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BIODIVERSITY THEORY

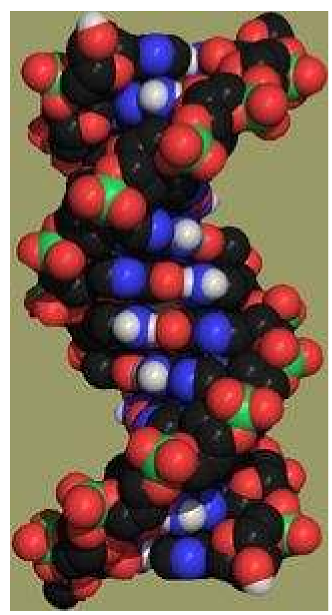
Three Levels of Biodiversity

Genetic Diversity | Species Diversity | Ecosystem Diversity

Researchers generally accept three levels of biodiversity: genetic, species, and ecosystem. These levels are all interrelated yet distinct enough that they can be studied as three separate components. Some researchers believe that there are fewer or more levels than these, but the consensus is that three levels is a good number to work with. Most studies, either theoretical or experimental, focus on the species level, as it is the easiest to work on both conceptually and in practice. The following parts will cover all levels of diversity, though examples will generally use the species level.

Genetic Diversity

What is it?



Genetic diversity is the variety present at the level of genes. Genes, made of DNA (right), are the building blocks that determine how an organism will develop and what its traits and abilities will be. This level of diversity can differ by alleles (different variants of the same gene, such as blue or brown eyes), by entire genes (which determine traits, such as the ability to metabolize a particular substance), or by units larger than genes such as chromosomal structure.

Genetic diversity can be measured at many different levels, including population, species, community, and biome. Which level is used depends upon what is being examined and why, but genetic diversity is important at each of these levels.

Why is it important?
The amount of diversity at the genetic level is important because it represents the raw material for evolution and adaptation. More genetic diversity in a species or population means a greater ability for some of the individuals in it to adapt to changes in the environment. Less diversity leads to uniformity, which is a problem in the long term, as it is unlikely that any individual in the population would be able to adapt to changing conditions. As an example, modern agricultural practices use monocultures, which are large cultures of genetically identical plants. This is an advantage when is comes to growing and harvesting crops, but can be a problem when a disease or parasite attacks the field, as every plant in the field will be susceptible. Monocultures are also unable to deal well with changing conditions.

What is it related to?
Within species, genetic diversity often increases with environmental variability, which can be expected. If the environment often changes, different genes will have an advantage at different times or places. In this situation genetic diversity remains high because many genes are in the population at any given time. If the environment didn't change, then the small number of genes that had an advantage in that unchanging environment would spread at the cost of the others, causing a drop in genetic diversity.

In communities, it can increase with the diversity of species. How much it increases depends not only on the number of species, but also on how closely related the species are. Species that are closely related (*e.g.* two species of maple) have similar genetic structures and makeup and therefore do not contribute much additional genetic diversity. These closely-related species will contribute to genetic diversity in the community less than more remotely-related species (*e.g.* a maple and a pine) would.

An increase in species diversity can also affect the genetic diversity, and do so differently at different levels. If there are many species, the genetic diversity at that level will be larger than when there are fewer species. On the other hand, genetic diversity within each species can decrease. This can happen if the large number of species means so much competition that each species must be extremely specialized, such as only eating a single type of food. If they are so specialized, this specialization will lead to little genetic diversity within any of the species.

Species Diversity

Biodiversity studies typically focus on species. They do so not because species diversity is more important than the other two types, but because species diversity is easier to work with.

Species are relatively easy to identify by eye in the field, whereas genetic diversity (above) requires laboratories, time and resources to identify and ecosystem diversity (see below) needs many complex measurements to be taken over a long period of time. Species are also easier to conceptualize and have been the basis of much of the evolutionary and ecological research that biodiversity draws on.

Species are well known and are distinct units of diversity. Each species can be considered to have a particular "role" in the ecosystem, so the addition or loss of single species may have consequences for the system as a whole. Conservation efforts often begin with the recognition that a species is endangered in some way, and a change in the number of species in an ecosystem is a readily obtainable and easily comprehensible measure of how healthy the ecosystem is.

For more information on the species level of biodiversity, visit the Redpath Museum's Biodiversity of Quebec website (link will open in a new browser window).

Ecosystem Diversity

Ecosystem-level theory deals with species distributions and community patterns, the role and function of key species, and combines species functions and interactions. The term "ecosystem" here represents all levels greater than species: associations, communities, ecosystems, and the like. Different names are used for this level and it is sometimes divided into several different levels, such as community and ecosystem levels; all these levels are included in this overview. This is the least-understood level of the three described here due to the complexity of the interactions. Trying to understand all the species in an ecosystem and how they affect each other and their surroundings while at the same time being affected themselves, is extremely complex.

One of the difficulties in examining communities is that the transitions between them are usually not very sharp. A lake may have a very sharp boundary between it and the deciduous forest it is in, but the deciduous forest will shift much more gradually to grasslands or to a coniferous forest. This lack of sharp boundaries is known as "open communities" (as opposed to "closed communities," which would have sudden transitions) and makes studying ecosystems difficult, since even defining and delimiting them can be problematic.

Some researchers think of communities as simply the sum of their species and processes, and don't think that any of the properties found in communities are special to that level. Many others disagree, claiming that many of the characteristics of communities are unique and cannot be extrapolated from the species level. Examples of these characteristics include the levels of the food chain and the species at each of those levels, guilds (species in a community that are functionally similar), and other interactions.

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