Biodiversity – short for "biological diversity"; definitions vary and include (1) (Convention on Biological Diversity, Rio Summit) Variability among living organisms from all sources (marine, aquatic, terrestrial) and the ecological complexes of which they are a part (2) (Canadian Biodiversity Strategy) the variety of species and ecosystems on Earth and the ecological processes of which they are a part.

Levels of Biodiversity (1) genetic – the ultimate source of biodiversity at all levels, can be measured at a variety of spatial and organizational scales

Biological systems are organized on a hierarchy of different levels: molecules, cells, organisms, populations, communities and ecosystems.

Species diversity is a characteristic unique to the community level of biological organization. Higher species diversity is generally thought to indicate a more complex and healthier community because a greater variety of species allows for more species interactions, hence greater system stability, and indicates good environmental conditions. A variety of **diversity indices** can be calculated to compare ecological communities. In addition, pairs of communities can be compared using **community similarity** indices.

Richness - number of species found in a community
Evenness - relative abundance of each species in a community.

A community is said to have high species diversity if many nearly equally abundant species are present. If a community has only a few species or if only a few species are very abundant, then species diversity is low. Consider a community with 100 individuals distributed among 10 species. It should make sense that if there are 10 individuals in each of the 10 species in the community it is more diverse than if there are 91 individuals in one species and one individual in each of the other nine species.

Levels of Biodiversity
Genetic diversity – variety at the gene level; can be measured at many different levels that include species, population, community, and ecosystem. Greater genetic diversity can be advantageous over long-periods of time because it provides more "adaptive cards" to play if environmental change is encountered. In the short-term, however, sometimes less genetic diversity can be advantageous if the genes available are providing fitness and competitive advantage over others. Specialists, or those species that have narrow well-defined niches or life-requirements (e.g., diet, space;), typically have less genetic diversity than those species that can fulfill life requirements in a broader array of environs and conditions (e.g., generalists). Many of the species that have been extirpated by humans in the last 10,000 years were specialists (e.g., Ivory-billed woodpecker, Bachman's warbler).

Species diversity – species are the most commonly used and perhaps easily comprehended units or currency by which biological diversity is measured. A greater number of species = greater species diversity within a defined area and time. The

Shannon-Weiner index is a commonly used method of measuring species diversity within a defined place based on collected field data.

Ecosystem diversity – diversity at levels greater than that found at the species level are often defined within associations, communities, or ecosystems. One problem with measuring diversity at spatial scales beyond the species level is that higher systems are hard to define. Where does a community or ecosystem begin and end?

Gaining and Losing Biodiversity
To detect the gain or loss of biodiversity it must first be measured. Three ways to do this include numbers, evenness, and difference. Measuring numbers requires quantifying how many (e.g., species, taxa) are within a defined area. Evenness refers to the distribution of individuals among species or other level. Difference refers to the evolutionary distance among species or other level within a defined area. Which is a more diverse system, an island (# 1) with 2 species of toads, 2 macaws, 5 insects, 2 reptiles, and 2 lemurs, or island # 2 with 3 species of macaws, 4 warblers, 2 toucans, 3 corvids, 2 gulls, 2 raptors, and one insect? This can sometimes be a difficult question to answer. Although island # 2 has greater species richness, island # 1 could arguably be labeled as more diverse because the evolutionary distance among its taxa is much greater. Island 2 consists of several bird species and one insect species, while that on Island # 1 has reptiles, amphibians, insects, birds, and mammals.

Gaining Biodiversity
Mutation consists of changes in the genome of an organism that may confer selective advantages to offspring within a current or rapidly changing environment. Changes in the genome can alter the organism in ways that ultimately cause **speciation**, or the creation of a new species. However, speciation often occurs more rapidly via other mechanisms such as **competition** and **geographical isolation**. Competition can cause selective pressure between or among species to an extent as to lead to changes in some or all species involved. A superior competitor may over time eventually cause an inferior competitor to change its resource acquisition strategy or use new resources. The inferior competitor may change phenotypically in a way that allows it to more effectively acquire other resources. A change in beak morphology (e.g., birds) or tooth structure and digestive morphology (e.g., ungulates) are some examples in which differences in basic body plan are slightly altered to enhance resource procurement and reduce competition.

Geographical isolation that isolates members of species can be caused by sudden climatological or geological events (floods, earthquakes, volcanoes) or can occur slowly over longer periods of time (e.g., Madagascar slowly breaking away from Africa). Separated populations are then subjected to selective environmental pressures unique to each geographical area. The populations evolve in ways unique to each area and can become two distinct species over time.

Immigration of new species can lead to an increase in biodiversity by simply increasing the total number of different species present. **Succession** is the process of change within an ecological community towards a more stable state. Typically, diversity increases as succession proceeds towards a "climax" community, particularly with regard to animals, although plant diversity sometimes peaks at mid-stage of succession. Climax systems with small disturbances will have a higher biodiversity than those that are relatively homogenous. This is because these disturbances support their own unique community of early successional species that are additive to the diversity found in the climax stage matrix.

Losing Diversity

Extinction occurs when a species no longer exists. **Extirpation** is local extinction of a species (e.g., panther in Kentucky). Most species that have lived on Earth are now extinct as a result of individual species extinction or by mass extinctions that have periodically occurred as a result of globally cataclysmic events (e.g., meteor strike 65 mya). Individual genes can go extinct if they are not passed on to future generations. Ecosystems can go extinct if their enough biotic components are lost. **Competition** may cause local extirpation or extinction of less fit competitors and therefore reduce the total number of species in a system. A good example of this is in Australia where a number of small mammals species have become extinct as the result of introduction and subsequent competition from exotic species such as the Norweigan rat. **Disturbances,** especially at large scales, can reduce diversity be destroying habitat for or directly extirpating species. Genetic diversity can be lost when most of the individuals of a species die. The remaining individuals have fewer genes among them (thus less diversity). This can lead to problems in the future when the population again increases. A less genetically diverse population will have fewer genetic cards to play if environmental conditions change. A population that has experienced a numerical crash and recovery that leads to reduced genetic diversity is said to have undergone a **genetic bottleneck**. The African cheetah has low genetic diversity because it nearly went extinct several thousand years ago, but then recovered. This leaves the cheetah susceptible to environmental influences such as diseases because it has fewer genes with which to adapt to change.

Patterns of Biodiversity in Space and Time

Diversity has been increasing throughout the life of Earth. Why? Well, if you are self-replicating molecule or cell with the basic machinery for life a likely means to outcompete your peers and pass on your genes is to develop strategies that allow you to utilize different resources or acquire them more effectively. Thus, life diversifies in response to resource availability and relative competition for them to maximize fitness and reproduction.

The number of species typically increases from the equator to the poles. This is due to the fact that polar areas receive less sunlight that results in more harsh temperature extremes and less primary productivity that could support other life. Larger areas typically contain more species than smaller ones because they usually have more resources (space, food etc.). Usually the total number of species increases with increasing area to a certain point than plateaus. More species are found at lower elevations (less temp extremes) and at lower ocean depths to a point at which the water pressure and available sunlight again limits the number of species. Seasonal differences of biodiversity within the same ecosystem are usually minimal even though the casual observer would think they were much greater. This is because many species are still present but have sought refuge and/or are dormant or have changed forms that make them less conspicuous.

Be able to determine where and when you would likely find highs and lows of biodiversity within systems!

Diversity and Ecosystem Functioning

How does biodiversity relate to ecosystem function?

Rivet Hypothesis – each species added to an ecosystem increases ecosystem function. The functional increase may slow as more species are added, however. In this model, any species loss should be noticeable.

Redundant Hypothesis – assumes that ecosystem functioning increases with increasing number of species up to a point at which additional species are redundant in function and therefore do not have any additional effect on ecosystem function.