3.1: Organizing organisms (hierarchically)

Carl Linnaeus (1707-1778) was the pioneer in taking the similarities between different types of organisms seriously. Based on such similarities (and differences), he developed a system to classify organisms in a coherent and hierarchical manner. Each organism had a unique place in this scheme. What was, and occasionally still is, the controversial aspect of such a classification system is in how to decide which traits should be considered significant and which are superficial or unimportant, at least for the purposes of classification. Linnaeus had no real theory to explain why organisms could be classified in such a hierarchical manner and based his model only on observations. This might be a good place to reconsider the importance of hypotheses, models, and theories in biology. Linnaeus noticed the apparent similarities between organisms and used it to generate his classification scheme, but he had no explanation for why such similarities should exist in the first place, very much like Newton’s law of gravitation did not explain why there was gravity, just how it behaved. So what are the features of a model? A model has to suggest observations or predict outcomes that have not yet been observed. It is the validity of these predictions that enable us to identify useful models. A model that makes no empirically validated predictions is not particularly useful, as least from a scientific perspective. A model that makes explicit predictions, even if they prove to be wrong, enables us to refine our model or force us to abandon the model and develop a new one. A model that, through its various predications and their confirmation, refutation, or revision, has been found to accurately explain a particular phenomenon can become promoted to a theory. We assume that the way the model works is the way the world works. This enables us to distinguish between a law and a theory. A law describes what we see but not why we see it. A theory provides the explanation for observable phenomena.58

Back to Linnaeus, whose classification system placed organisms of a particular type together into a species. Of course, what originally counted as a discrete type of organism was based on Linnaeus’s judgement as an observer and classifier; it depended on which particular traits he felt to be important and useful to distinguish organisms of one species from those of another, perhaps quite, similar species. The choice of these key traits was subject to debate. Based on the perceived importance and presence of particular traits, organisms could be split into two or more types.
(species), or two types originally considered separate could be reclassified into a single species.

As we will see, the individual organisms that make up a species are not identical but share many traits. In organisms that reproduce sexually, there are often dramatic differences between males and females of the same species, a situation known as sexual dimorphism. In some cases, these differences can be so dramatic that without further evidence, it can be difficult to tell whether two animals are members of the same or different species. In this light the primary criteria for determining whether sexually reproducing organisms are members of the same or different species is whether they can and do successfully interbreed with one another in nature. This criterion, reproductive compatibility, can be used to determine species distinctions on a more empirical basis, but it cannot be used with asexual species (such as most microbes). Within a species, there are sometimes regional differences that are distinct enough to be recognizable. Where this is the case, these groups are known as populations, races, or subspecies. While distinguishable, the organism in these groups retain the ability to interbreed and so are members of a single species.

After defining types of species, Linnaeus next grouped species that displayed similar traits into a larger group, known as a genus. While a species can be considered a natural, interbreeding population, a genus is a more artificial group. Which species are placed together within a particular genus depends on the common traits deemed important or significant by the person doing the classifying. This can lead to conflicts between researchers that can be resolved by the collection of more comparative data.

In the Linnaean classification scheme, each organism has a unique name, which consists of its genus and species names. The accepted usage is to write the name in italics with the genus name capitalized, for example, *Homo sapiens*. Following on this pattern, one or more genera are placed into larger, more inclusive groups, and these groups, in turn, are themselves placed in larger groups. The end result of this process is the rather surprising observation that all organisms fall into a small number of “supergroups” or phyla. We will not worry about the traditional group names, because in most cases they really do not help in our understanding of basic biology. Perhaps most surprising of all, all organisms and all phyla fall into one and only one group - all of the organisms on earth can be placed into a single unified phylogenetic "tree" or perhaps better put, bush – they are connected. That this should be the case is by no means obvious. This type of analysis could have produced multiple, disconnected classification schemes, but it did not.

Contributors and Attributions

- Michael W. Klymkowsky (University of Colorado Boulder) and Melanie M. Cooper (Michigan State University) with significant contributions by Emina Begovic & some editorial assistance of Rebecca Klymkowsky.