|  |  |
| --- | --- |
| **iLearn BI 101**  **Procedures** | **Systematics Assessment:**  **Nailing Cladistics** |

Now is your opportunity to demonstrate what you have learned about systematics. After completing this activity and question set you will be submitting a report for grading through the course website. Upon completion of this assignment with the minimum required score, you will have completed the History of Life and Systematics module. The details on the grading and submission process can be found on the course website.

You will need one additional document, which can be found in the course module.

* **Nailing Cladistics Report**: Record your answers to the questions below in this document. This report is to be submitted through the submission page on the course’s website.

For this assignment, you may find it useful to print out the report and fill in your diagrams and tables by hand before entering your final draft into the document you will submit.

**Introduction**

At first glance, any habitat seems to be populated with a bewildering array of plants, animals and other organisms. However, within the enormous diversity of form and function, many simplifying patterns are available to the careful observer. Features that are shared by groups of organisms form the basis of the modern system of classification which arranges organisms into related groups and attempts to clarify the evolutionary relationships between groups. This branch of science is known as taxonomy.

**Cladistics**

Modern taxonomists seek to classify organisms by their evolutionary history, or **phylogeny**. Recognizing evolutionary history can be challenging, and the conclusions reached are often dependent on the background of the scientist constructing the phylogeny. Thus, conclusions are often controversial, even among taxonomists. However, the basic principle is well accepted. Organisms with common ancestors will have inherited common features. For example, animals with bony internal skeletons are assumed to be related to each other. Unfortunately, this does not evaluate the chronological order in which various features arise. Furthermore, variations in a feature, ability to fly for example, may have developed spontaneously in unrelated groups, such as the case with insects, bats (a mammal), and birds.

One approach to deciphering relationships is **cladistics**. Cladistics is a form of analysis which group organisms together based on common ancestry *and* the relative chronology of the appearance of new features. The group formed by cladistic analysis is called a **clade**. It consists of an ancestral organism and all of its descendents. The premise of cladistics is that organisms with identical inherited traits must have a common ancestor.

For example, all flowering plants are assumed to be related because all have flowers. These plants also have green leaves (due to the presence of chlorophyll), as do other plants that do not produce flowers, thus flowering plants are related to non-flowering plants, but more distantly than they are to each other. The presence of chlorophyll is considered an **ancestral trait,** or one that can be seen in all organisms in a clade. Species that have only the ancestral trait constitutes an **outgroup**.

Cladistic analysis is also vulnerable to the spontaneous appearance in unrelated species. Structures which reflect inheritance from a common ancestor are called homologous structures. Those that are similar because they perform similar functions, but are not related through common ancestry are called analogous structures. Distinguishing between the two can sometimes be difficult.

**Part 1: Plant Cladistics**

Consider the following example:

**Table 1.** Characteristics Observed in Plants

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Moss** | **Fern** | **Pine** | **Alder** | **Rose** |
| **Chlorophyll** | Present | Present | Present | Present | Present |
| **Vascular tissue for water transport** | Absent | Present | Present | Present | Present |
| **Seed produced in ovary** | Absent | Absent | Present | Present | Present |
| **Ovary contained within a flower** | Absent | Absent | Absent | Present | Present |

**Figure 1**. Plant Kingdom Clade.

Rose

Moss

Fern

Pine

Alder

Ovary within flower

Seed produced in ovary

Vascular Tissue

Chlorophyll

Some things you should have noticed about the development of traits in the plant kingdom:

* The organism that occurs at the bottom of the cladogram (the organism with the longest branch, in this example moss) has only the ancestral trait, whereas the organism at the top of the cladogram has all the traits listed in Table 1.
* The top 2 organisms have all four traits
* Organisms have all the traits that occur below them on the cladogram, and none that occur above them.

Answer the following questions in regards to the example above in your report:

1. Which plant can be considered the outgroup?
2. Which characteristic can be considered the ancestral trait?
3. Based on this information, which organisms do you think were the last to evolve?

**Part 2: Dinosaur Cladistics**

One of the most challenging groups for taxonomists has been birds. Birds seem to have no close relatives, but clearly are related to other vertebrate animals. Using cladistics, some biologists have reached the conclusion that a direct relationship exists between birds and dinosaurs. Along with many skeletal similarities, a small number of feathered dinosaur fossils have been discovered. Feathers are observed only in living birds. The theory is not without controversy, and there is debate regarding the exact nature of the relationship.

Using the principles of cladistics, try to construct a cladogram for dinosaurs and birds using the anatomical information given below. Take note of the hint provided below the table! You may find it useful to sketch out your cladogram on a separate piece of paper before you fill out the diagram in your lab report. Create your cladogram in your report by clicking on each box in the diagram provided and enter your text.

Answer the following questions in regards to the cladogram you created in your lab report:

1. Which animal can be considered the outgroup?
2. Which characteristic can be considered the ancestral trait?

**Table 2. Dinosaur Characteristics**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Allosaurus** | **Coelophysis** | **Archaeopteryx** | **Velociraptor** | **Diplodocus** | **Pigeon** |
| **# of functional toes** | 3 | 3 | 3 | 3 | 5 | 3 |
| **Moon-shaped wrist bone** | Absent | Absent | Present | Present | Absent | Present |
| **# of fingers** | 3 | 4 | 3 | 3 | 5 | 3 |
| **1st toe reversed** | No | No | Yes | No | No | Yes |
| **Hole in hip socket** | Yes | Yes | Yes | Yes | Yes | Yes |

**(Hint:** you may want to think about the number of fingers and toes as a loss of digits to enter as a trait in the cladogram, meaning that one step in the cladogram will have two traits, one lost finger and lost toes.**)**

**Part 3: Nailing Cladistics**

Now that you have practiced constructing cladograms using characteristics and organisms that are well understood, it’s your turn to analyze relationships and find common characteristics in a group of “organisms” that have not been well classified yet. For this activity you will need to collect 10 random pieces of hardware that are often used in every day construction and home repairs. To the right is a list of suggested pieces that are often found around the average home. You may need to visit your local hardware store to purchase a few single items to give yourself enough pieces to include in your cladogram.

Record in your report the items which you plan to include ion your clade. Just be sure that you start out with 10 items.

**List of Suggested Hardware**

Thumb Tack Partially Threaded Screw

Threaded Nut Flat Head Screw

Wing Nut Nail

Washer Large Screw

Small Screw Medium Screw

**Procedure:**

1. Lay out your “organisms” on a work surface. List all the characteristics you see for each object, based on what you know (or don’t know) about each object. Look at shape, size, raw material, etc. Is it threaded? Does it have a head or a sharp point? Do you know what the function of the piece is? The more observations you make, the easier it will be to find connections and relationships to illustrate in the cladogram.
2. Which characteristic do all the “organisms” have in common? Recall that this is the ancestral trait. It is of little value in analyzing the relationships within a group since all members possess this characteristic, but it does demonstrate the loose relationship they all have to each other.
3. Again look at the data to determine common characteristics that only a portion of the group has. These are referred to as derived, or advanced, characteristics. They are usually more advanced features that were added to the primitive features found earlier. The largest group of these derived characteristics will be the first to branch from the main trunk of the cladogram. Name the derived characteristic and list all the objects that have that characteristic. Continue analyzing similarities and differences in each organism until you have nailed down a chronological order to the derived characteristics and identified each individual with an increasing amount of those characteristics, from the organism that contains only one trait to the organism(s) that has all derived traits. On a separate piece of paper, try to construct a table like those in part 1 and 2 of the lab to help you determine the organisms and traits that appear in your clade.

Picture courtesy of pixabay.com

1. You may come to the conclusion that one or two of your organisms, upon closer inspection, do not belong to this clade of hardware. This is acceptable, but no more than one or two should be excluded, and you must explain why you feel they did not belong.
2. Fill out the table and cladogram in the report with the list of “organisms” in the first row, and your characteristics in the first column, just like the tables 1 and 2 of the lab, indicating presence or absence of each trait in the corresponding cell for each “organism”. Next fill in the boxes of the cladogram skeleton, following the format of Figure 1 of the lab. If you chose to eliminate one or 2 items from your list, you may not need the entire cladogram.
3. After completing your cladogram answer the questions located on the third page of the report.

