The last cynodonts went extinct in the early Cenozoic, about 60 mya. In order to appreciate the huge periods of time between the times of emergence for each major group, review those distances on the TimeMap of your area (compared with a mm for 10 years).

Most importantly, notice the total absence of fossils for each group prior to their first appearance in the fossil record (their emergence). In the future, we may find fossils that shift the origin of a particular group back slightly (say a few million years - a few football fields back!), but it is now extremely unlikely that we'll ever find any modern-type mammal fossils that are older than about 220 million years. Out of the millions of mammal fossils that have been found, none are older than that. Be sure to remind your partners of this when you practice explaining the diagrams to each other.

PRACTICE: You should practice showing your partners how long ago the earliest member of each vertebrate group appeared by pointing to its scale distance-equivalent on the map, relative to the location of your school (using the scale of a 10-year period of your life as being 1mm). And use the **Animals of the Past** diagram to emphasize the **total absence of fossils** for each group prior to its first appearance, while you point out that slightly earlier fossils did have some features that anticipate their greater development into those major groups that we know so well.

Chronology of Fossil Vertebrates

Your teacher may also ask you to build a **Vertebrates Over Time** diagram. You will be given a page with a timeline going back to about 600 million years, with long horizontal lines marking every 20 million years. You will be asked to place a horizontal tic mark for the beginning time of each vertebrate group, starting with the oldest (Cephalochordates - at 530 mya) near the lower left hand corner, about 1 cm to the right of the numbers, then shifting about 2 cm to the right for each successive group (in time). (A chart with tic marks already in place might be provided to save time). In any case, draw a vertical line from each tic mark to the top line (present time), and label each vertical line with the name of that group. It should look something like a simplified version of the vertebrate portion of the **Animals of the Past** diagram. Finally, draw a dotted line from the lowest end of each vertical line, curving down slightly and over to the left, to the preceding vertical line. This shows the likely pathway through which each group most likely emerged over time, from the preceding group. Be sure to connect the "Reptiles" and "Pre-Mammals" to the "Amphibian" line, as that is what the fossils tell us. Likewise, connect the "Birds" to the nearby "Reptile" line.

Review this by taking turns explaining the **Vertebrates Over Time** to each other in your teams.