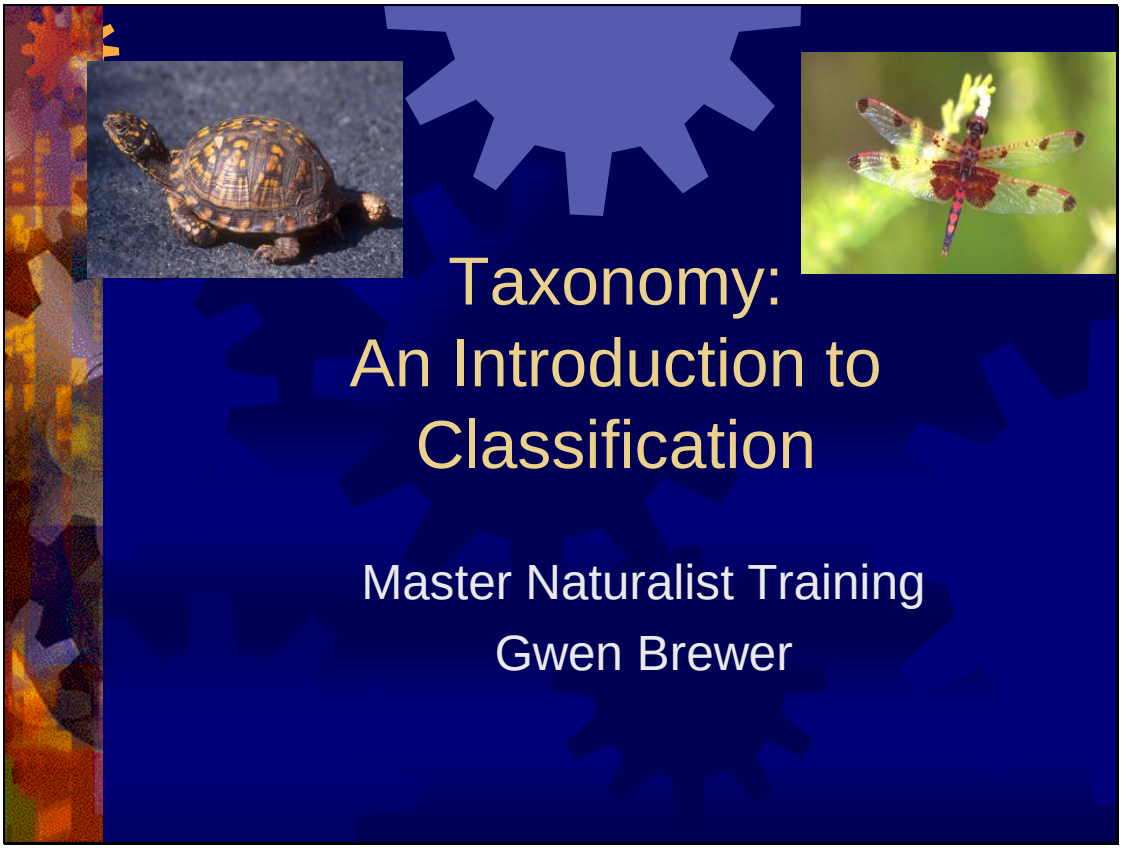
Unit 2: Taxonomy – Pre-Reading

Gwen Brewer
Slide 1



Welcome to the wonderful world of taxonomy! You will see that there are still plenty of controversies and things to be worked out in this topic area. This presentation will go over some definitions, a little history, characters and systems for classification, species concepts, and Kingdoms and their characteristics to whet your appetites for topic areas to come.

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The biological world contains an incredible amount of diversity. A few examples are pictured here. In order to communicate about these organisms and start to understand their relationships to one another, names are an important first step.

(Images not for use outside of presentation)

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We as humans have a natural tendency to want to understand and organize the world around us. These were skills that helped us to be successful through our evolution. As the former slide stated, we also need to name things to be able to communicate about them. By using a common language for scientific names (Latin), this communication is possible worldwide. One interesting thing to contemplate is how our basic worldview structures our classification system and how we order our world.

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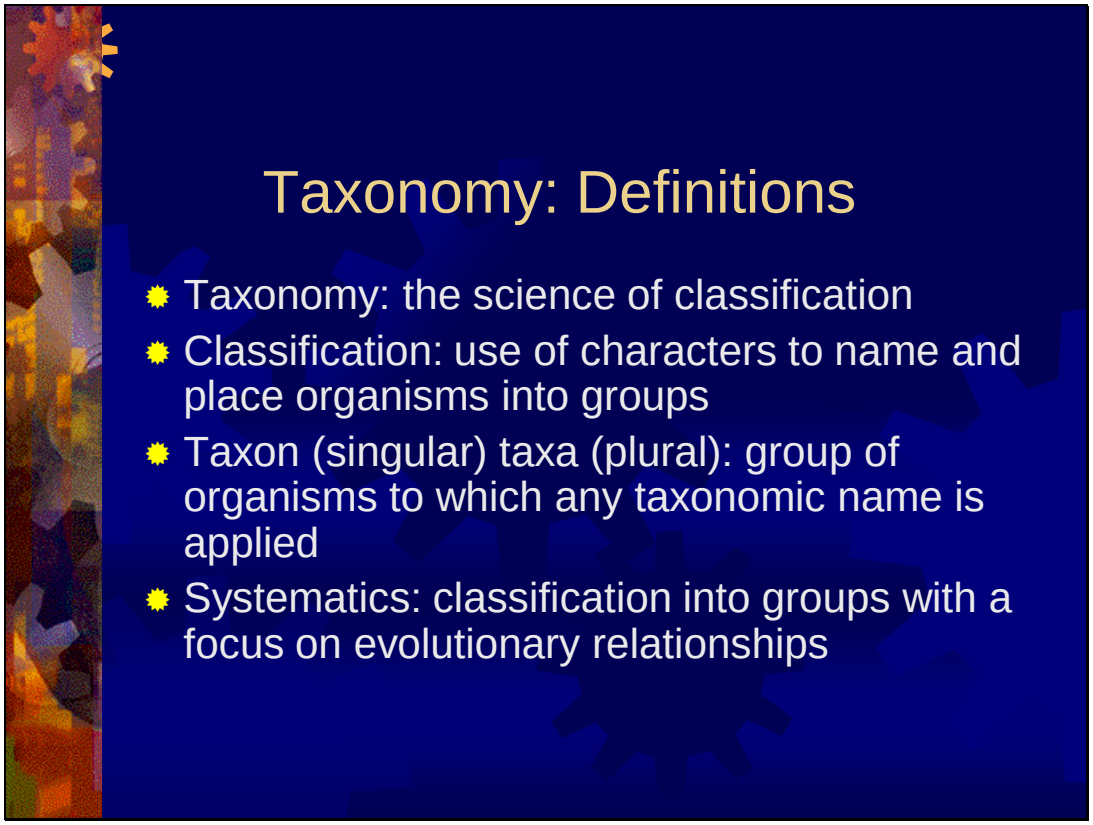

Time for some definitions- and there are plenty in this field. Like many scientific fields, this one just about requires you to learn a new language. Let's follow through these connected words.

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Now that we have a few terms under our belts, let's take a look back at classification systems past and present. The classification used today got its formal start with Linnaeus back in the early 1700's. Like others before him, he grouped organisms based on similarities that they shared- these could be external or internal characters. Linnaeus took information from his investigations and those of others and put it all into one large document, the Systema Naturae, and also used consistently a certain way of assigning names to species- a 2-part specific epithet with genus and species. Latin was the scientific language of the day, and Carl von Linne liked it so much that he Latinized his own name.

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The structure for naming and Latin convention of Linnaeus stuck. Species are still named using a binomial (two names) with the format described here. It is important to note that the name of a species must have these two parts. Type specimens are the individual specimens that represent the named species, often the first described individual given that specific epithet. Who is the type specimen for humans? Edward Drinker Cope. ICZN stands for the International Commission on Zoological Nomenclature.

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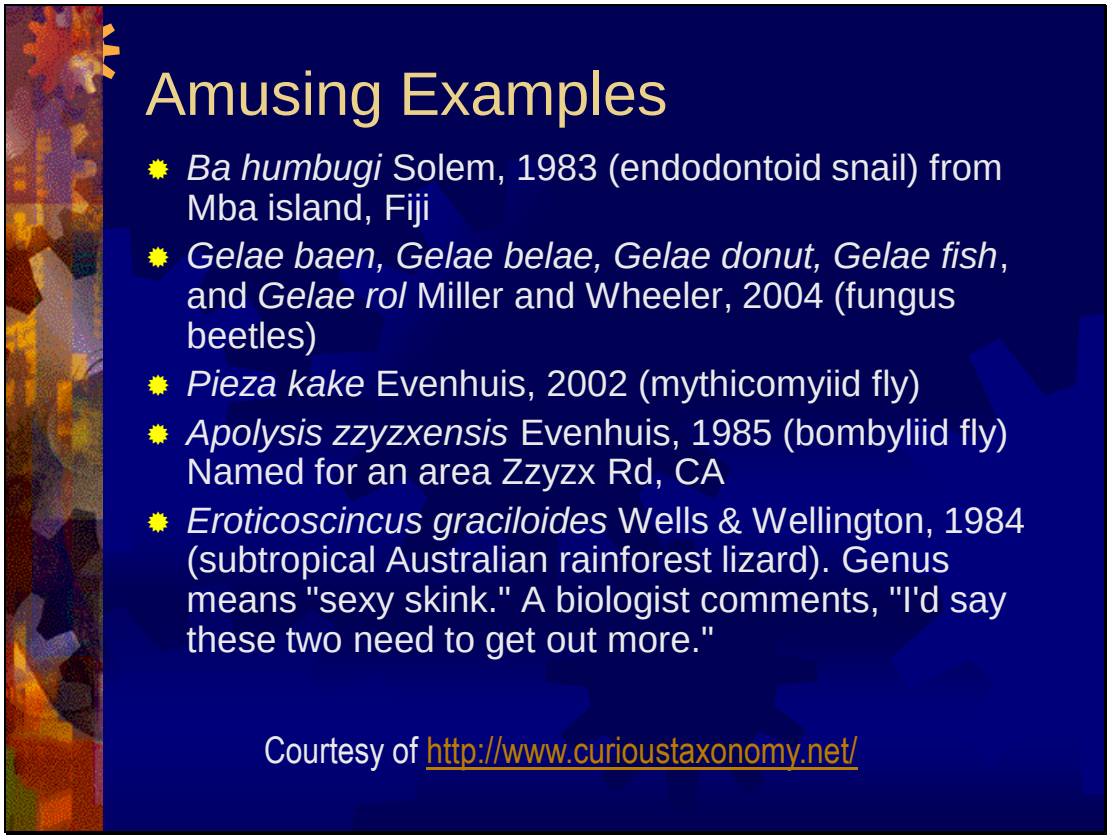

Some scientists spend too much time in a lab or under harsh conditions that seem to warp their sense of humor a bit. Here are some funny examples of real scientific names. A fun website with these and more is listed at the bottom of the page.

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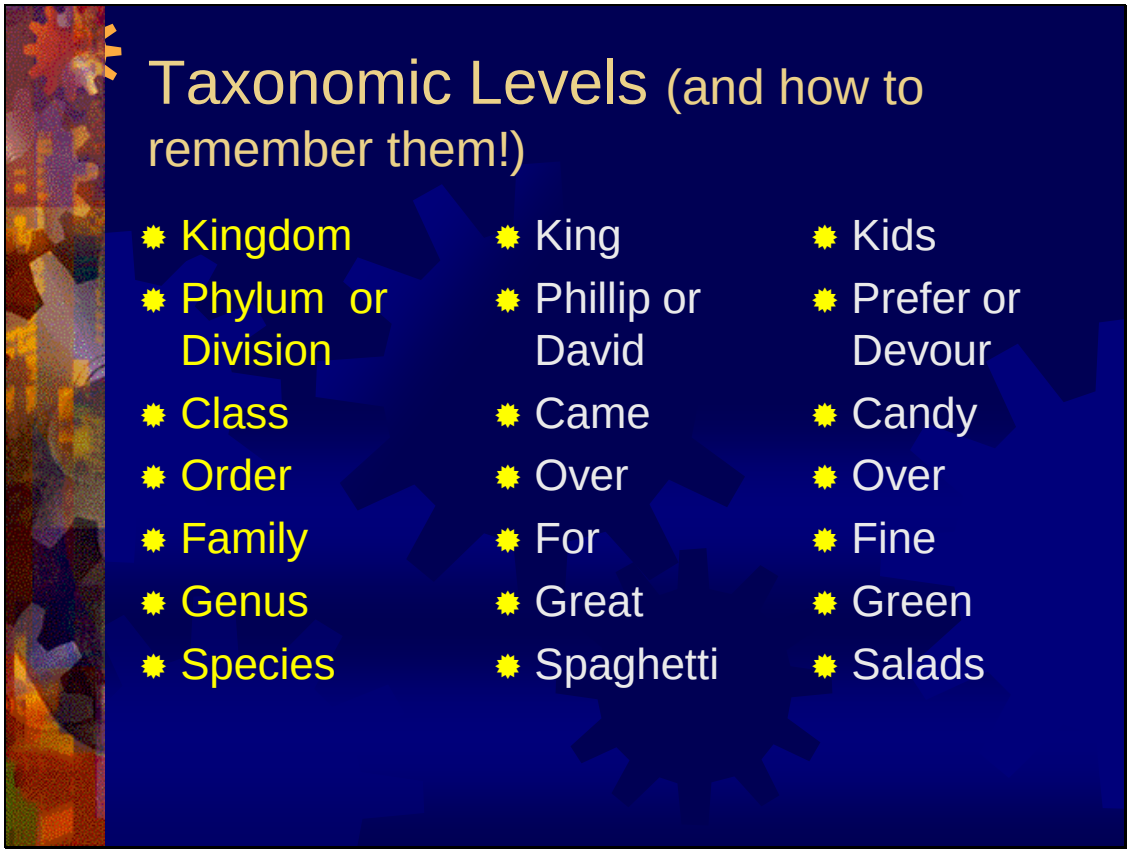

So far we have just looked at the genus and species levels of taxonomy. Higher levels of organization are also used to organize similar groups. Various mnemonics are used to remember this order- or make up your own. Phylum is used for animals and Division is used for plants.

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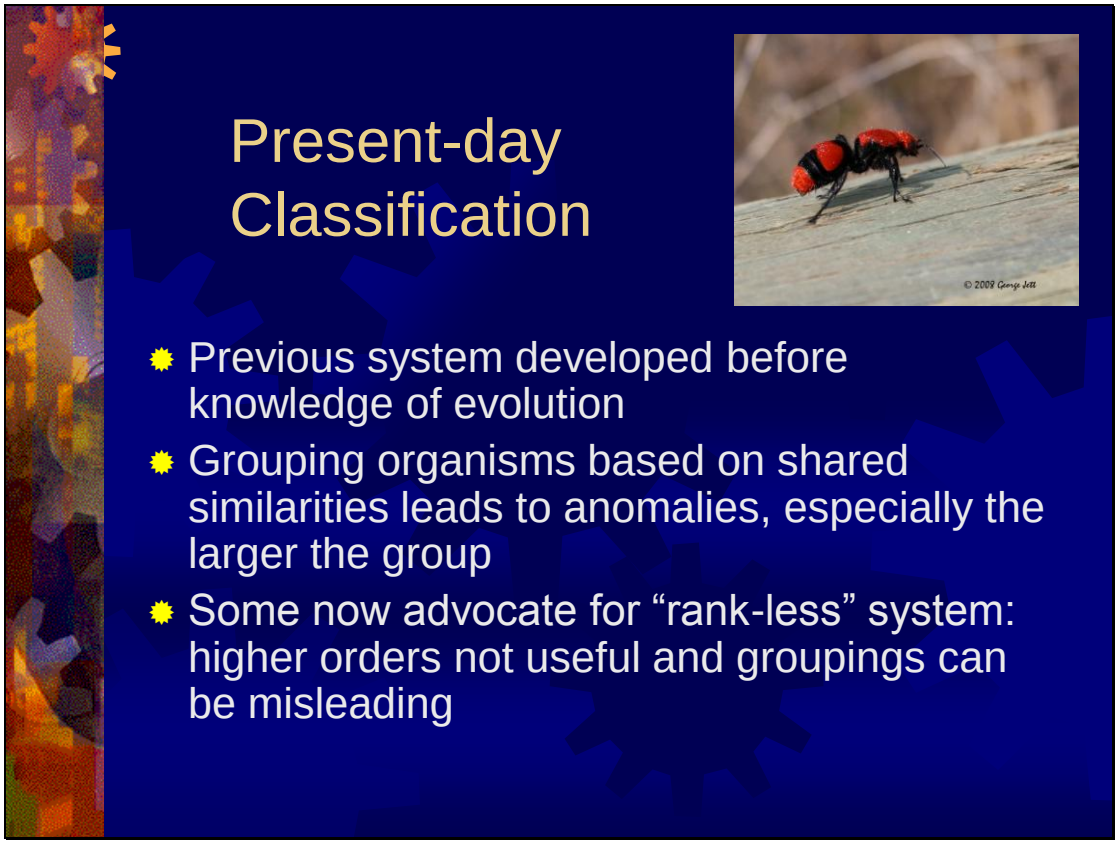

All that having been said, today we understand the world differently than in the time of Linnaeus. Specifically, we know how evolution has shaped the origin of new species. We also have a wider variety of characteristics to use to classify organisms. Genetic characters have largely changed the face of the science of classification and given us the focus on systematics-thinking about evolutionary relationships to classify organisms into groups and examine relatedness. The use of molecular information and focus on evolution has led some to conclude that groupings above genus and species are suspect and not useful.

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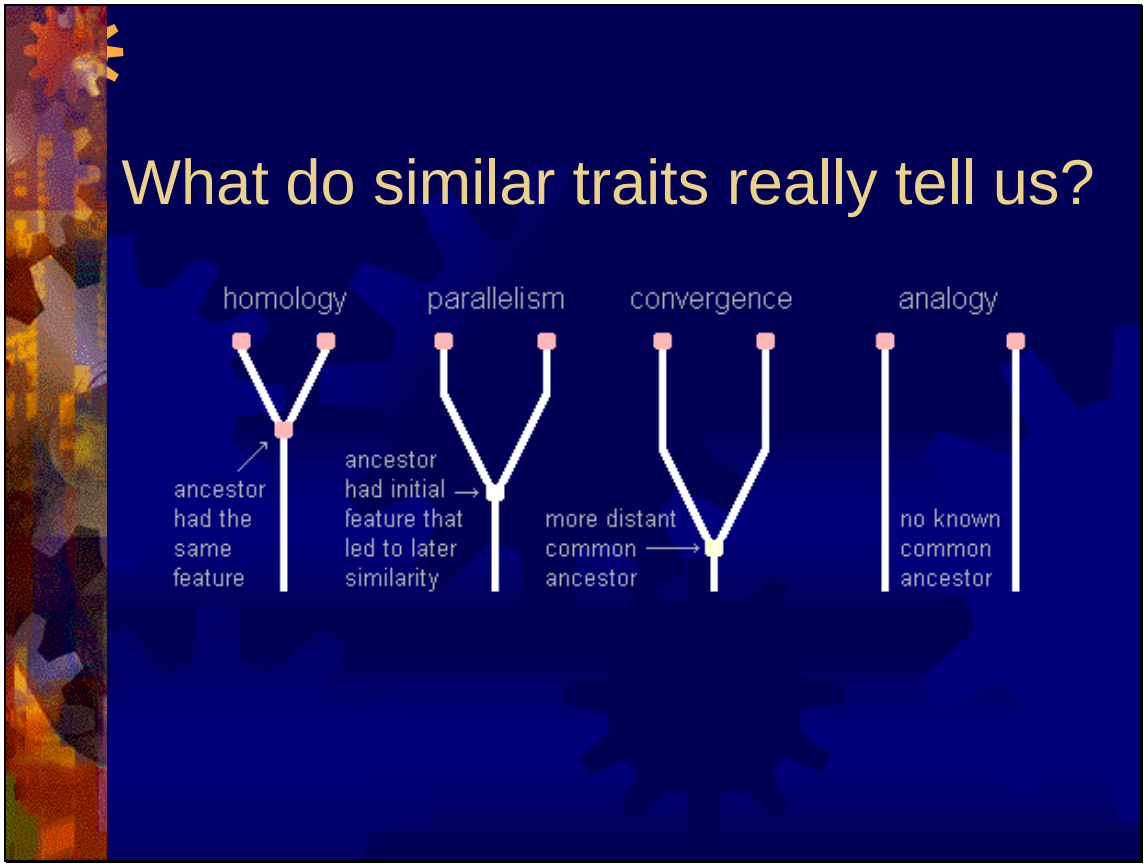

Let's take a closer look at this change in thinking about taxonomy, the science of classification. Here come some more terms! One challenge is the interpretation of characteristics. What does it really mean if organisms share similarities? Does that necessarily mean that they are closely related? This diagram illustrates several explanations for similarity in traits. Imagine that there is a time scale along the left side of the diagram. Traits may be similar due to ancestry or relatedness, but traits may also be similar when organisms respond to the same environmental pressures in the same way through time.

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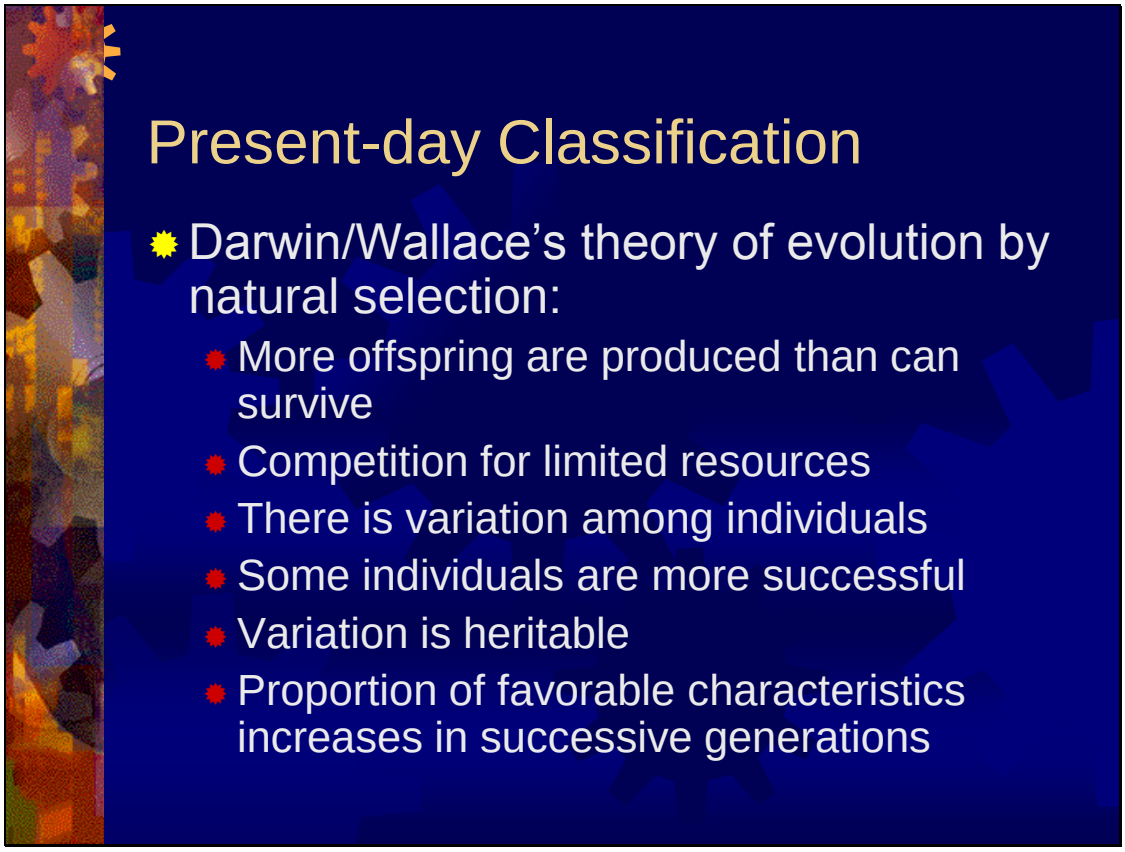

Taking a further look into what makes organisms similar or not, and the use of evolution as a basis for taxonomy, a review of evolutionary theory is helpful here. This is Darwin's and Wallace's basic formulation of evolution by natural selection, the most familiar pathway to evolution.

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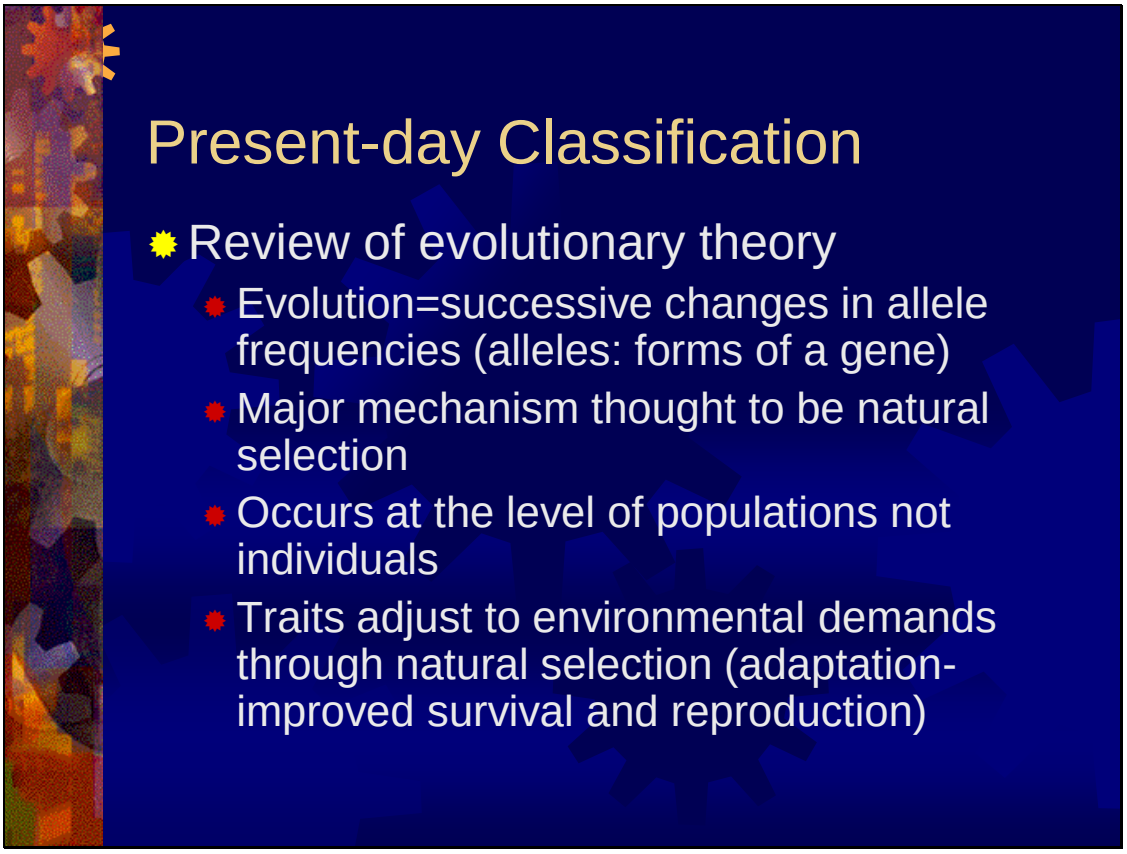

But what is evolution anyway? With our current understanding of molecular genetics, we view this a little differently than Darwin and Wallace did. One of the most important things to note about evolution is that populations evolve, individuals don't. "Survival of the fittest" doesn't quite capture evolution by natural selection either- the key is reproduction, not just survival.

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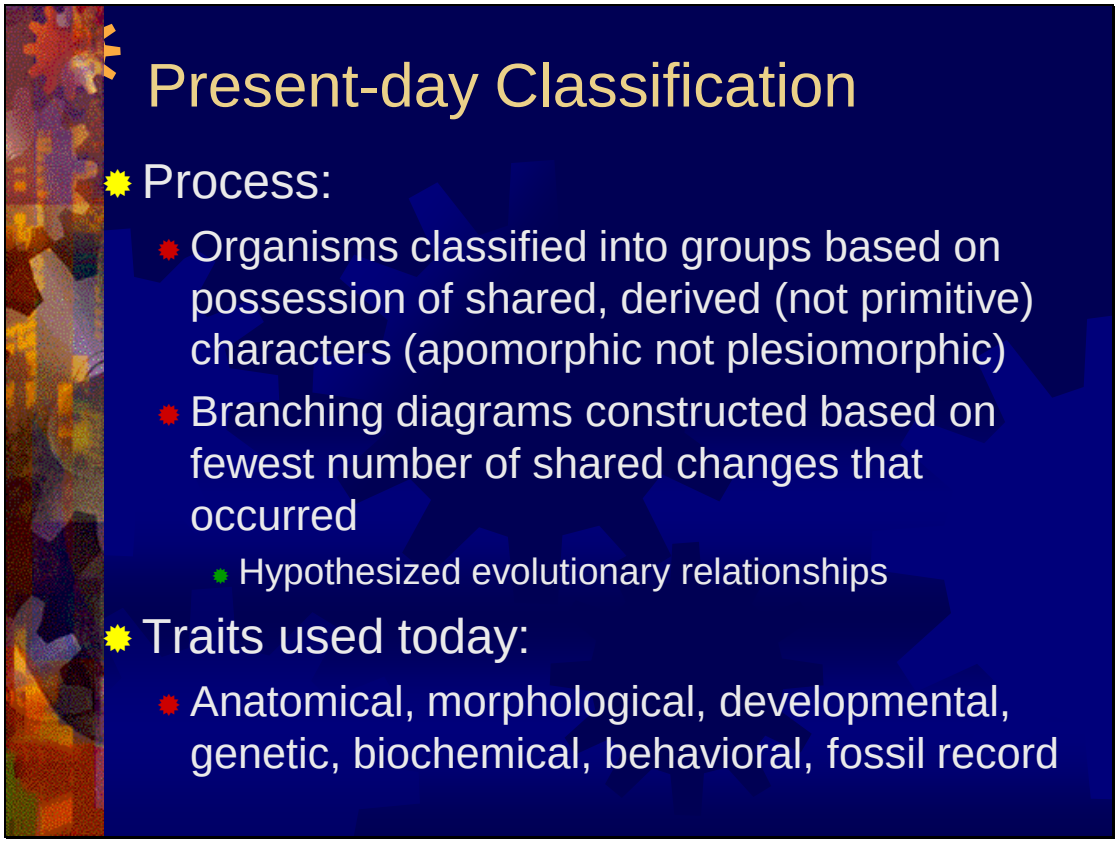

With a background of evolutionary theory, how do modern-day taxonomists work to classify organisms? The kinds of traits they look for are those that are both shared and derived. These traits are also referred to as apomorphic- apo: "from or away" from a "primitive" form (morph); opposite is plesiomorphic ("near" "form"). There are lots more terms to describe traits but I'll spare you!

These useful traits are put together into branching diagrams (similar to a family tree) essentially in the most simple way possible. This branching diagram then shows a set of hypothesized evolutionary relationships between the organisms. The traits can (and should) include a mixture of different types like those listed here.

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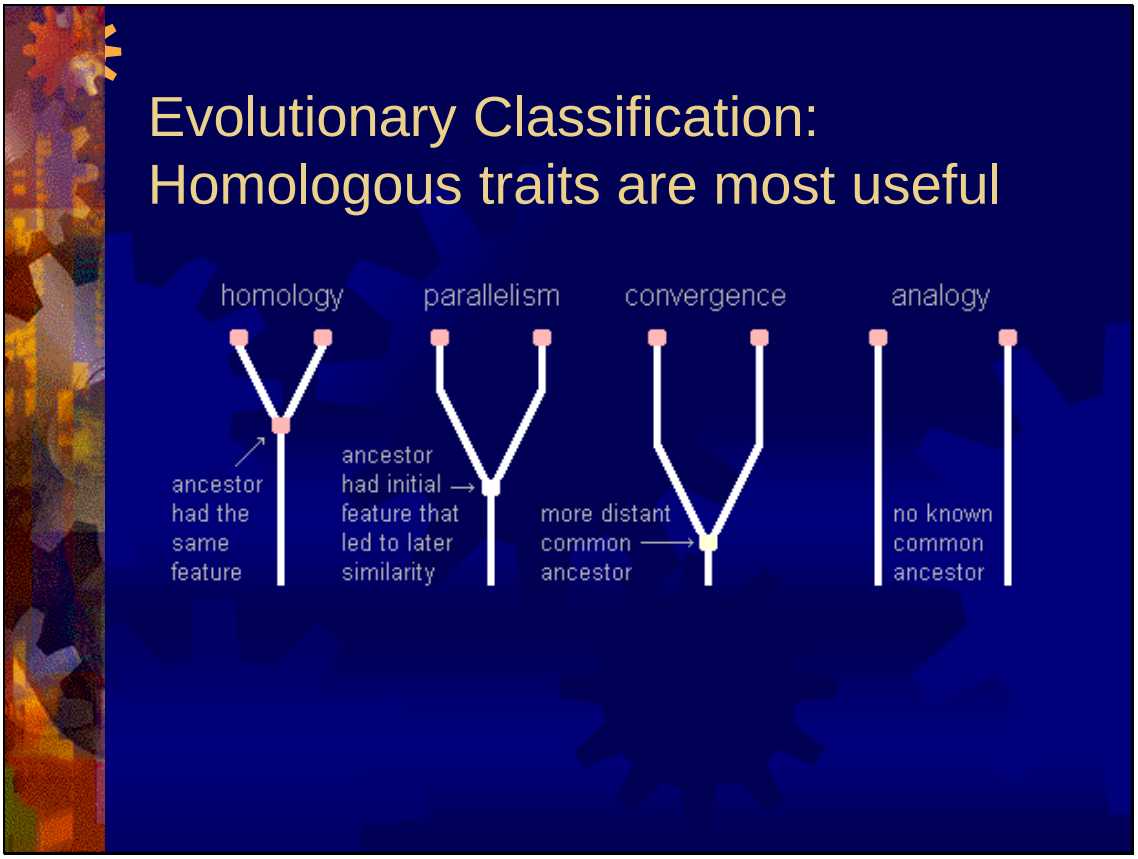

Going back to our look at what can make organisms have similar traits, we can identify that it is homologous traits that are the shared derived characters that taxonomists find most useful to reconstruct evolutionary histories. Can you see how the use of other kinds of traits could be misleading?

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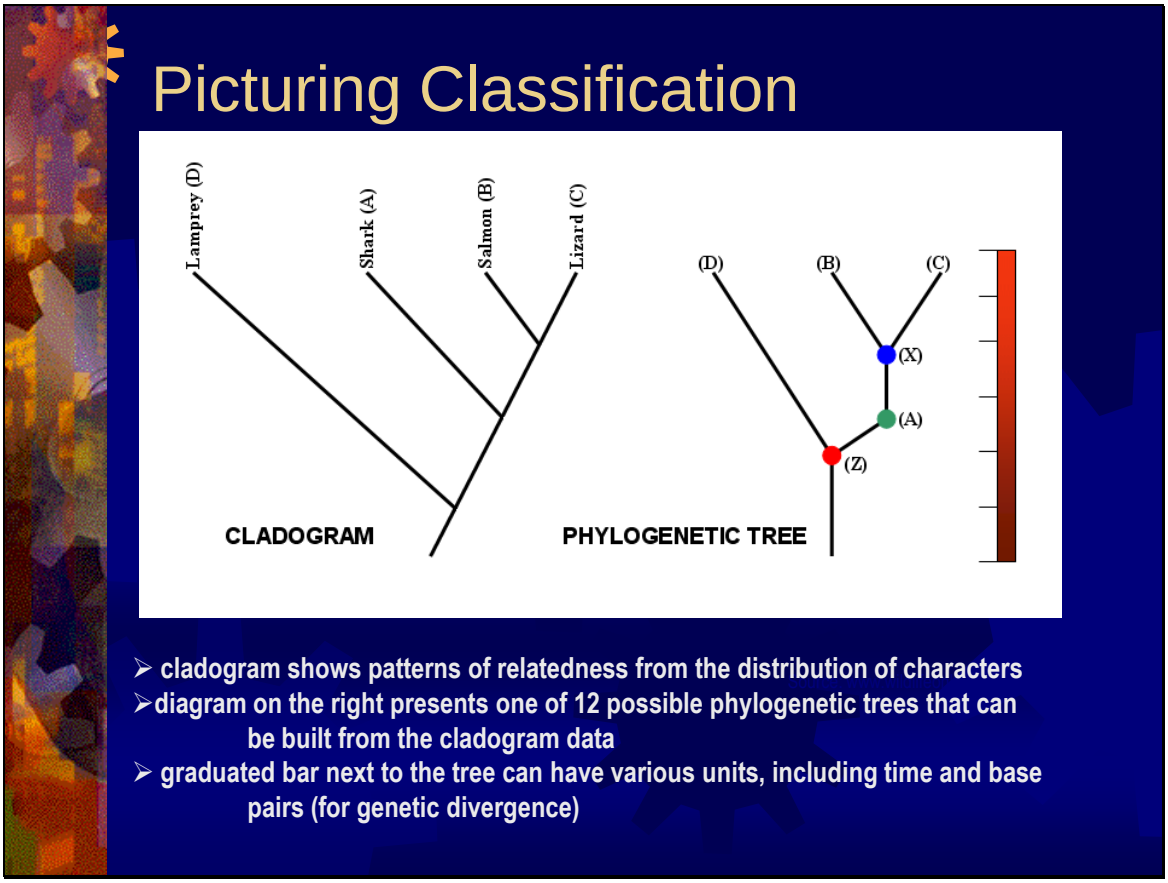

Phylogenetic trees have long been used to picture relationships. Note that the cladogram does not show the exact pattern of ancestry and that the phylogenetic tree includes a hypothetical ancestor (letter Z) and a hypothetical descendent (X).

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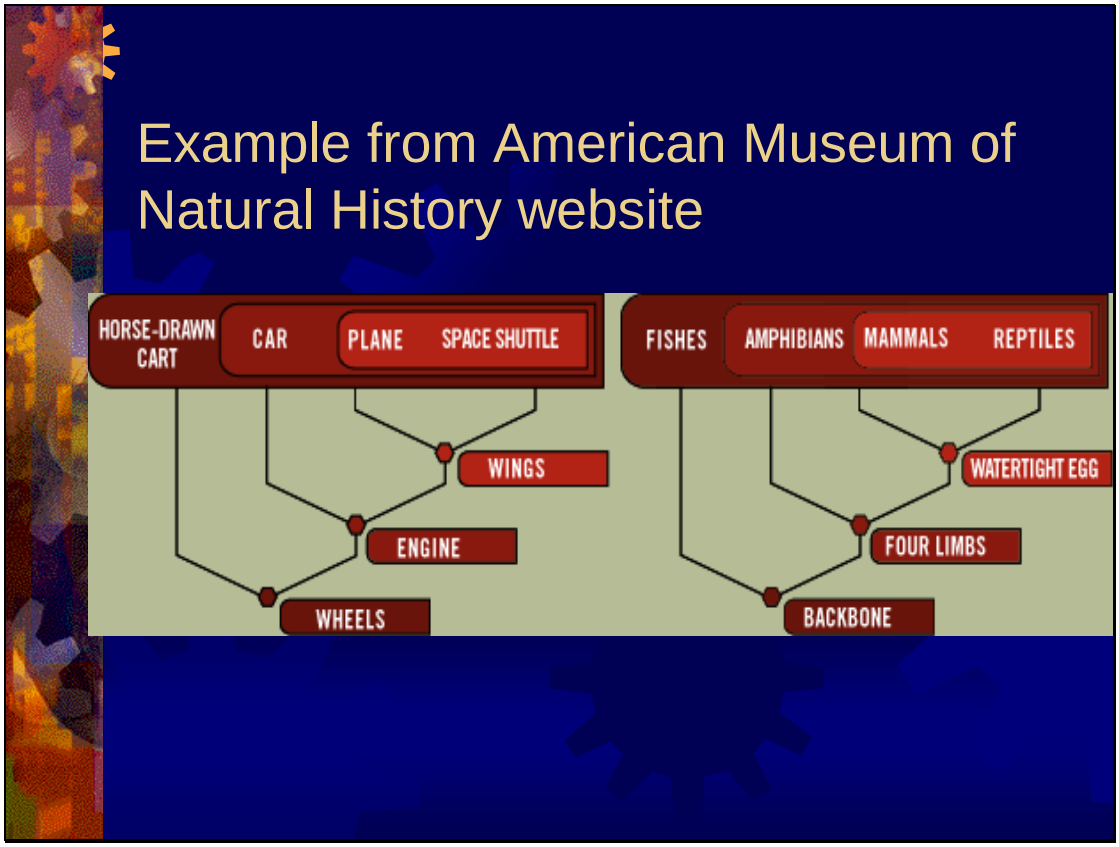

Here is an example from the AMNH website of the type of branching diagram that taxonomists use. Note that in these diagrams, we can picture time proceeding along the vertical axis and the number of shared characters increasing from left to right. The red nodes indicate a feature coming on the scene. All of the example objects/organisms appear at the same time level across the top since they are all still in existence today. Each object/organism has the characteristics of the node it branches off from and all of the nodes to its left. We will try our hand at constructing this sort of diagram during class time.

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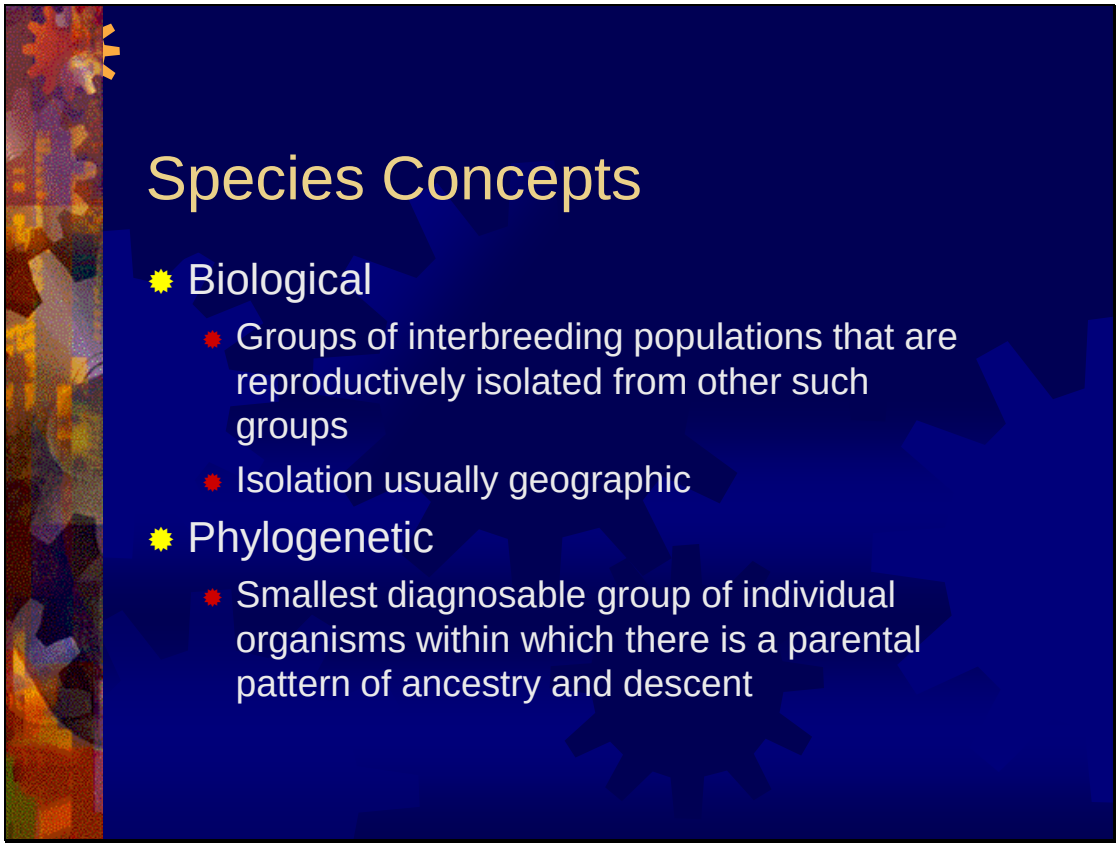

We now have some experience with thinking about taxonomy and classification at the higher levels of organization. Now let's take a closer look at species and how they are determined, then we will go back to the higher levels and look at some examples. This will set the stage for coming sessions in your Master Naturalist training.

Just like with classification in general, determining species has become less straightforward with our ability to use molecular characters. These two species concepts, or ways to define and identify species, are still the subject of scientific debate. Each has its merits and problems.

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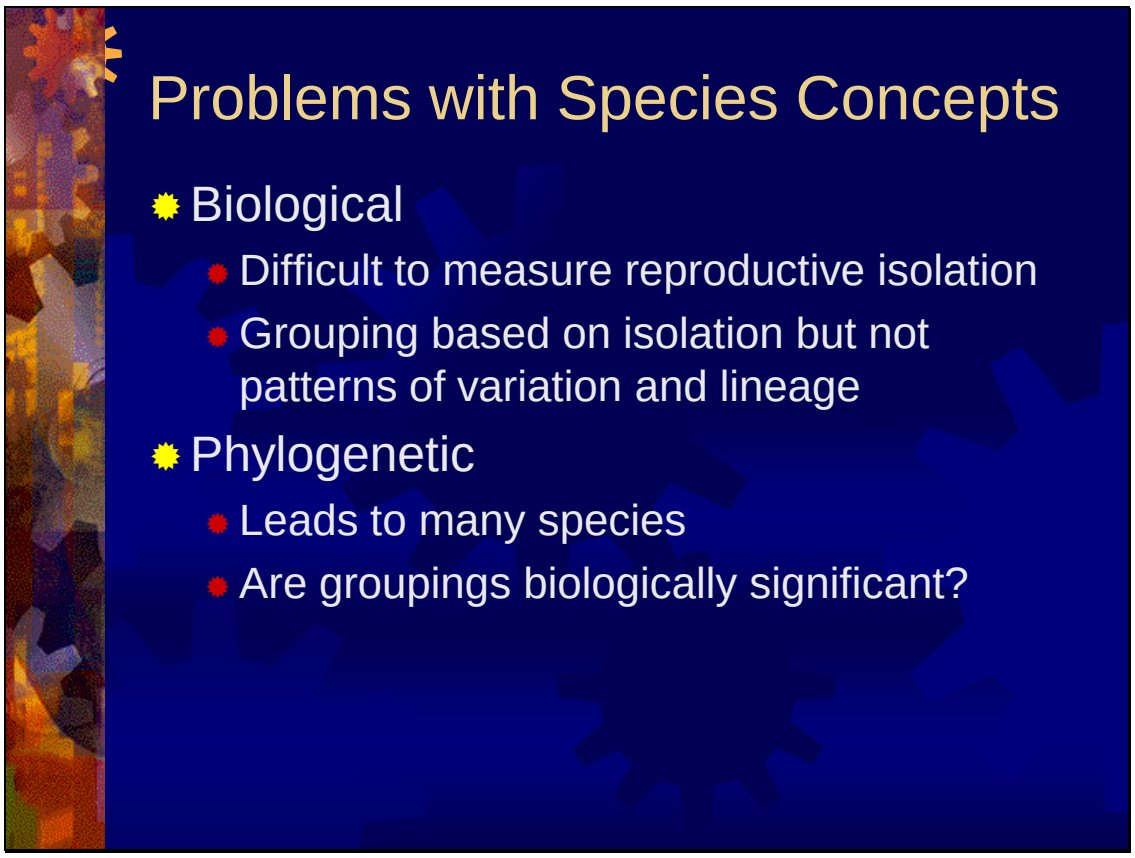

The biological species concept is appealing because it seems to be more what the animals are telling us. However, it is not as firmly based in evolutionary theory and it is difficult to tell if groups are truly isolated reproductively in the field.

The phylogenetic species concept, although relying on patterns of genetic relatedness, can lead to many groups being identified as separate species and the biological relevance of these groups can be questionable.

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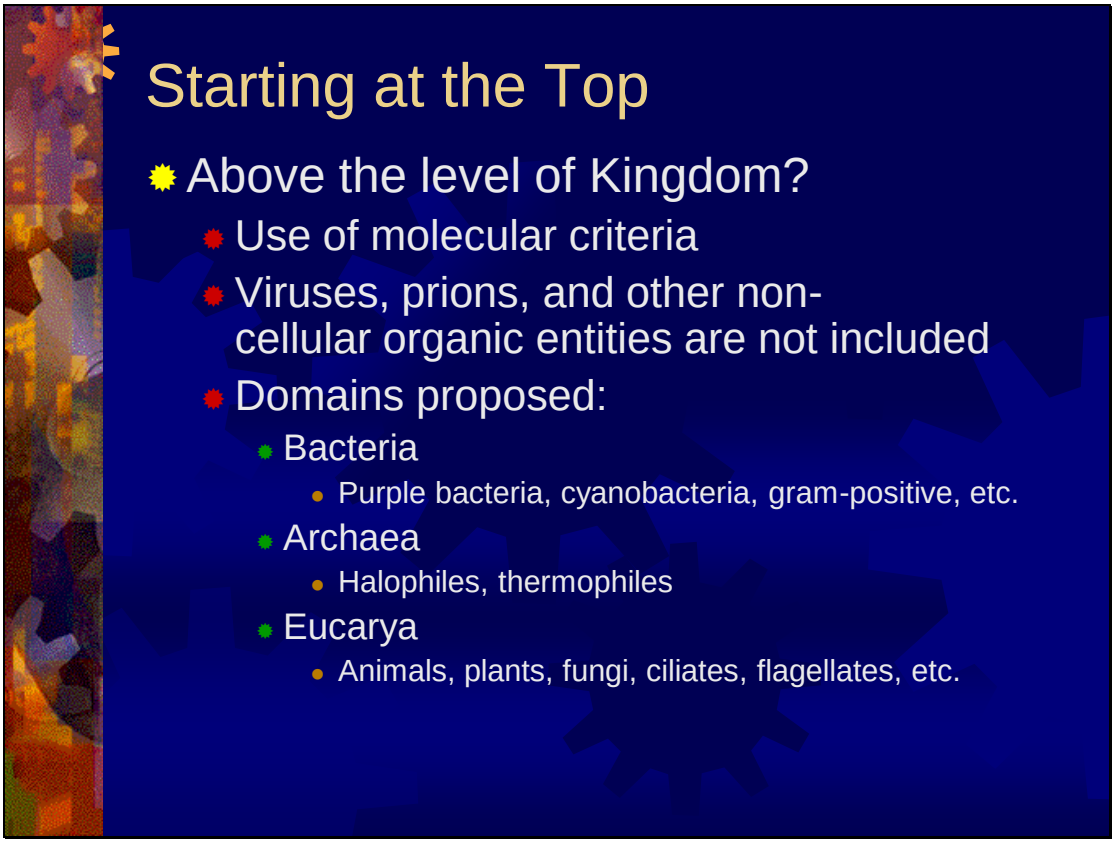

Okay- let's go back up the levels of organization and get into another set of controversies! You can see that this taxonomy thing is not all so straightforward and does not fit into a nice formula that everyone agrees on.

Remember the most inclusive level of organization from our mnemonics to remember the levels? Kingdom. Recent work using molecular criteria suggests that actually a level more inclusive than Kingdom can be identified: Domain. The Domains and the organisms they include are listed here.

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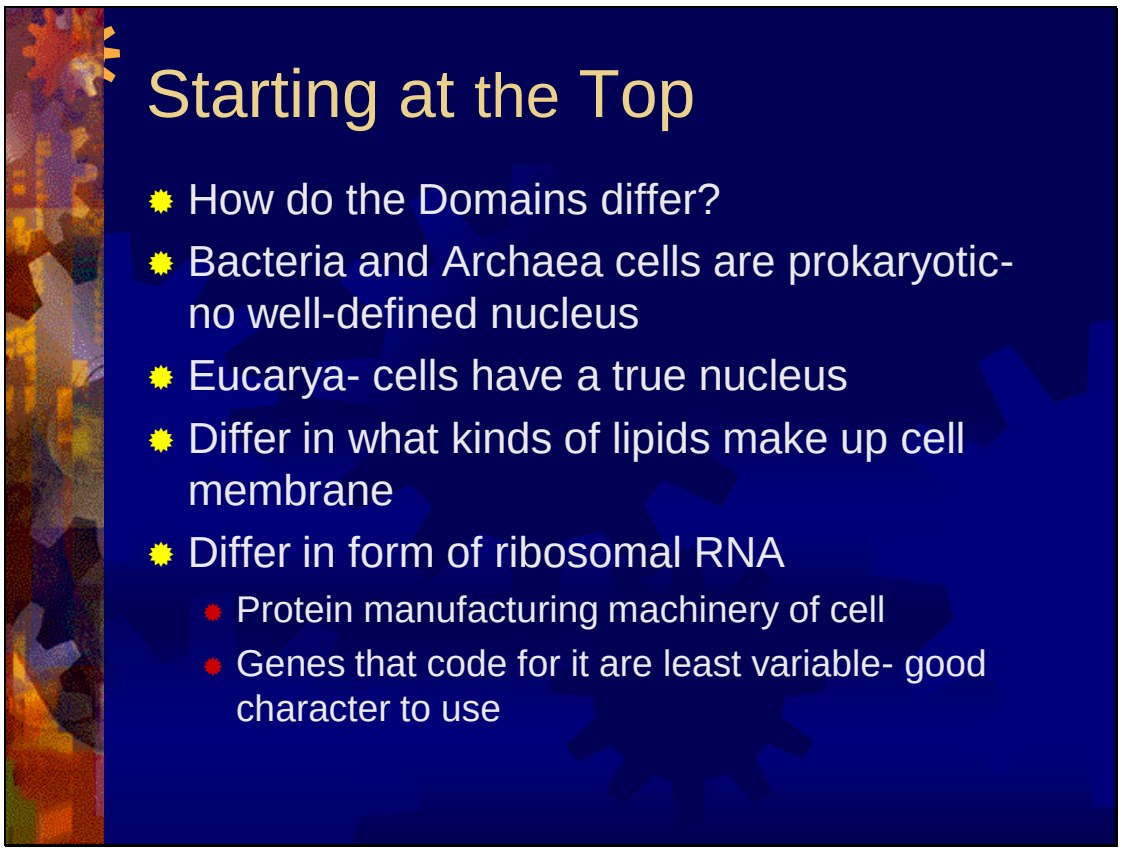

Domains are defined by these characteristics.

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Let's go back to Kingdoms. The typical arrangement has been to use these 5 Kingdoms, but these concepts were formed without the benefit of information on evolutionary ancestry.

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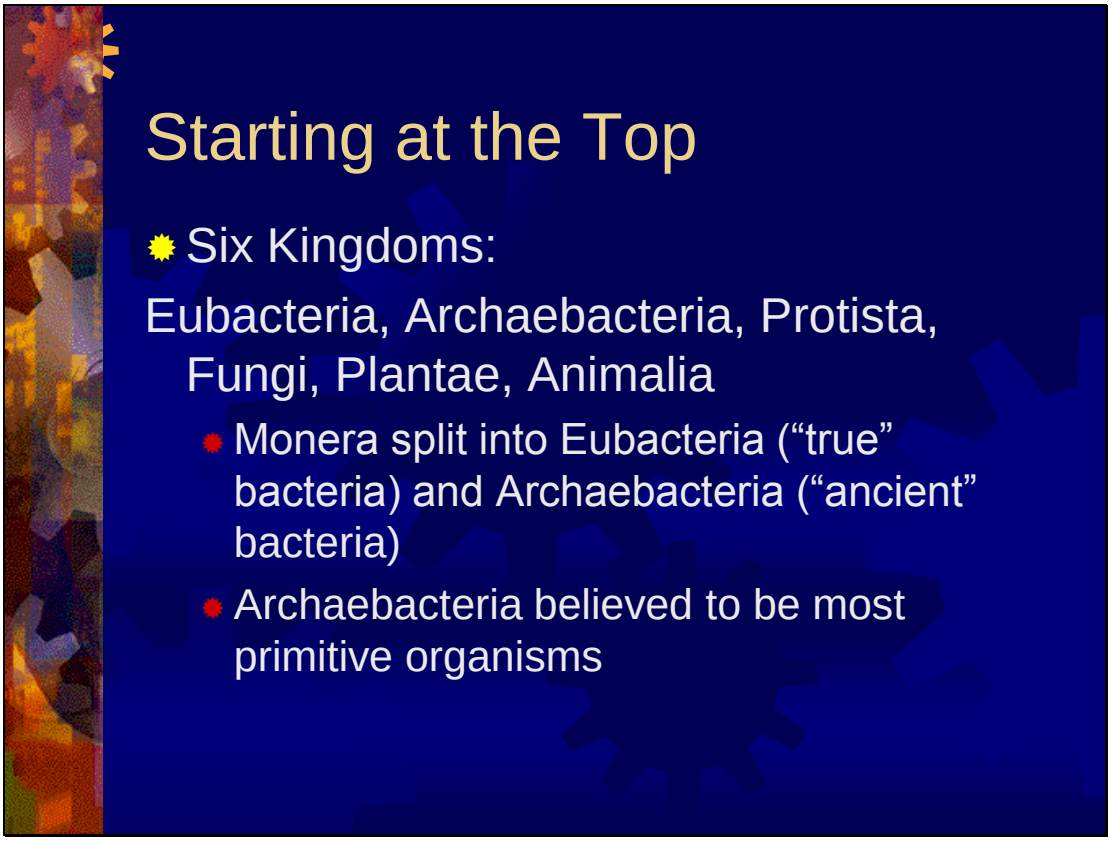

Taking a look at molecular evidence, six Kingdoms are now proposed for general use. The additional Kingdom comes from splitting the Monera into Eubacteria and Archaebacteria.

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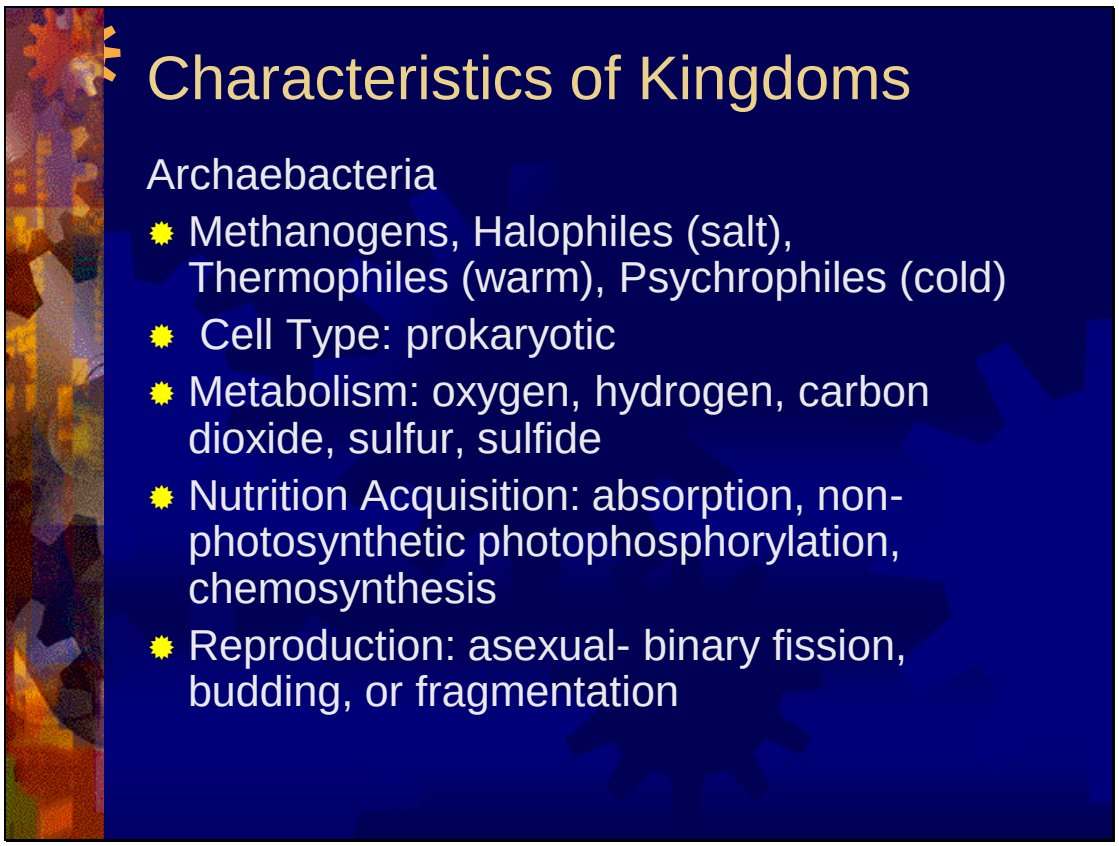

Let's go through the characteristics of these six Kingdoms. Keep these descriptions in mind as you proceed in the course to learn about different groups of organisms. For each Kingdom, I will show examples, cell type, metabolism, how nutrients are acquired, and type of reproduction. Some groups are quite variable in these characteristics while others are not. As you can see, the Archaebacteria are in the variable category- living in some of the most inhospitable environments on the planet. These organisms have a cell wall made of a different material than Eubacteria (proteins and noncellulosic polysaccharides rather than murein) and ribosomal or messenger RNA more like eukaryotes.

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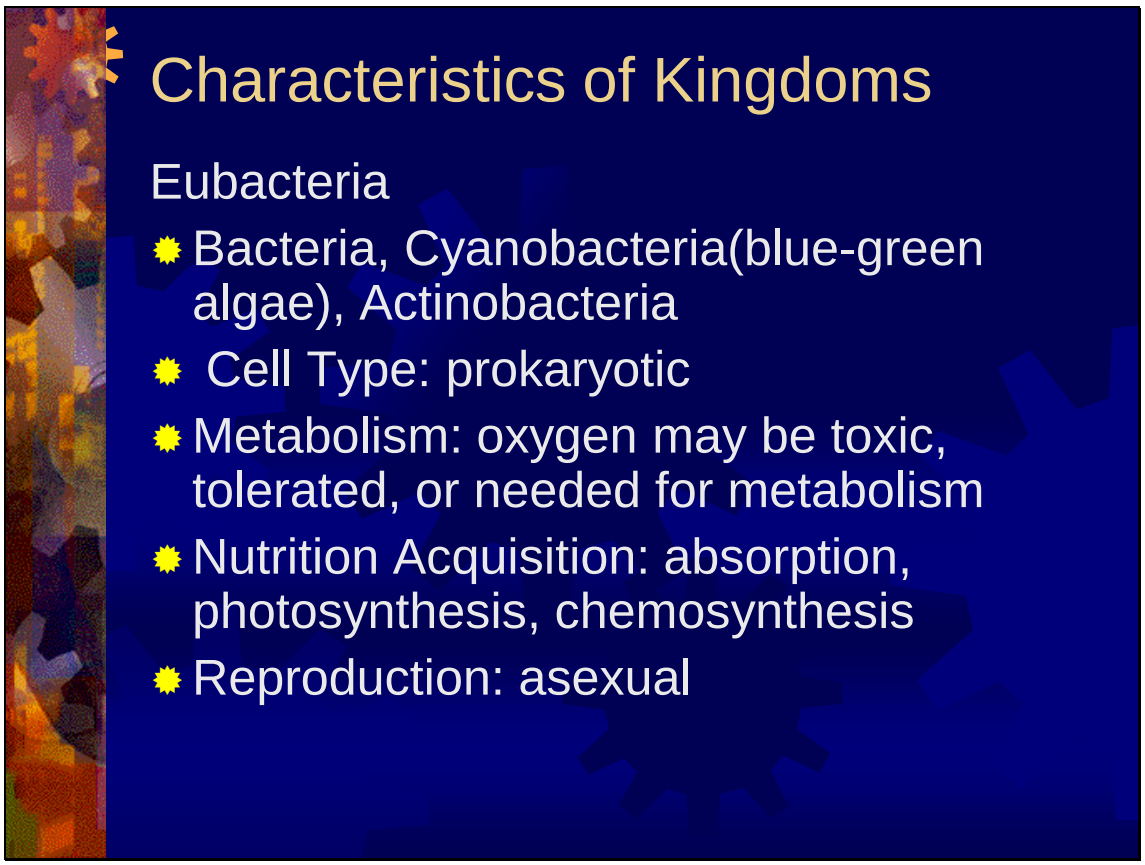

The Eubacteria are more familiar, but still have a variety of ways to obtain nutrients and variable tolerance/need for oxygen.

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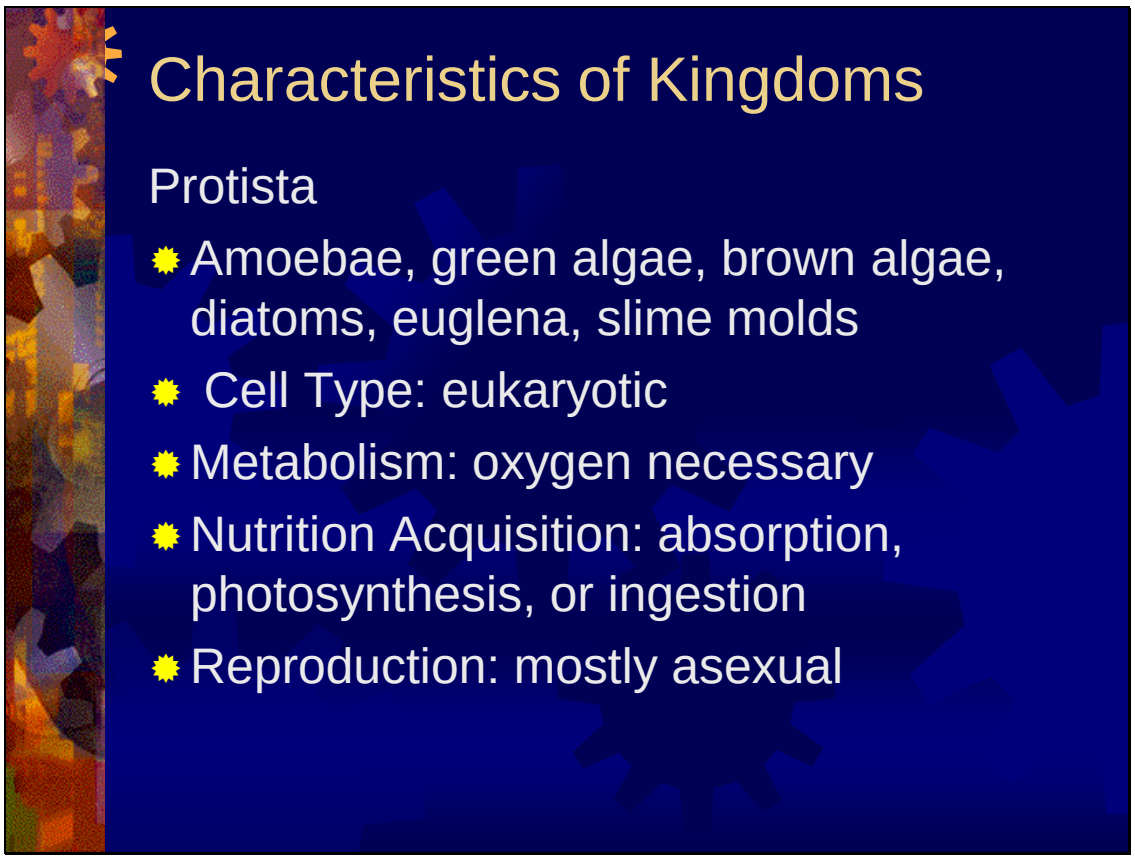

Protista need oxygen but still have an array of ways to get the nutrients they need. They also have eukaryotic cells- those with true nuclei.

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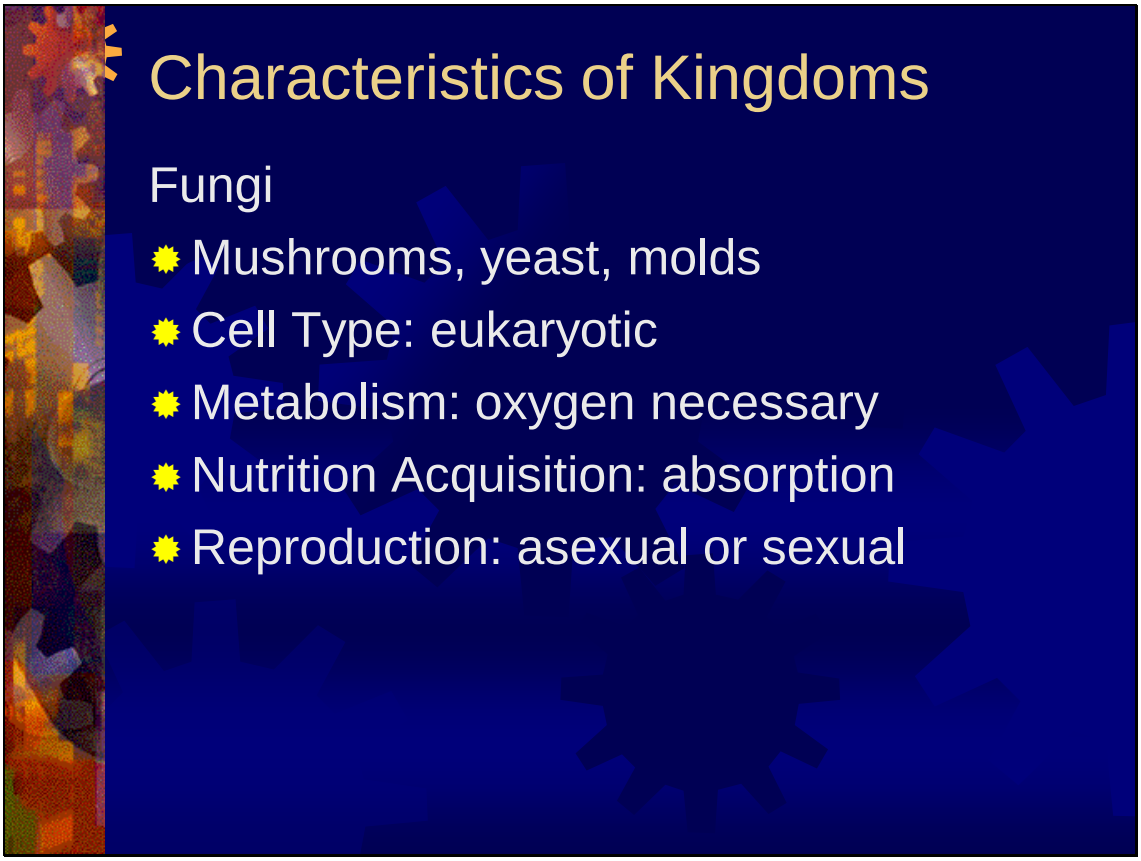

Fungi are even less variable for these categories compared to previous groups, although reproduction can vary between sexual and asexual. We are getting into groups that you would at least consider eating now! We will look more in-depth at this Kingdom and the coming two after an overview of the Kingdoms.

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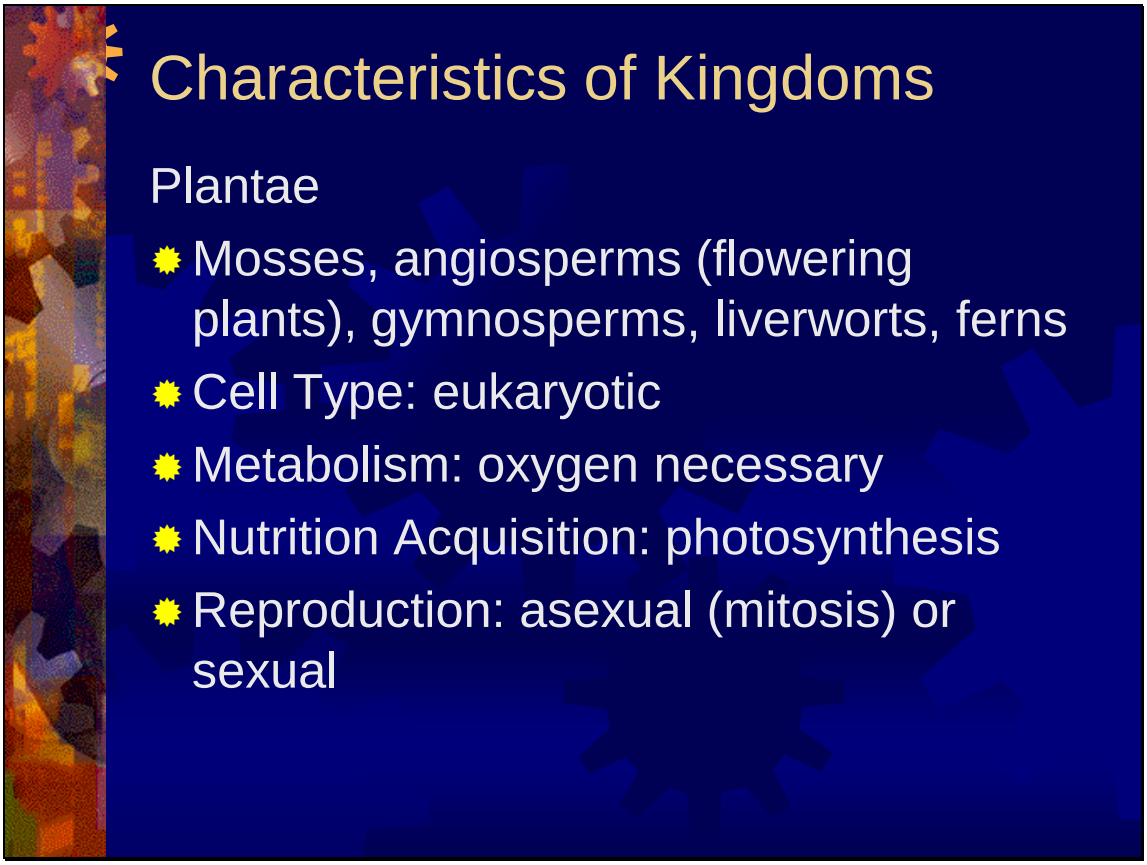

Despite the amazing array of plants, many basic characteristics are shared.

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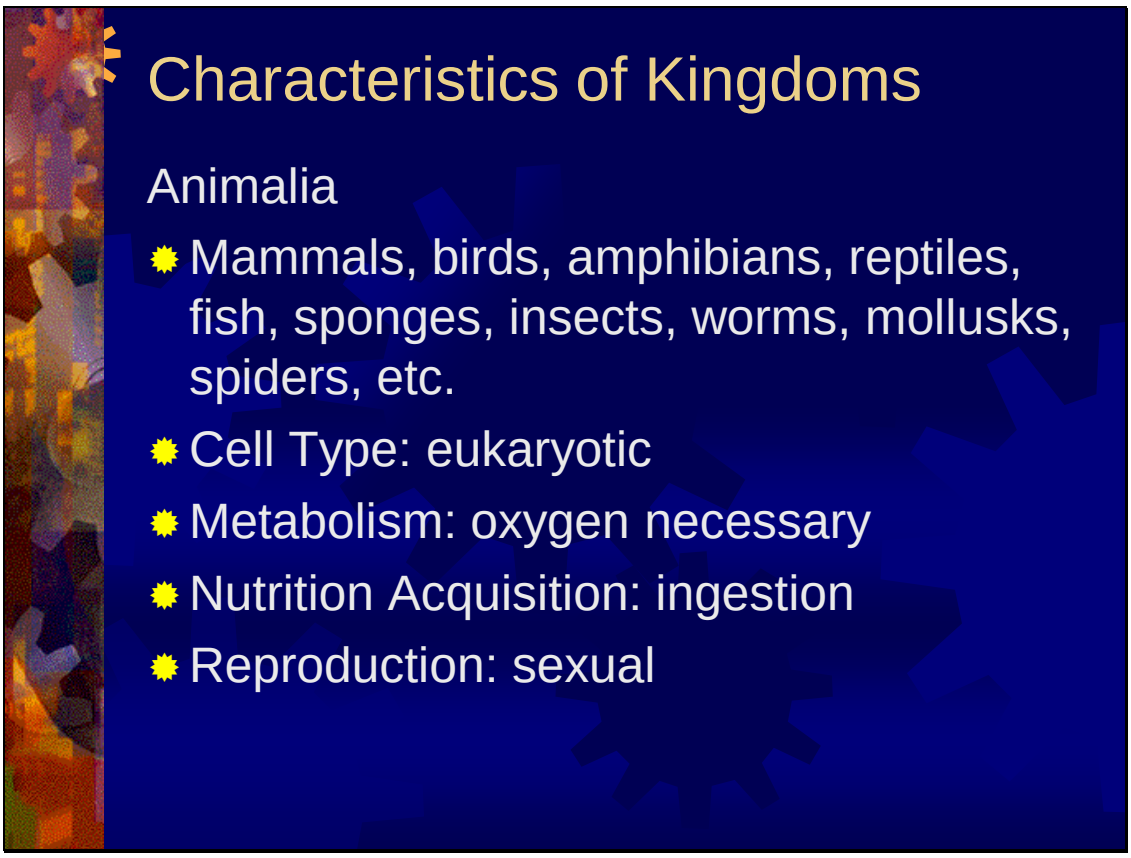

The same can be said for animals.

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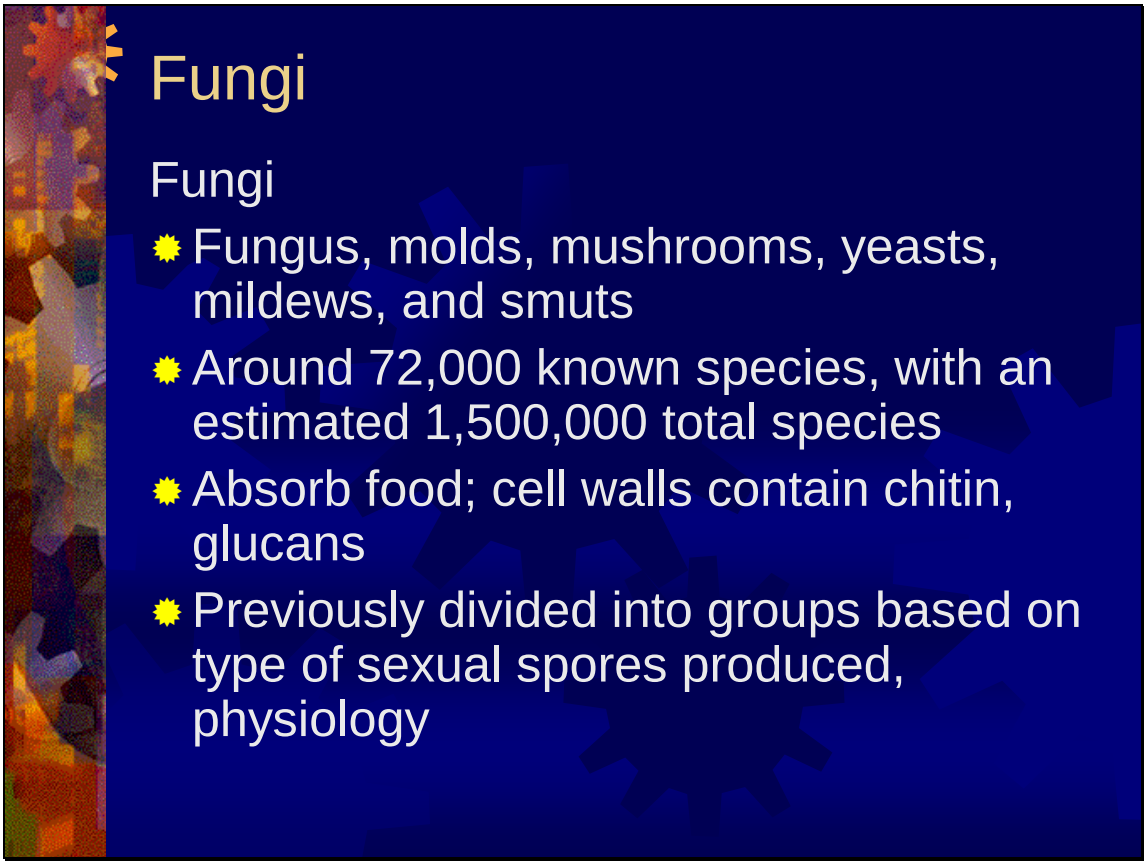

Let's take a closer look at three of the Kingdoms, as you will be covering organisms in these during the training. We will go over example organisms, number of species, and some other characteristics of each of these groups. I will present what has been used to group these organisms into less general levels of organization, but this is an active field of study and the addition of molecular data may be changing groupings.

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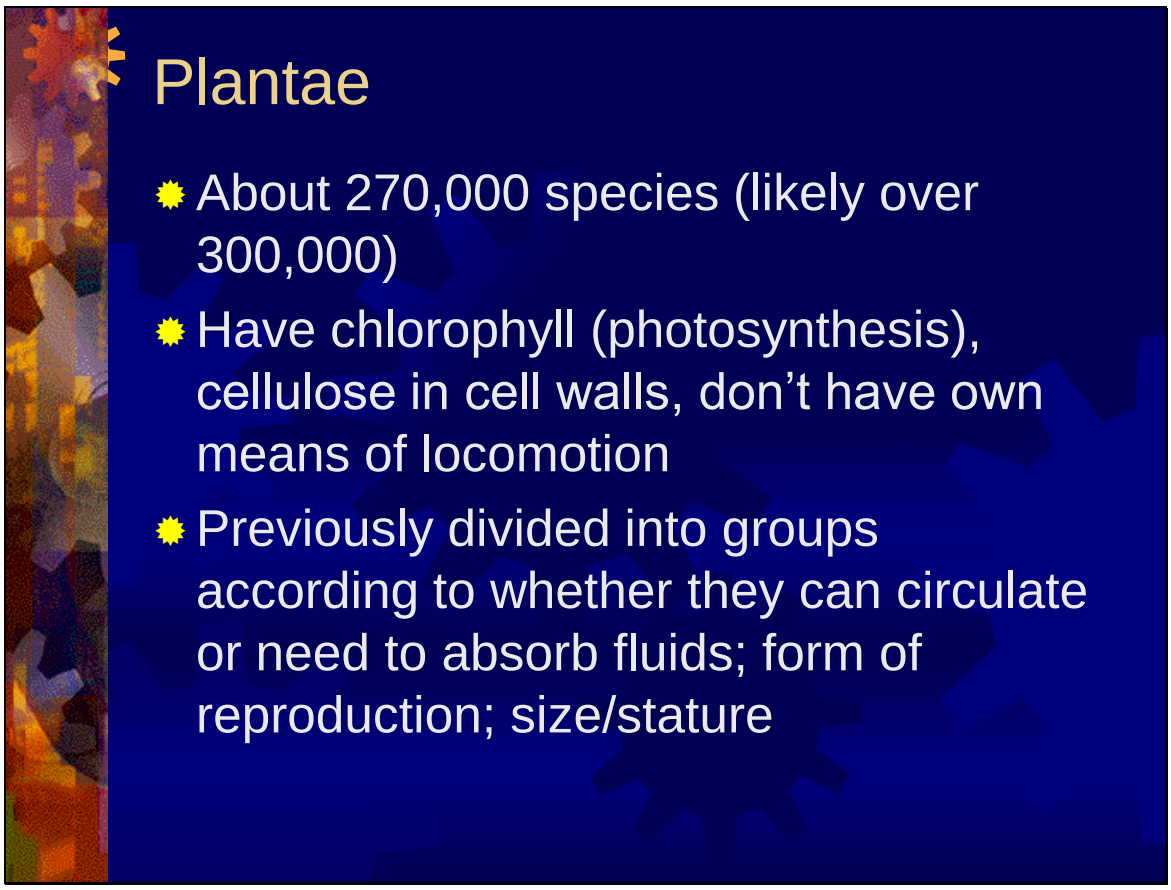

You will hear a lot more about plants in a future session.

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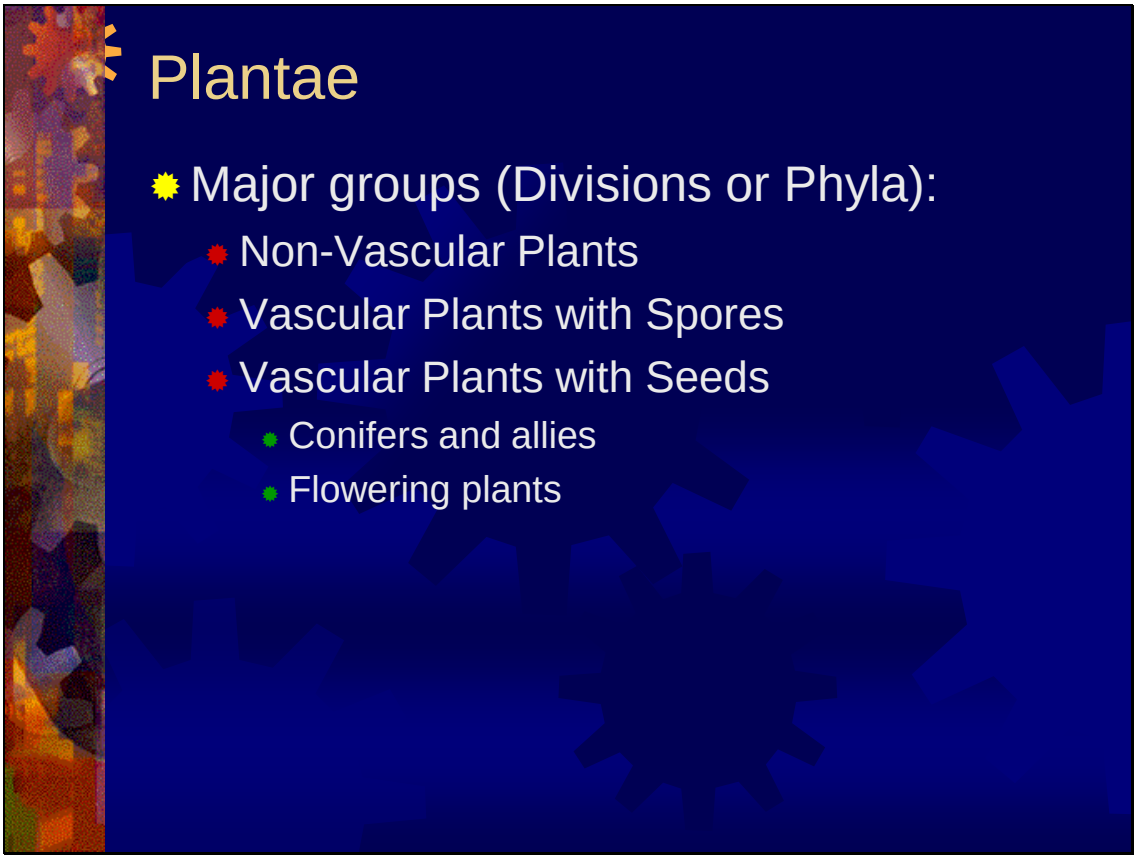

Plants are divided into non-vascular and vascular, and vascular plants according to whether they produce spores or seeds. Vascular plants have specialized tissues that circulate resources throughout the plant. Non-vascular plants may only have specialized tissues that transport water and have no true roots, stems, or leaves.

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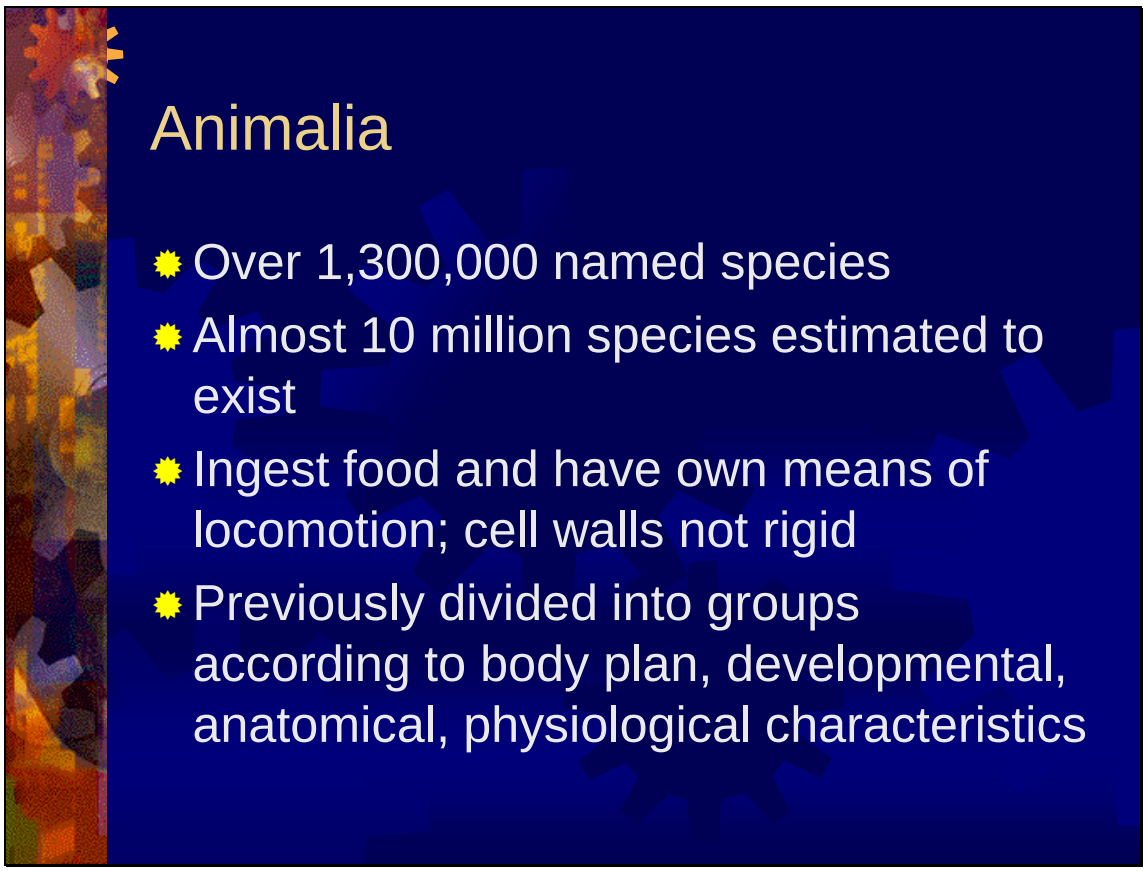

There are an amazing number of animal species that have not yet been named. Can you guess which group of animals is thought to have the most unnamed species? (Insects)

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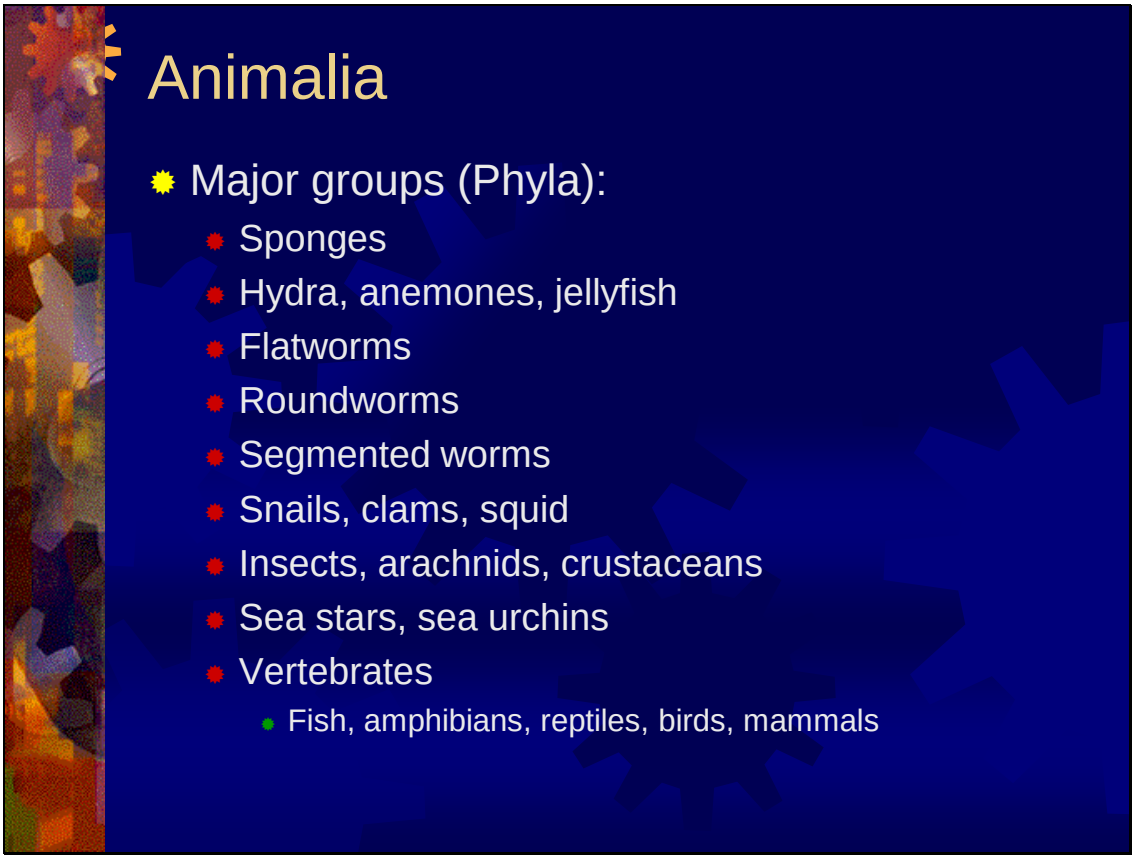

You are likely familiar with the various groups of animals. Future lectures in this training will focus more on the vertebrates than on the invertebrates.

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By now, you may be wondering if this taxonomy stuff has an application to conservation. What does all of that naming and classifying do to help the organisms? Kofi Annan would argue that understanding what is there is an integral part of being able to protect and sustain it. I hope you agree!

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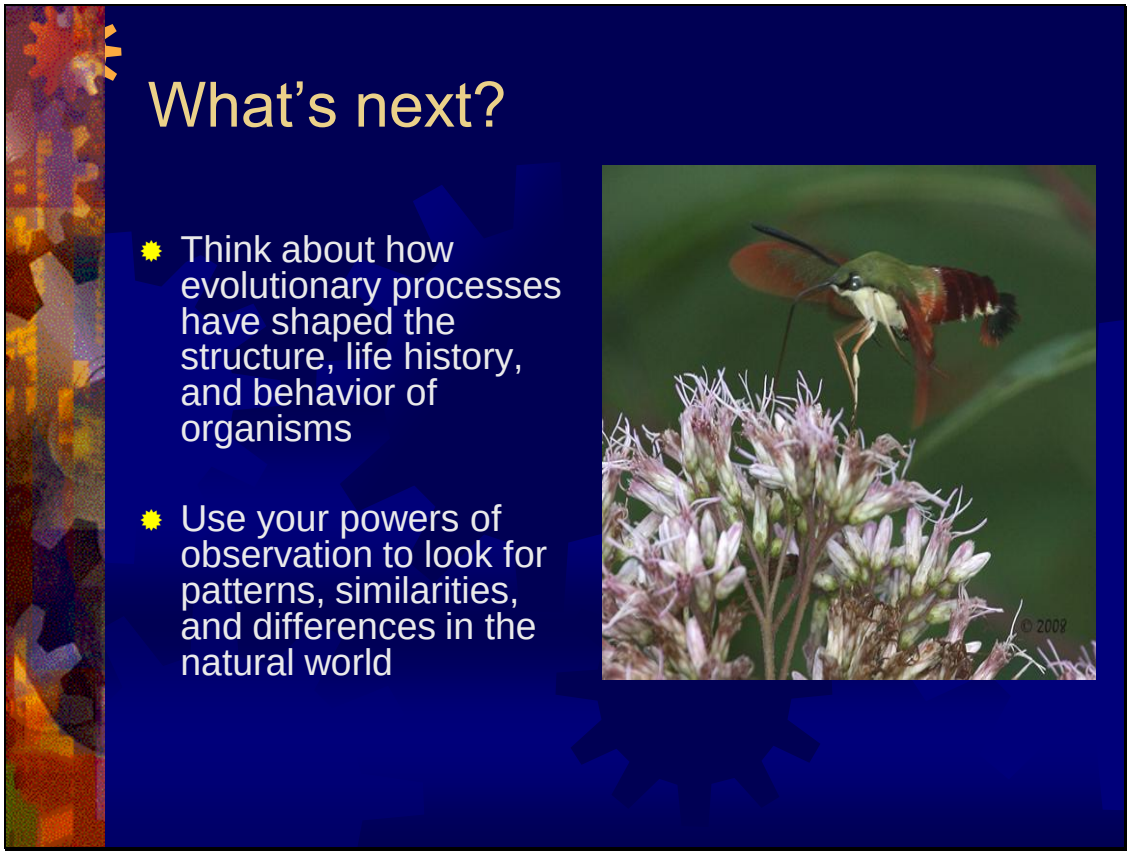

Now that you have some background in taxonomy, take this understanding into future training sessions and especially outdoors to enrich your appreciation and ability to protect our unique natural resources!

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