# TITLE: It Runs in the Family

***Subtitle: Identifying synapomorphies to understand evolutionary relationships***

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**Field-tested with:** 11th and 12th grade WHS students.

**Module type:** Lab activity

**Duration:** 120 minutes

**Key materials:**

* Blank paper
* Scissors
* Glue/glue sticks
* Trait materials – see materials list

**Concepts:** Groups; Traits; Characteristics; Family tree; Derived; Ancestral; Evolution; Parallel Evolution; Convergent Evolution; Morphology; Genetics.

**Skills:**

* Recognizing patterns
* Assessing physical evidence

**NGSS DCI:**

 LS3A – Inheritance of traits

 LS3B – Variation in traits

 LS4A – Evidence of Common Ancestry and Diversity

**NGSS CCC:**

 Patterns: MS-LS4-1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.

 Cause and Effect: HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

**Overview:** This module is an opportunity for students to learn:

* How organisms are grouped together
* How to interpret relationships among groups of organisms

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# Background for Teachers

**Why this matters:**

 With so much life surrounding us, it is easy to feel overwhelmed by it, let alone try to teach it. How do students, begin to make sense of it all? This module is designed to target the very core of this question. Even when exposed to just a sliver of such diversity, it is commonplace to see students begin to retreat and disengage from the material. This module is designed to serve as the first step in the biodiversity of life – taxonomy. Why and how, are animals grouped together?

The purpose of this module is for students to shift their focus from the organism as a whole and begin to look at the traits that each species possesses to then gain an understanding of the relatedness among species. Upon completion of this module, students should have a better understanding of why assemblages of animals are grouped together and become both more familiar with taxonomy. The module will end with a discussion of evolution, shared derived traits, and common ancestry.

**Assumed background:**

Students should have some previous experience with the following concepts:

* Genotype vs. phenotype
* What is a trait/characteristic?

**Special context:**

Animals are classified based on evolutionary relatedness based on shared, derived morphological characteristics, or traits. Animals can also be classified based on their genetic make-up, but that is beyond the scope of this module.

**Scaffolding supplements:**

 The module starts with an exploration exercise, where the teacher walks through the class from our earliest known ancestor, all the way to humans. The exercise is from the website [the tree of life web project, and we start at eukaryotes.](http://tolweb.org/Eukaryotes/3) From there, we work through our ancestry, talking about key events in animal evolution, until we arrive at humans. The chain of links for the website is as follows:

Terrestrial Vertebrates -> Amniota -> Synapsida -> Therapsida -> Mammalia -> Eutheria -> Primates -> Catarrhini -> Hominidae -> Homo.

Keep in mind that although this appears like a strictly linear progression, one group leading into the other, the actual pattern of evolutionary change is more accurately visualized as a branching sequence where one lineage can split and “become” two separate lines of descent.

From there, we switch our focus to the traits of some of the animals, and begin to have a bit of fun, using the website: [Switchzoo.com](http://switchzoo.com/zoo.htm). This website allows us to play with template animals (e.g., elephant, dog, cat, etc.) and begin to freely alter some of their traits to create some unusual looking creatures.

#  Module Description

**Materials** (For each student)**:**

* Blank piece of white 8.5”x11” paper.
* Sharpie

**Materials** (For pairs of students)**:**

* Glue stick
* Scissors
* Scotch tape

**“Trait” MaterialsΔ** (Communal - for entire class)**:**

* Container of faux feathers\*
* Container of pleather\*
* Container of blue beads\*
* Container of faux fur\*

Δ These “trait” materials are absolutely flexible. If the teacher so desires, they can come up with their own crafting materials to add more, or different traits.

**\*** Indicates items that can be purchased from arts & crafts stores.

## Preparation:

* The communal materials should be placed in their containers prior to the start of the module.

## Timeline:

Part 1: Tree of life walkthrough – what does it mean to be “human?” 15 minutes

Part 2: How do we group organisms? 5 minutes

Part 3: Build your own animal - 45 minutes.

Part 4: Using taxonomy and genetics to infer evolutionary relatedness – 40 minutes.

Part 5: Synthesis and cleanup: 15 min.

## Starting Point For Inquiry:

There is an overwhelming diversity of life on our planet. This module teaches the students to focus more on the trait patterns of the organism, rather than focusing on the organism itself to gain an understanding (and appreciation) for how we classify the world around us.

## Detailed Procedure:

Part 1: Tree of Life web project Internet exploration - 10 minutes

 This introduction provides the students with the opportunity to see what traits humans have that make them human. Using the Tree of Life Web Project and the handout, the teacher will walk backwards in time to when animals first came onto land. During each step, the synapomorphies, or shared, derived characteristics are discussed.

Part 2: This activity will serve as a fun, interactive introduction for the rest of the module. To begin, the teacher will ask the class to define what an “animal” is. Then, using the website Swtichzoo.com, the teacher and students will swap animal parts to create a fictional mammal. For the sake of clarity, only switch traits that belong to mammals. At the end of this activity, the teacher will explain that this is exactly what the students will be doing.

Part 3: Students will create their own, unique animal, custom fit with different degrees of various traits. Using the materials (i.e., traits) available to them, students should use their imagination to create a bizarre looking animal. Here, we want students to become focused on the traits that they are using to build their fictional animals.

Part 4: Once all the students have built their animals, we will reconvene as a class, and collect all the animals. Then, we will display all of the animals atop a few adjoined tables and begin to group these fictional organisms together based on the traits the students have used to create them (i.e., shared characteristics). We hope that this activity sparks some debate, as this is exactly what we find in science. The students will first use morphological traits to group organisms that they create. Once the students have developed their groups, simply pose the question, “what naturally occurring phenomenon could explain why these animals have similar traits?” The answer is evolution, and if the students don't arrive at this answer, try to direct them to it. Once the answer has been reached, an explanation of shared, derived characteristics should be given (definition can be found in glossary). Using the common ancestry section of the worksheet, describe what synapomorphies are and how they help infer relatedness among organisms. This is also the time to introduce common ancestry and explain that the groups of organisms all share a common ancestor that has given rise to their group(s) of organisms.

 Now that everyone is comfortable with their morphological groupings, it is time to introduce some doubt! Begin by explaining evolutionary concepts that cause some problems with grouping organisms using morphological traits (e.g., convergent evolution, parallel evolution, etc.; definitions found in glossary). After these concepts have been explained,15 students will randomly be given a piece of paper with 10 codons of DNA written on them. Briefly explain to the students that these strips of DNA can give us a better idea of the relatedness among organisms based on the similarities of their codes. The students will then be charged with finding their closest relative based on similarities found in their DNA (i.e., the strips of DNA that have the most shared codons in the same relative positions). Most likely, the groups of organisms that the students create will be different from the groups they constructed from morphological traits. This is good!

Part 5: End the lab with a discussion of how this is a perfect example of how science is an ever-changing process, as our understanding and technologies grow to better understand the biodiversity of life in our world.

## Assessment Methods:

The students may be assessed on the effort and thought put into creating their creatures. Additionally, the students may be required to create a phylogenetic tree of the organisms we grouped together as a class.

## Possible pitfalls:

We are asking students to be creative, and come up with an imaginative creature. It would not be terribly unlikely for the creatures to be so disparate that grouping them would not make any sense. Repeatedly checking in on students as they are creating their organisms, and encourage creative, but realistic ideas might help avoid this pitfall.

## Glossary:

Taxonomy – The branch of science concerned with classification, especially of organisms.

Trait – A distinguishing quality or characteristic.

Shared trait – One that two lineages have in common

Derived trait – One that evolved in the common ancestor of multiple lineages, and that sets members of those lineages apart.

Common ancestry – Organisms that share a more recent common ancestor are more closely related.

Synapomorphy – a trait that is shared by two or more taxa and believed to have been present in both of their most recent common ancestor, but was absent from more distant ancestors.

Taxa – A group of one or more populations of an organism or organisms to form a unit.

Parallel Evolution – Species evolve similar traits from their own, distantly related ancestors (e.g., forms of leaves, where patterns have appeared multiples times in separate genera and families).

Convergent evolution – The independent evolution of similar features in species of different lineages (e.g., evolution of the complex eye in cephalopods (octopuses), vertebrates (mammals), and cnidarian (box jellyfish).

Divergent evolution – The accumulation of differences between groups that can lead to the formation of new species.

**NGSS Standards Addressed**

**Disciplinary Core Ideas**

 LS3A – Inheritance of traits

 LS3B – Variation in traits

 LS4A – Evidence of Common Ancestry and Diversity

**Cross Cutting Concepts**

 Patterns: MS-LS4-1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.

 Cause and Effect: HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

Guide to supplemental material

**Worksheet -** This worksheet is to be completed as the human lineage is traced. A key is provided.