Name: ______________________________ Date: ______________

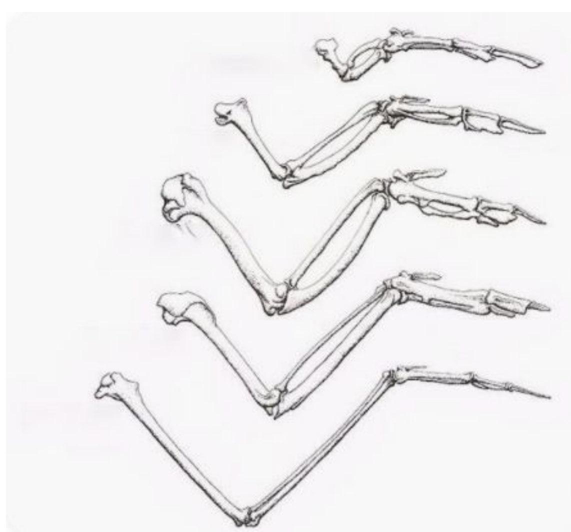
# How do scientists use fossils to figure out what an organism that lived millions of years ago may have looked like?

As scientists, if we want to know something about modern penguins, we can observe them. We can also take measurements of their bodies, watch their behaviors, and investigate their environments. We cannot do all those things with penguins, or any other organisms, that lived millions of years ago! Yet, scientists often try to visualize what organisms from long ago looked like based on measurements of the size and shape of a fossil. **How do scientists *know* all this just from looking at fossils?**

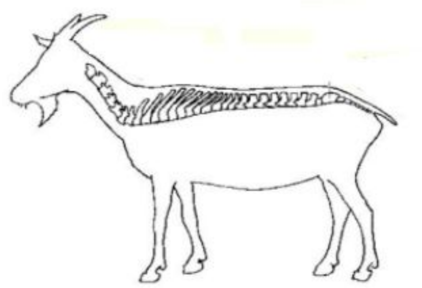
Think about the question in bold as you read further. As you develop an answer to that question, also think about what limitations there are on the conclusions we come to.

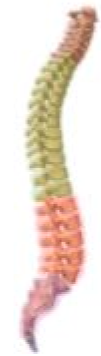
We know how fossils are formed. The process that turns the solid parts of organisms like bones, teeth, hooves, and shells into fossils creates a pretty accurate re-creation of the shapes and sizes of those original parts. Fossils can be directly observed and measured. Fossils are a good source of evidence about what those parts of organisms that lived millions of years ago looked like. But very few fossils represent complete skeletons. The bones are almost always disorganized in the rocks, and usually several pieces are missing.

To figure out what a whole skeleton of a fossilized organism would have looked like, scientists make comparisons with living, modern organisms. They know a lot about how skeletons are organized from observing and measuring modern organisms. The bones have certain specific shapes, and they fit together in certain specific ways. All birds' wings have similar bones that fit together in similar ways, even though there may be minor differences in the sizes or shapes of the bones in different birds.

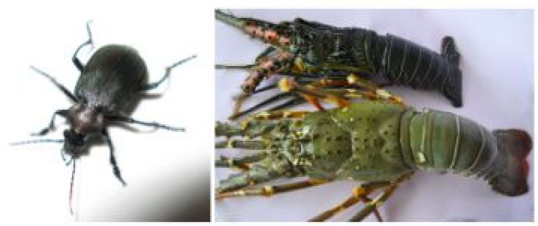


Some animals also have a backbone made up of vertebrae that fit together in a long column with each bone matching the shape of the bones next to it, sort of like a puzzle.





The segments of shells of many organisms like beetles and lobsters fit together in predictable ways based on their size and shape too.



If someone gave you a puzzle with some of the pieces missing, you would probably be able to put most of the puzzle together and then make predictions about what the missing pieces would likely look like and how they would be shaped. The more pieces of the puzzle you have, the better your predictions about the missing pieces would be. Based on our knowledge of skeletons of living organisms, we can figure out what bones are missing in a skeleton of a fossil and what they are likely to have looked like. As with a puzzle, this is easier to do if there are only a few pieces missing. This is why scientists are always very excited to find almost-complete skeletons in fossils (like Pedro!).

But this is still only bones. How do scientists know what size ancient penguins were based on only their bones? Again, they can make some predictions based on what they know about organisms alive today. For example, from a simple measurement of a femur bone we can make a pretty accurate prediction of the overall height of an organism.

For example, a mathematical model used in forensic medicine by scientists as far back as 1899 shows that there is strong linear association between femur length and a person's height. These are the equations that are used to predict the height of an individual (y) based on just the length of their femur (x):

For men: $y = 0.2610x + 44.201$

For women: $y = 0.2019x + 67.579$

Similar mathematical models exist for other organisms too, like penguins and horses. So if we know that a particular ancient penguin's femur is a certain length, we can use that to make predictions about its overall height. We can also do this for weight. This is based on having a mathematical model that describes the relationship between how much weight the bones of modern penguins support compared to the size and thickness of their bones. We also know that scientific principles like those that describe the relationship between weight and gravity or forces and distance were the same millions of years ago as they are today. So scientists can use those scientific principles to support their models for ancient penguins.

Fossil bones can also tell us how muscles might have been attached to those bones and how the overall limb functioned. For example, modern penguins with larger rib cages tend to have larger lungs. They also tend to have larger bones and more muscular bodies that enable them to hold their breath longer and to dive more deeply than smaller penguins. Scientists can use this relationship to make predictions that penguins with larger bones in certain parts of their bodies would have been able to hunt for food longer before coming up for air and would have been able to dive deeper into the sea when they did so.

Scientific artists use all this information to create reconstructions of what an ancient penguin probably looked like and where it was found. However, we cannot always be sure about the shapes of the soft parts of an organism's body or the color of its fur or plumage (except in some cases like Pedro's). Artists make decisions about these surface details based on the best scientific evidence they have, but they are still only guesses based on what we know about penguins living today. So not every artist's reconstruction of the same penguin fossil will look exactly the same:

Combining what is known about the structures of ancient penguins with other information about their fossils, we can even make some predictions about their interactions with their local environment when they were alive. We can learn what their local environment was like from the chemical content of the rocks where their fossils were found, the known climate that existed at the time they died, and the fossils that are found near them in the same layer of rocks they were found in. Fossils of plants, plankton, or microorganisms are especially helpful in determining what kind of environment they lived in. Putting all this information together, scientists can make predictions about what ancient organisms might have eaten and whether there were predators in the environments they bred or hunted in.

**Summarize, in the space below, what you figure out related to these two questions:**

- How can scientists determine some of the characteristics of an ancient organism since they cannot directly observe what that organism looked like when it was alive?
- What are some limitations on the conclusions they can make based on the data they have?