Biodiversity

As far as scientists can tell, the Earth is unlike any other place in the entire universe. For among the countless stars, moons, asteroids and other bodies arrayed across the vastness of outer space, only our tiny planet Earth is known to support life. And it does so everywhere: on the slopes of high mountains and on the floors of the oceans, in scorching deserts and at the frigid poles. This life which has been supported on planet Earth comes in many shapes, forms and sizes ranging from blue whales and redwoods to butterflies and even tiny microbes. This array of life is known as biodiversity. Biodiversity is both a measure of the variety of life and an indicator of the overall health of our planet. To date scientists have identified and counted about 1.4 million species, which is only a small fraction of the number of species that they think, may exist on our tiny planet.

What is Biodiversity?

The word "*biodiversity"* is a contracted form of the term 'biological diversity'. The Convention on Biological Diversity defines biodiversity as:

> ***"the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species, and of ecosystems."***

Thus, biodiversity includes genetic variation within species, the variety of species in an area, and the variety of habitat types within a landscape. Biological diversity is of fundamental importance to the functioning of all natural and human-engineered ecosystems, and by extension to the ecosystem services that nature provides free of charge to human society. Living organisms play central roles in the cycles of major elements (carbon, nitrogen, and so on) and water in the environment, and diversity specifically is important in that these cycles require numerous interacting species.

The following are different types of biodiversity

1. *Genetic diversity*: variety in the genetic makeup among individuals within a species
2. *Species diversity*: variety among the species or distinct types of living organisms found in different habitats of the planet
3. *Ecosystem or ecological diversity*: variety of forests, deserts, grasslands, streams, lakes, oceans, coral reefs, wetlands and other biological communities
4. *Functional diversity*: biological and chemical processes of functions such as energy flow and matter cycling needed for the survival of species and biological communities

This rich variety of genes, species, biological communities and life-sustaining biological and chemical processes that give us food, wood, fibers, energy, raw materials, industrial chemicals and medicines all

of which pour hundreds of billions of dollars into the world economy each year. It also provides us with free recycling, purification and natural pest control services.

Every species here today contains genetic information that represents thousands to millions of years of adaptation to the earth's changing environmental conditions and is the raw material for future adaptations. Loss of biodiversity not only reduces the availability of ecosystem services but also decreases the ability of species, communities, and ecosystems to adapt to changing environmental conditions. Biodiversity is nature's insurance policy against disasters.

Some people also include human cultural diversity as part of the earth's biodiversity. The variety of human cultures represents numerous social and technological solutions to changing environmental conditions.

Table 1 represents the number of living species of all organisms currently known (source: http://www.globalchange.umich.edu/globalchange2/current/lectures/biodiversity/biodiversity.html)

Group	Number of Described Species
Bacteria and blue-green algae	4,760
Fungi	46,983
Algae	26,900
Bryophytes (mosses and liverworts)	17,000
Gymnosperms (conifers)	750
Angiosperms (flowering plants)	250,000
Protozoans	30,800
Sponges	5,000
Corals and Jellyfish	9,000
Roundworms and earthworms	24,000
Crustaceans	38,000
Insects	751,000
Other Arthropods and minor invertebrates	132,461
Mollusks	50,000
Starfish	6,100
Fishes (teleosts)	19,056
Amphibians	4,184
Reptiles	6,300
Birds	9,198
Mammals	4,170
Total	**1,435,662**

Genetic diversity

Figure 1 - The genetic diversity among individuals of one species of Caribbean snail is reflected in the variations in shell colour and banding patterns. (source: G. Tyler Miller – Living in the environment)

Genetic diversity is the "*raw material*" that permits species to adjust to a changing world whether these changes are due to natural factors or are caused by human factors. It refers to the variation at the level of individual genes and provides a mechanism for populations to adapt to their ever-changing environment. The level of similarity (homogeneity) or difference (heterogeneity) in the genetic makeup of a population of the same species indicates to what extent genetic material can be exchanged between populations and still maintain a species-specific gene pool. The more variation there is, the better the chance that at least some of the individuals will have an allelic variant that is suited for the new environment, and will produce offspring with the variant that will in turn reproduce and continue the population into subsequent generations. In understanding the mechanism by which genes are exchanged within a species, we can begin to understand the role of sometimes geographically diverse populations in maintaining a species' genetic diversity, or in leading to the isolation and creation of distinctive new genomes and potentially species. There is a delicate interdependence between biological and genetic diversity: changes in biodiversity result in changes in the environment, requiring subsequent adaption of the remaining species. If there are changes in genetic diversity, particularly loss of diversity through the loss of species, it results in a loss of biological diversity.

Species Diversity

Figure 2 Two species found in tropical forests are part of the earth's biodiversity. On the right hand side is the world's largest flesh flower (*Rafflesia arnoldi)* growing in a tropical rainforest in Sumatra. On the left is a cotton top Tamarin (source: G. Tyler Miller – Living in the environment)

Species diversity is a measure of the diversity within an ecological community that incorporates both species richness (the number of species in a community) and the evenness of species' abundance. Species diversity is one component of the concept of biodiversity and is influenced by species richness. All else being equal, communities with more species are considered to be more diverse. For example, a community containing 10 species would be more diverse than a community with 5 species. Species diversity is also influenced by the relative abundance of

individuals in the species found in a community. Evenness measures the variation in the abundance of individuals per species within a community. Communities with less variation in the relative abundance of species are considered to be more even than a community with more variation in relative abundance. Consider the following two communities.

Community A	
Species	**Abundance**
1	20
2	20
3	20
4	20
5	20

Community B	
Species	**Abundance**
1	96
2	1
3	1
4	1
5	1

All five species in Community A have the same abundance, whereas there is great variation in abundance across the five species in Community B. For this reason, we would consider Community A to be more even. All else being equal, communities with greater equalness or evenness are considered to be more species diverse or have a greater species diversity. Even though the species richness of the two communities is equal, i.e. because each community has 5 different species, community B is less diverse than community A because most of the individuals in community B are of 1 specific species.

Ecosystem or ecological diversity

Ecological diversity or ecosystem diversity is the variety of biological communities, such as forests, deserts, grasslands and streams that interact with one another and with their physical and chemical (nonliving) environments. It relates to the different forms of life which are present in any one particular area or site, in more precise terms, it concerns the different species of a particular genus which are present in an ecological community. A biological community is defined by the species that occupy a particular locality or interaction between those species. A biological community together with its associated physical environment is known as an ecosystem. Within an ecosystem, water evaporates from biological communities and Earth's surface, to all again as rain or snow and replenish terrestrial and aquatic environment. Soil is built up out of parent rock material and decaying organic matter.

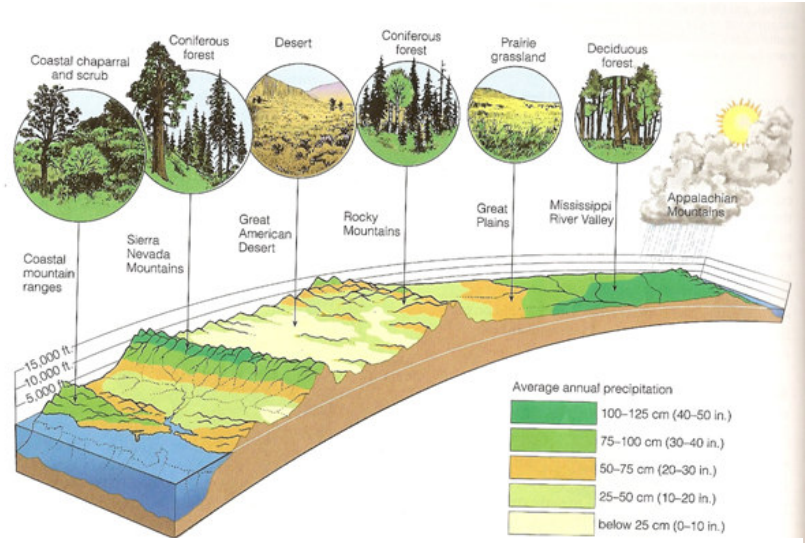

Figure 3 Different biological communities that can be found across the United States (source: G. Tyler Miller – Living in the environment)

Photosynthetic plants absorb light energy, and this energy is released back into the atmosphere as heat during the lives of plants and animals, as well as after they die and decompose. Plants absorb carbon dioxide and release oxygen during respiration, while animals and fungi absorb oxygen and release carbon dioxide. Mineral nutrients, such as nitrogen and phosphorus, cycle between the living and the non-living compartments of the ecosystem. The physical environment affects the structure and characteristics of a biological community; but the biological community can also have effects on the physical characteristics of the ecosystem. In a terrestrial ecosystem, for example, wind speed, humidity, and temperature in a given location can all be affected by the plants and animals present there. In aquatic ecosystem, such characteristics as water turbulence and clarity, water chemistry, and water depth affect the characteristics of the biological communities, but in turn biological communities such as kelp forests and coral reefs can affect the physical environment. Within a biological community each species utilizes a unique set of resources that constitute its niche. The niche for a plant species might consist of the type of soil on which it is found, the amount of sunlight it receives, the amount of soil moisture it requires, the type of pollination system it has, and its mechanism of seed dispersal. The niche for an animal might include the type of habitat it occupies, the types of food it eats over the year, and its requirements for overwintering dens. The niche of each species is the space where that species exists in nature and is not outcompeted by other species.

Functional diversity

Functional diversity refers to the diversity of ecological processes that maintain and are dependent upon the other components of diversity. Functional diversity includes the many ecological interactions among species e.g. competition, predation, parasitism, mutualism, etc. as well as ecological processes such as nutrient retention and recycling. It also includes the varying tempos and intensities of natural disturbances that many species and communities require if they are to persist.

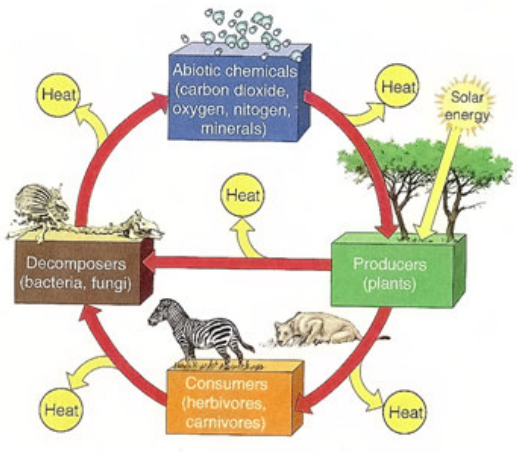

Figure 4 The main structural components of an ecosystem are linked by matter recycling and the flow of energy from the sun, through organisms and then into the environment as low quality heat. (source: G. Tyler Miller – Living in the environment)

Threats to Biodiversity

Extinction is a part of nature. In fact, an estimated nine (9) percent of species become extinct every million years or so, a rate that works out to between one to five species per year. Five times in Earth's history this rate has speeded up, causing extinction on a massive scale and eliminating at least half the animal species living. Now, 65 million years after that last of the dinosaurs disappeared in the most recent extinction episode, it is happening again. But this time, species are becoming extinct at a rate many times faster some scientists say that the rate has increased to 10,000 times faster than ever before, thus roughly 10,000 to 25,000 species are disappearing each year and dozens each day. But unlike extinction spasms before, the current one is not due to environmental changes, it is due to the very actions of our own species…man. Because of our actions, natural evolution will not be able to replace the species we have caused to become extinct and rebuild the ecosystems that we have destroyed, unless we change our actions to stop the following types of biodiversity loss.

- The exploitation of natural resources, such as the world's oceans and forests faster than they can be renewed, i.e. overharvesting of trees for timber and oceans for food
- Overpopulation – the world's population is estimated to be over 6 billion
- Draining wetlands, clearing forests and grasslands for agricultural purposes, towns and cities
- Ruining habitats by fragmentation, due to road construction and development
- The introduction of harmful species into foreign ecosystems, e.g. the introduction to black rats to Antigua and Barbuda, which has left the Antiguan Racer Snake as critically endangered.
- Releasing toxic pollutants into waterways and lands
- Climate change – continued rise of global temperatures
- Poaching as well as the unsustainable hunting and illegal trade of wildlife.

Biodiversity Hotspots around the Globe

Biodiversity hotspots are the Earth's biologically richest and most endangered ecosystems. Although living things can be found on all continents, in every sea and from pole to pole, biodiversity is not spread equally around the globe. Some areas possess a richer variety of species than others. The British biologist Norman Myers coined the term "biodiversity hotspot" in 1988 as areas that are characterised both by exceptional levels of plant endemism and also by serious levels of habitat loss. However, hotspots are also classified as those areas which support natural ecosystems that are largely intact and where native species and communities associated with these ecosystems are well represented. Hotspots are also areas with a high diversity of locally endemic species, which are species that are not found or are rarely found outside the hotspot.

At low elevations, species diversity is greater than at high elevations, where temperatures are cooler and the growing season is shorter. Areas in which a generous supply of rain encourages the growth of lush vegetation are more diverse than arid locations. In freshwater environments, species diversity tends to decrease as the water gets deeper. Biodiversity also tends to increase as you move from the poles to the equator. The sun shines more in the tropics than it does farther north and south, boosting

the productivity of equatorial ecosystems. Tropical climates also tend to be more stable, decreasing the chance of weather-related extinction there. Tropical forests also support a wider variety of habitats than other ecosystems and can therefore host a wider variety of species. Perhaps most importantly, the majority of the world's land mass lies in the tropics.

Hotspots listed according to their regions

Figure 5 Map of the world showing all the Biodiversity Hotspots

(source: Conservation International – http://www.biodiversityhotspots.org/xp/hotspots/resources/Pages/maps.aspx)

North and Central America

- California Florisitic Province
- Caribbean islands
- Madrean Pine-Oak Woodlands
- Mesoamerica

South America

- Atlantic Forest
- Cerrado
- Chilean Winter Rainfall – Valdivian forests
- Tumbes – Choco-Magdalena
- Tropical Andes

Europe and Central Asia

- Caucasus
- Irano – Anatolian
- Mediterranean Basin
- Mountains of Central Asia

Africa

- Cape Florisitic Region
- Coastal forests of Eastern Africa
- Eastern Afromontane
- Guinean Forests of West Africa
- Horn of Africa
- Madagascar and the Indian Ocean Islands
- Maputaland – Pondoland – Albany
- Succulent Karoo

Asia – Pacific

- East Melanesian Islands
- Himalaya
- Indo-Burma
- Japan
- Mountains of Southwest China
- New Caledonia
- New Zealand
- Philippines
- Polynesia – Micronesia
- Southwest Australia
- Sundaland
- Wallacea
- Western Ghats and Sri Lanka

Why is biodiversity important?

The natural environment is the source of all our resources for life. Environmental processes provide a wealth of services to the living world — providing us with air to breathe, water to drink and food to eat, as well as materials to use in our daily lives and natural beauty to enjoy.

Complex ecosystems with a wide variety of plants and animals tend to be more stable. A highly diverse ecosystem is a sign of a healthy system. Since all the living world relies on the natural environment, especially us, it is in our best interests and the interests of future generations to conserve biodiversity and our resources. The benefits and services provided by ecosystems include:

- Generation of soils
- Maintenance of soil quality
- Maintenance of air quality
- Maintenance of water quality
- Pest control
- Detoxification and decomposition of wastes
- Pollination
- Crop production
- Climate stabilization
- Prevention and mitigation of natural disasters
- Provision of food security
- Provision of health care – medicines
- Income generation
- Spiritual and cultural value

Some people may argue the point that some species have become extinct, with no obvious effect on the environment. But the Earth's systems are so complex that we are still learning about environmental processes and resources and the roles they play. The careless loss of any part of the natural environment means that we may never know what use it was or could have been in terms of future technologies, say, for medical science, or indeed for the health of the planet itself.

It's important to understand that environments are constantly changing. A healthy, robust environment evolves and adapts to naturally changing conditions. It is fascinating to observe the far-reaching effects even small changes can make and the importance of genetic diversity for species to adapt, survive and evolve.

Preservation of biodiversity is not necessarily about preserving everything currently in existence. It's more a question of 'walking lightly' on the Earth — a balance of respecting the natural changes that occur and of protecting species and environments from wanton extinction and destruction.

Life on Earth would not be the same if our planet's biodiversity were to be radically affected

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Useful reading

http://www.enfo.ie/leaflets/fs10.htm

http://www.greenfacts.org/en/biodiversity/index.htm

http://www.fathom.com/course/21701785/sessions.html

http://www.actionbioscience.org/biodiversity/simberloff.html

http://redpath-museum.mcgill.ca/Qbp/2.About%20Biodiversity/importance.html

http://www.biodiversityhotspots.org/xp/Hotspots/hotspots_by_region/Pages/default.aspx