Module 1:
What is Biodiversity?

Forestry Training Institute
Tubmanburg, Liberia

Key Topics

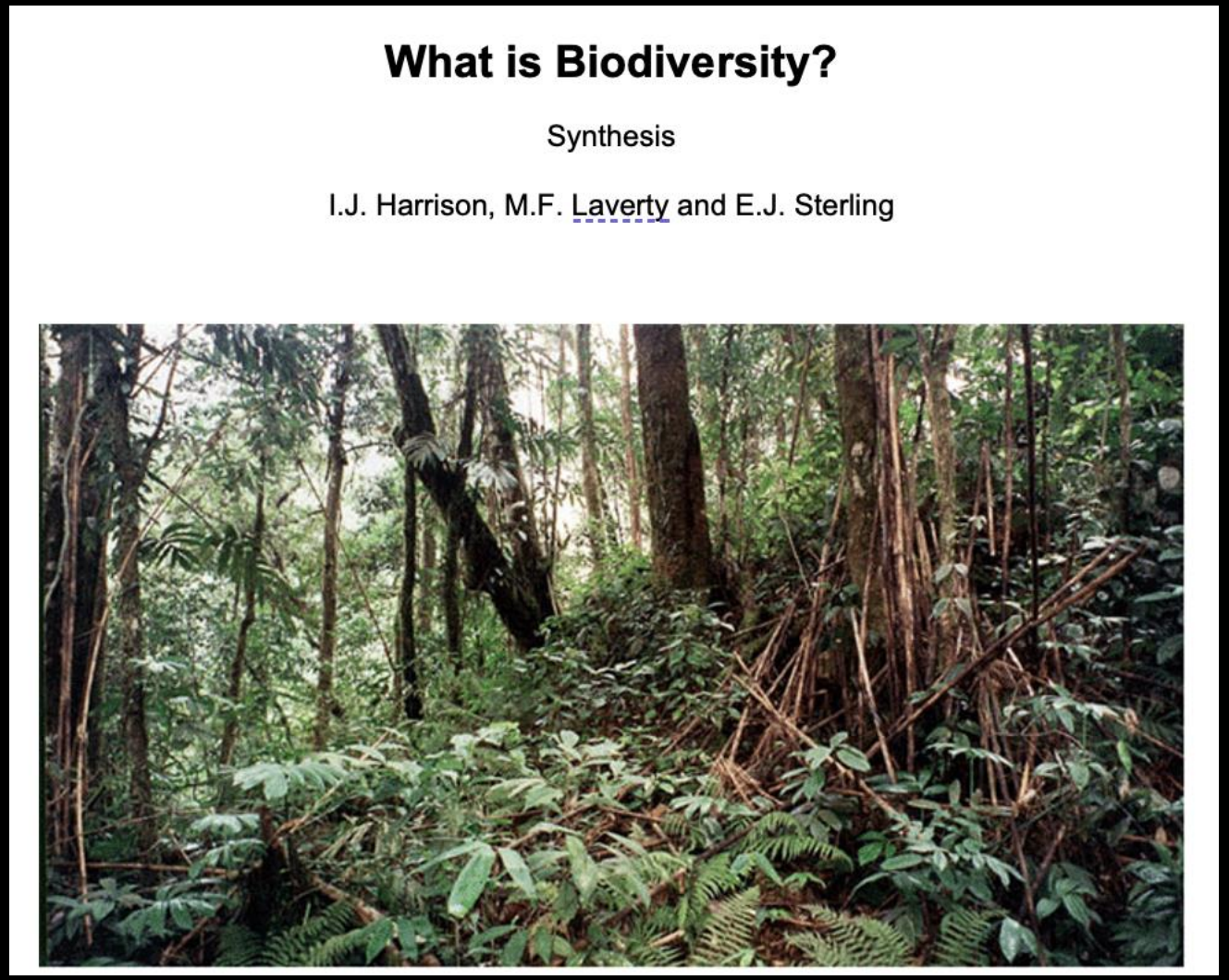
- Fundamentals of Biodiversity
- Threatened species and habitats
- Why conserve biodiversity?

Fundamentals of Biodiversity: Key Questions

1. How is the diversity of life distributed around the planet?
2. What threats does this diversity face?
3. What can people do to reduce or eliminate these threats and, when possible, restore biological diversity and ecosystem health?

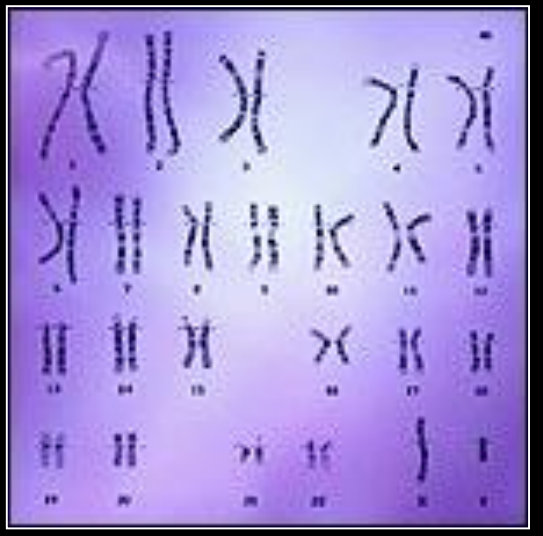
Fundamentals of Biodiversity: Reading

Harrison et al (2006)
“What is Biodiversity”



Fundamentals of Biodiversity: Definitions

Biodiversity is the variety of life on Earth at all its levels, from genes to ecosystems, and the ecological and evolutionary processes that sustain it.



Fundamentals of Biodiversity: Definitions

Biodiversity includes all living things -- including bacteria, fungi, plants, insects and other invertebrates, and vertebrates -- regardless of how similar they are to other species or how useful they are to people.

Fundamentals of Biodiversity: Definitions

Biodiversity includes individual organisms and their genetic material; groups of similar organisms, such as populations and species; and groups of species in communities, and ecosystems landscapes.

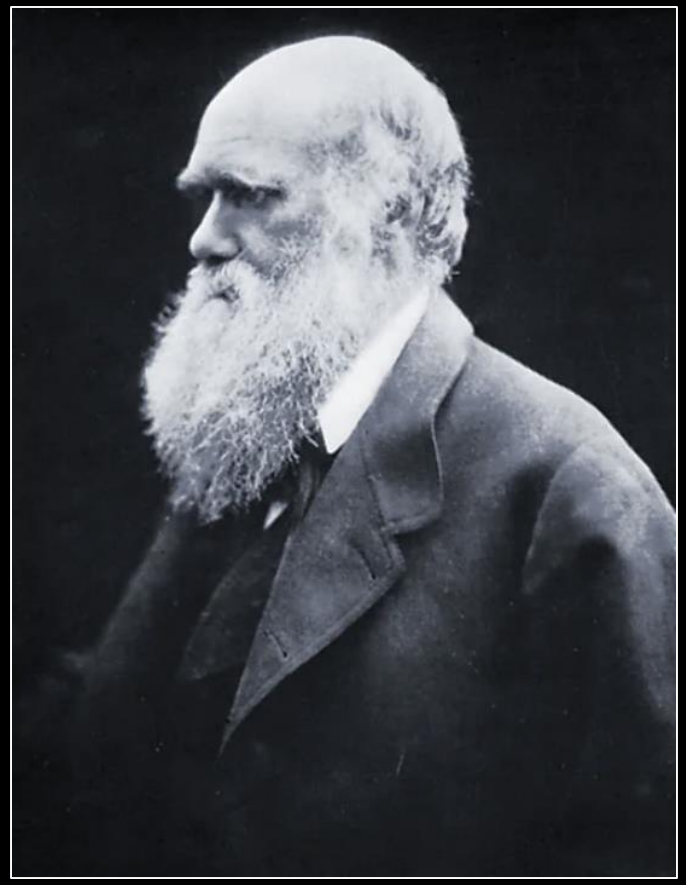
Fundamentals of Biodiversity: Definitions

Biodiversity also includes the ways the various parts interact with each other, including competition, predation and symbiosis.

Fundamentals of Biodiversity: Theory of Evolution

The theory of evolution is one of the great intellectual revolutions of human history, drastically changing our perception of the world and of our place in it. Charles Darwin put forth a coherent theory of evolution and amassed a great body of evidence in support of this theory.

Evolutionary change can be gradual and slow or rapid.

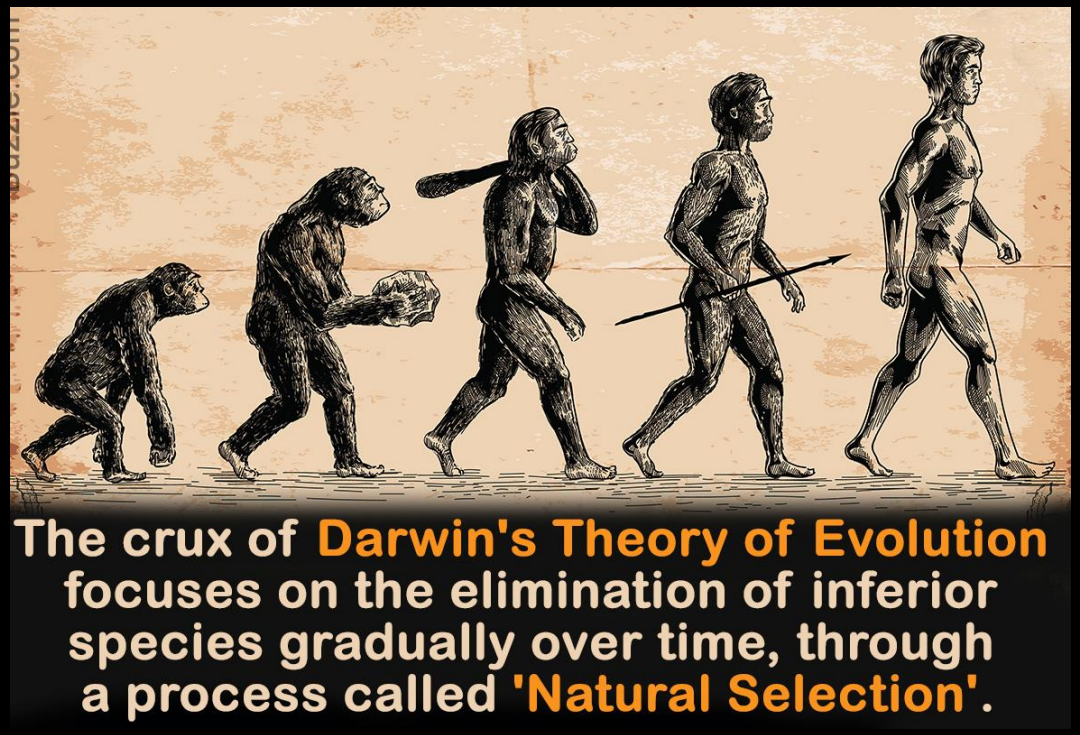


Charles Darwin, Author of "The Origin of Species"

Fundamentals of Biodiversity: Theory of Evolution

The theory of evolution can be summarized as:

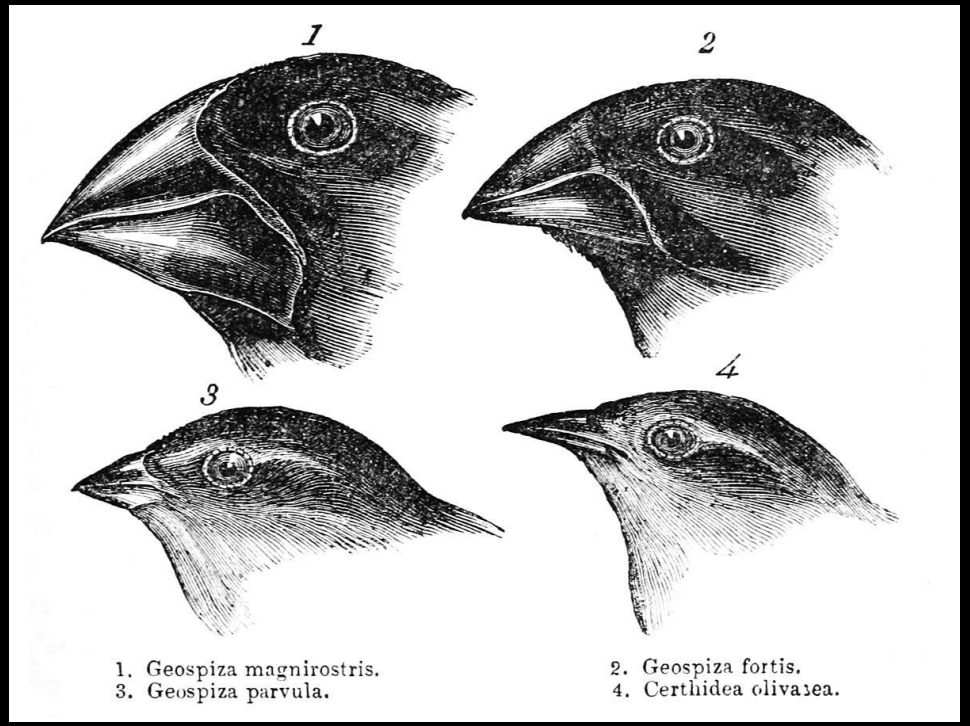
1. *All organisms share common ancestors with other organisms*. Over time, populations may divide into different species, which share a common ancestral population. Shared ancestry explains the similarities of organisms that are classified together since they inherited traits from a common ancestor.



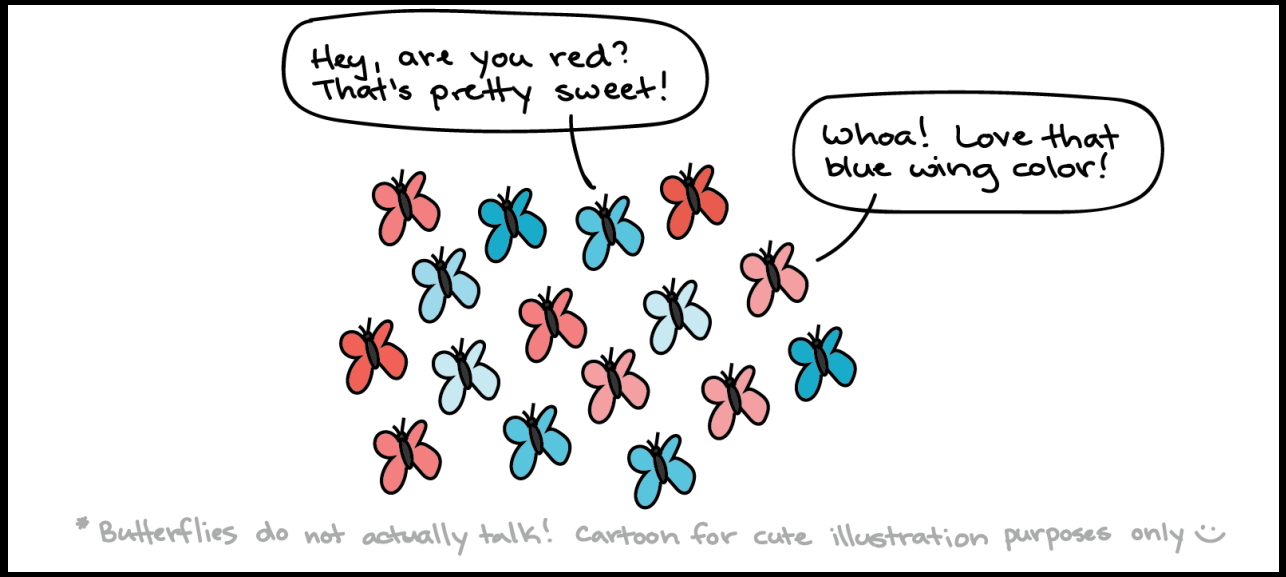
Fundamentals of Biodiversity: Theory of Evolution

The theory of evolution can be summarized as:

2. *Species change over time and space*. The representatives of species living today differ from those that lived in the recent past, and populations in different geographic regions today differ slightly in form or behavior.



Fundamentals of Biodiversity: Theory of Evolution

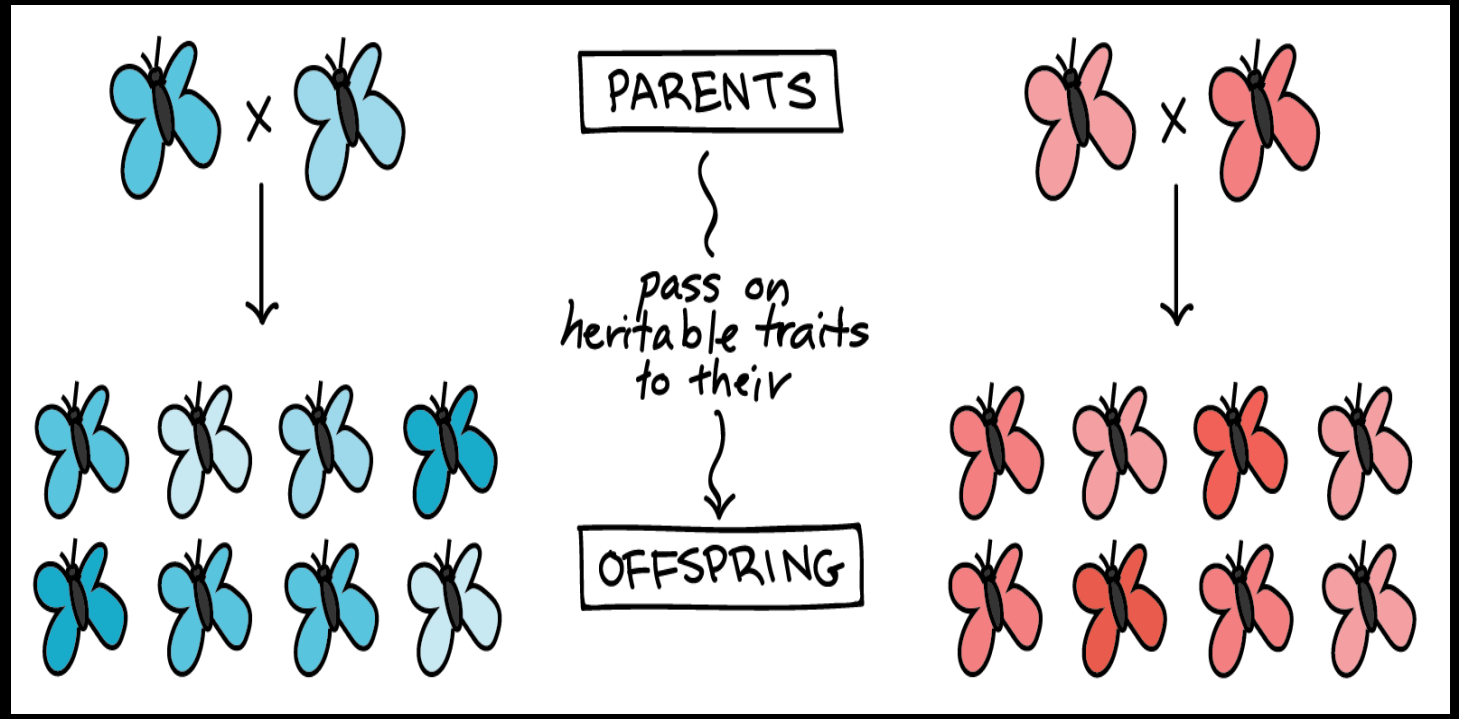


In a population, some individuals will have inherited traits that help them survive and reproduce (given the conditions of the environment, such as the predators and food sources present). The individuals with the helpful traits will leave more offspring in the next generation than their peers, since the traits make them more effective at surviving and reproducing.

Fundamentals of Biodiversity: Theory of Evolution

How Natural Selection Works

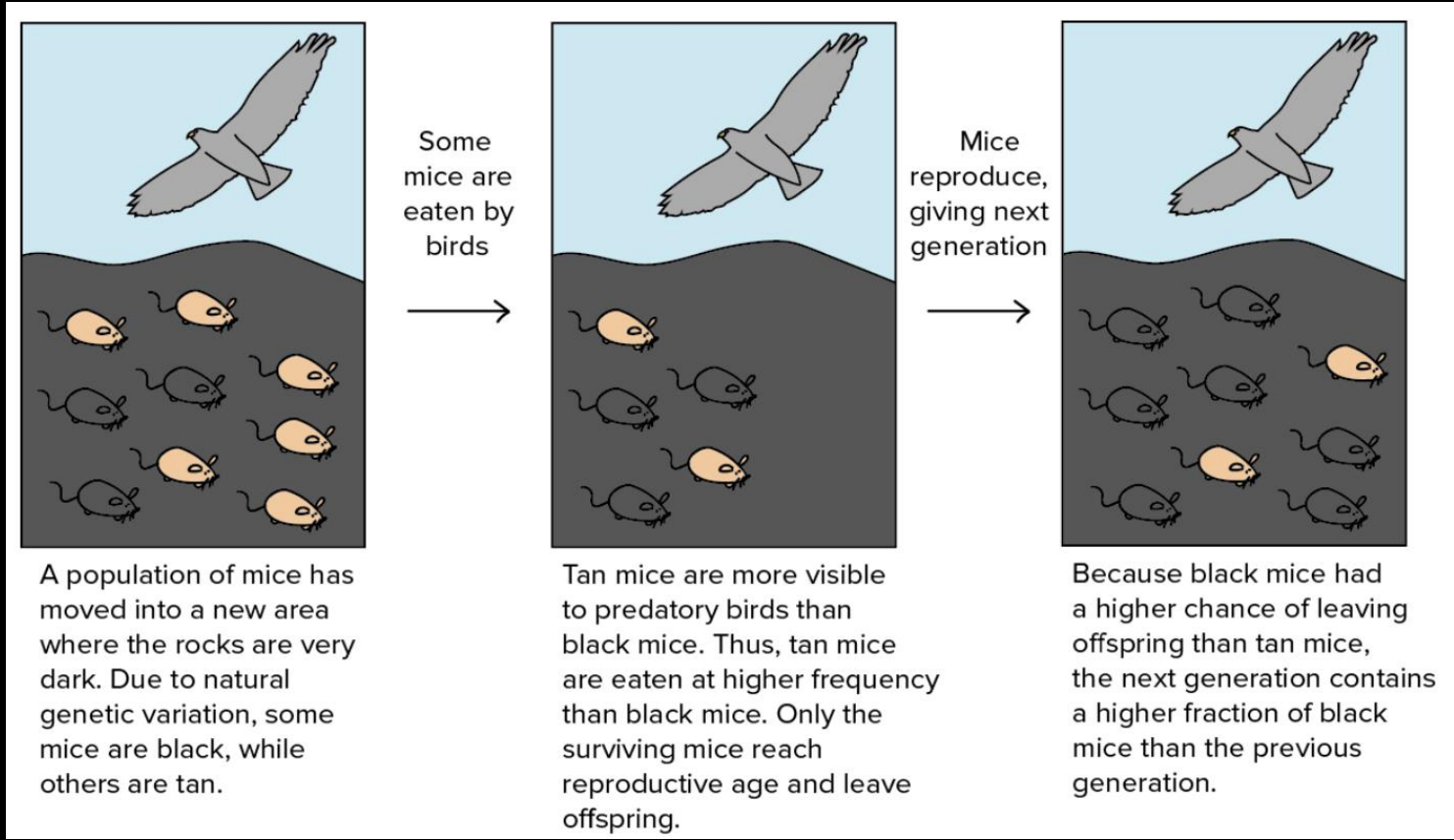
Traits are heritable. In living organisms, many characteristics are inherited, or passed from parent to offspring.



Fundamentals of Biodiversity: Theory of Evolution

How Natural Selection Works

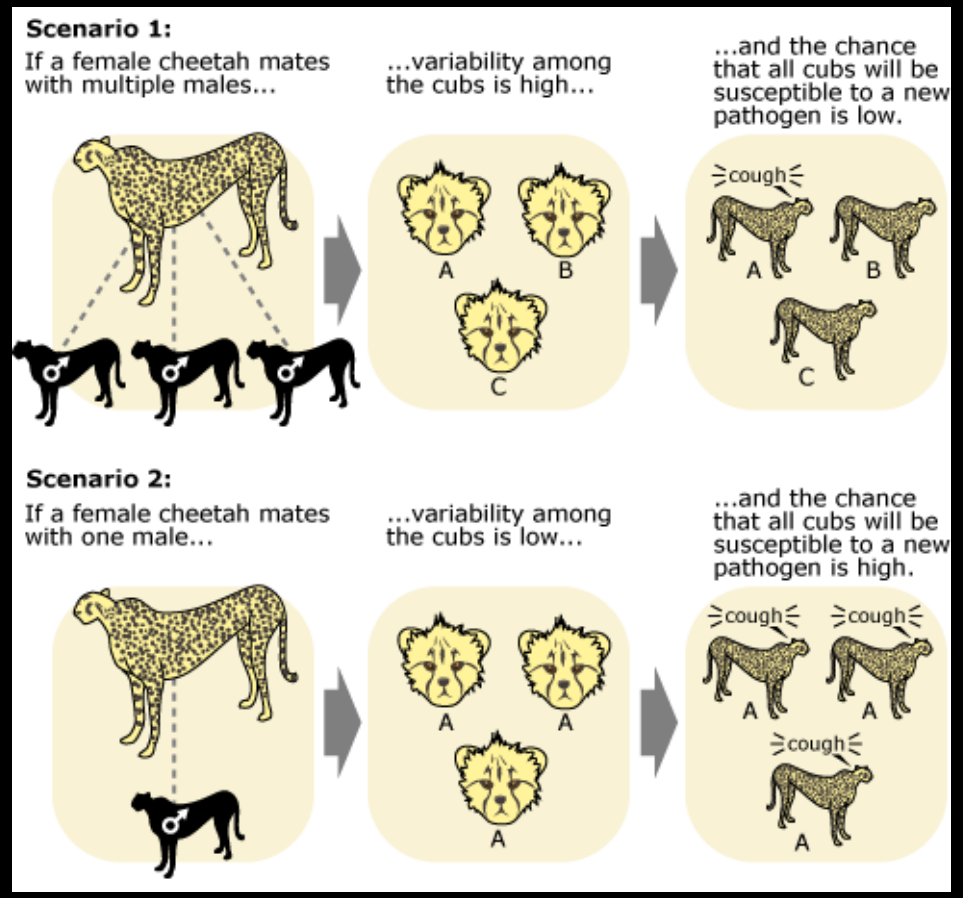
Because resources are limited in nature, organisms with heritable traits that favor survival and reproduction will tend to leave more offspring than their peers, causing the traits to increase in frequency over generations.



Fundamentals of Biodiversity: Theory of Evolution

How Natural Selection Works

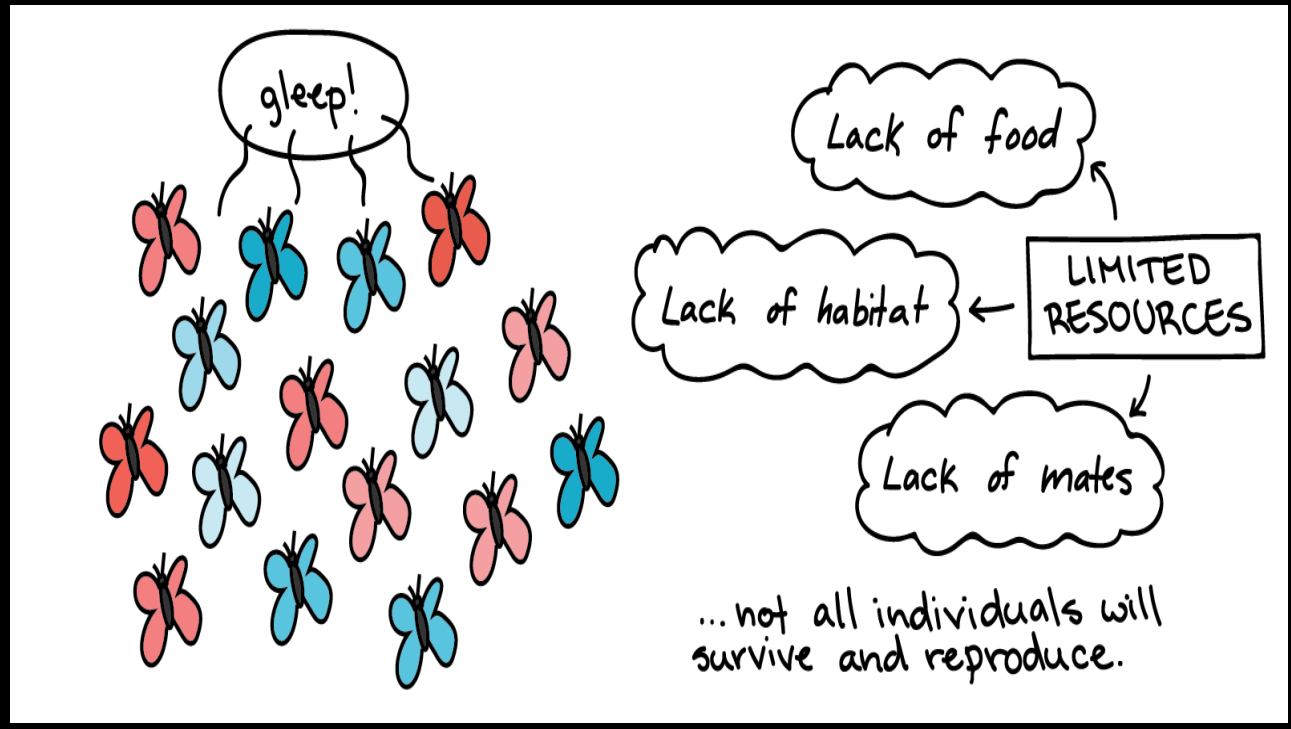
Organisms exhibit individual variation in appearance and behavior. These variations may involve body size, hair color, facial markings, voice properties, or number of offspring.



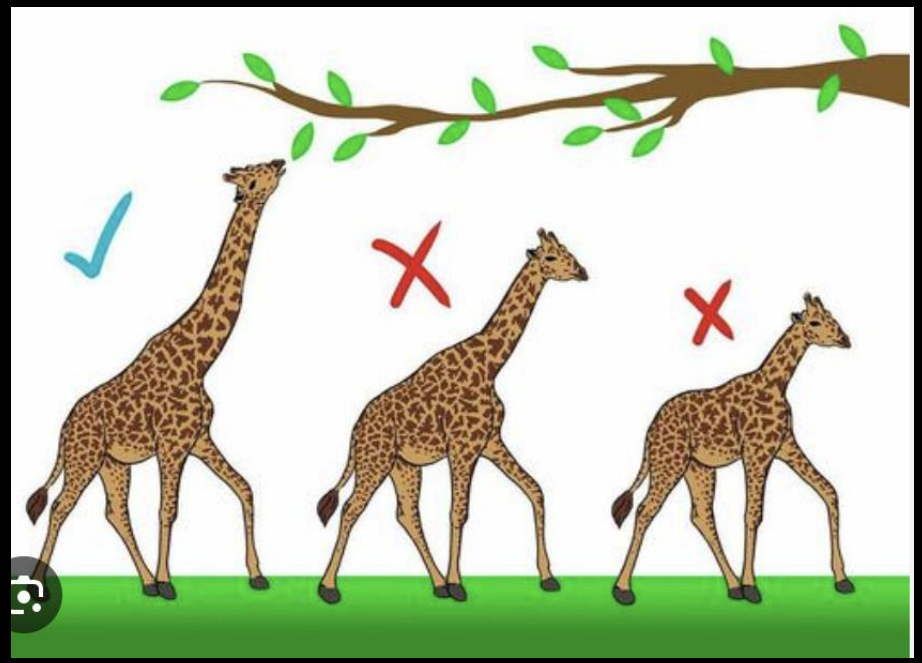
Fundamentals of Biodiversity: Theory of Evolution

How Natural Selection Works

More offspring are produced than can survive. Organisms are capable of producing more offspring than their environments can support. Thus, there is competition for limited resources in each generation. Since the environment can't support unlimited population growth, not all individuals will reproduce.



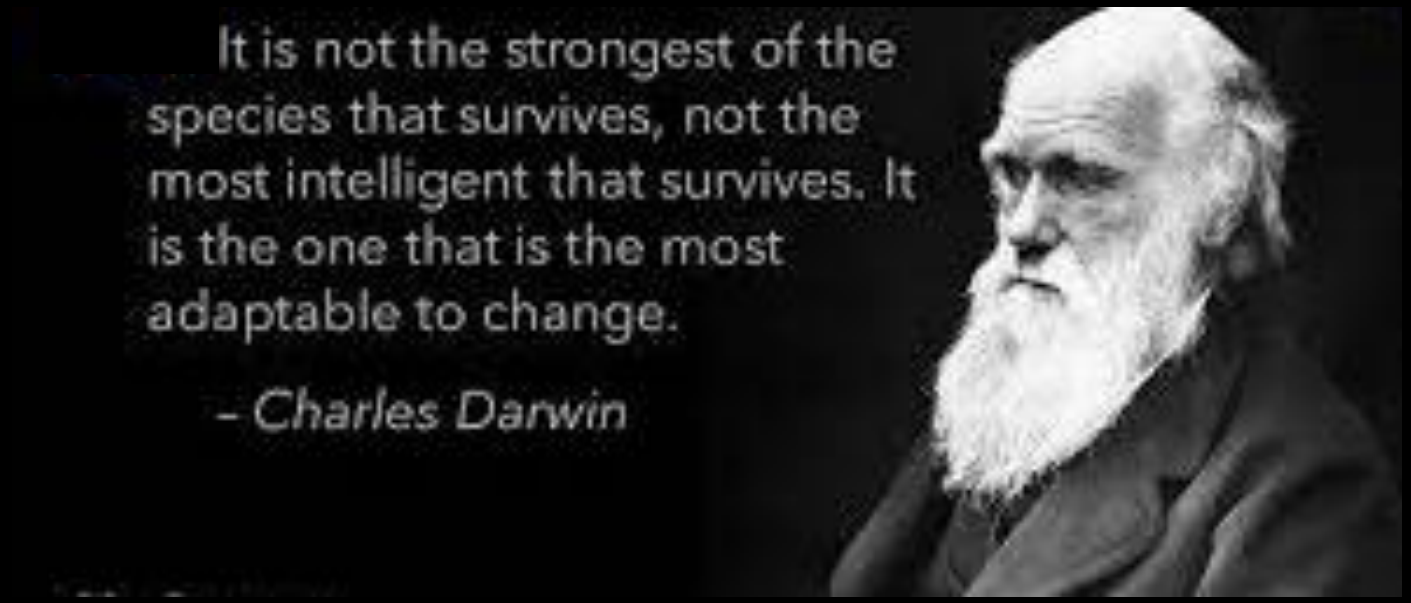
Fundamentals of Biodiversity: Theory of Evolution



Animal behavior is shaped by natural selection: many behaviors directly increase an organism's fitness, that is, they help it survive and reproduce.

What ultimately drives animal behavior is survival. Nature tends to reward the behaviors that best ensure an individual can escape predators or find food, i.e., survival of the fittest.

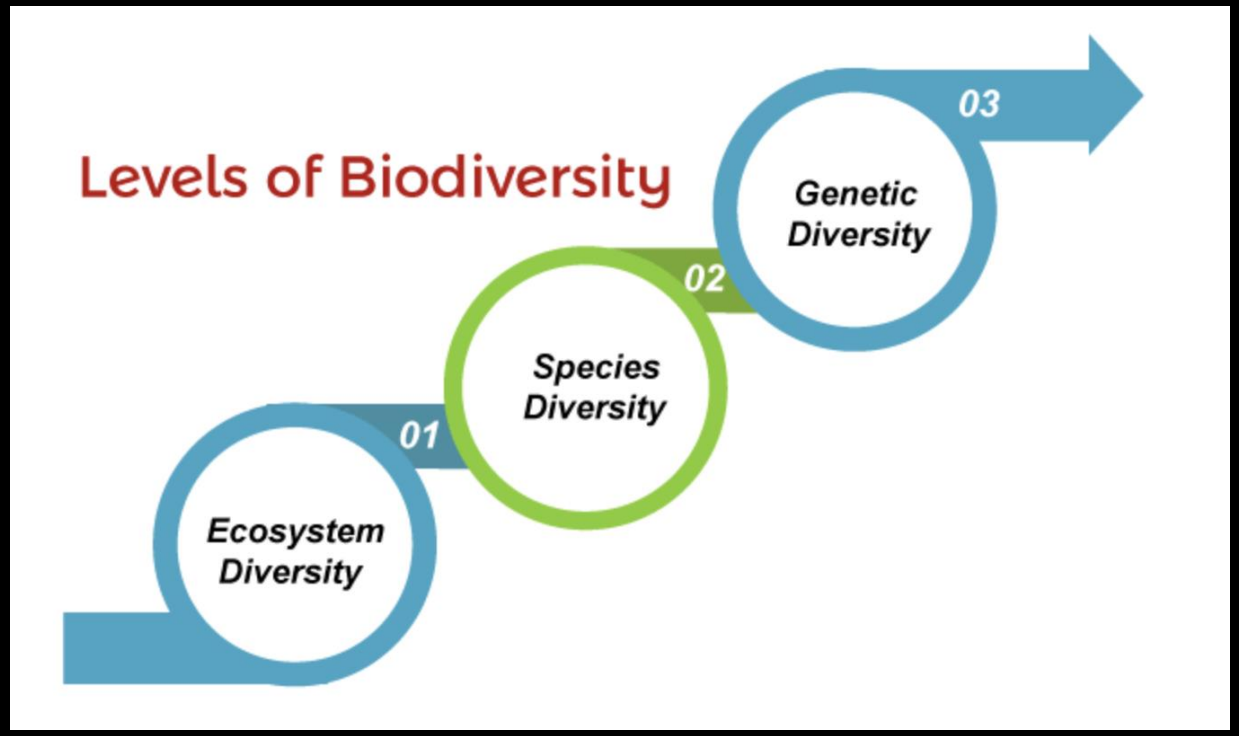
Fundamentals of Biodiversity: Theory of Evolution

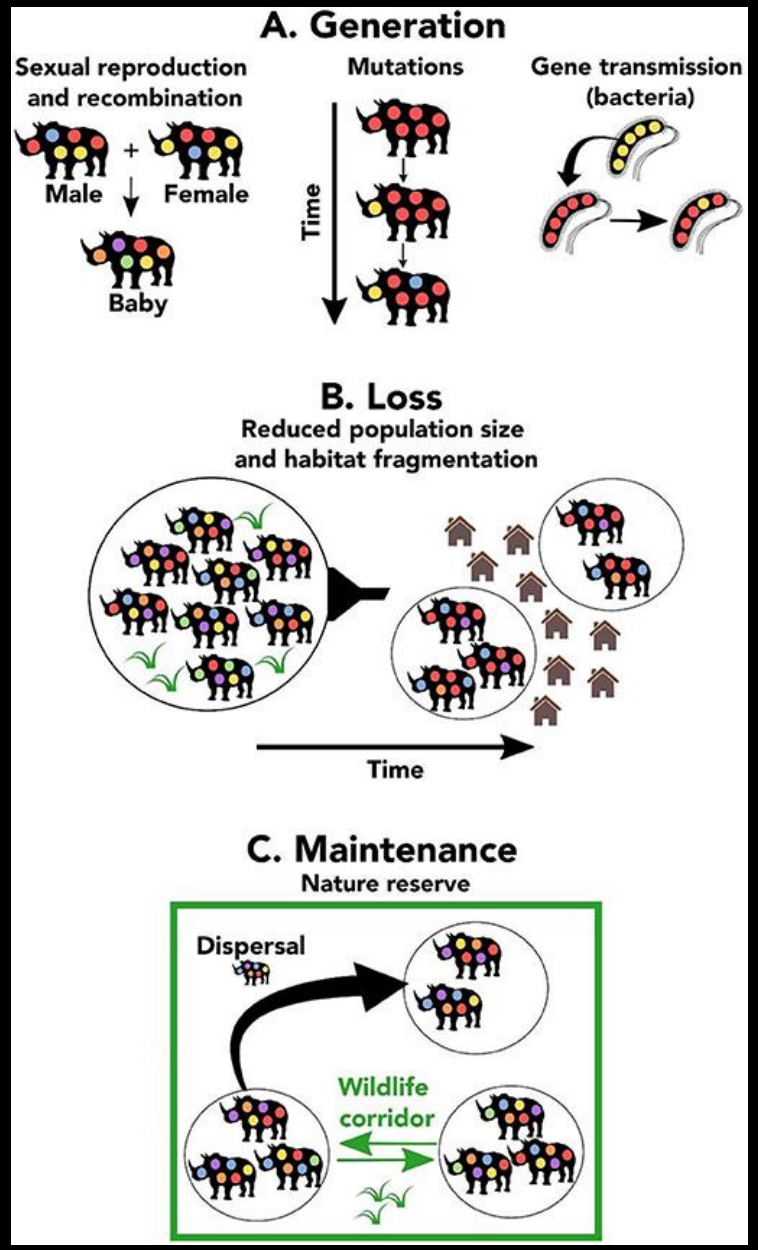


Reproductive success is a powerful force in nature and is the impetus for behaviors that ensure such success. In evolutionary terms, a life only matters insofar as the individual reproduces and passes along the genes that code for adaptive physical traits or adaptive behaviors.

Levels of Biodiversity

Biodiversity occurs at many levels, from genetic and species diversity, to ecosystem diversity. No one form of biodiversity is more important or more correct than any other. Rather, each represents a particular level of organization -- from the microscopic to the landscape -- that plays a unique role in how we can understand and appreciate all of the patterns and processes of life on Earth.





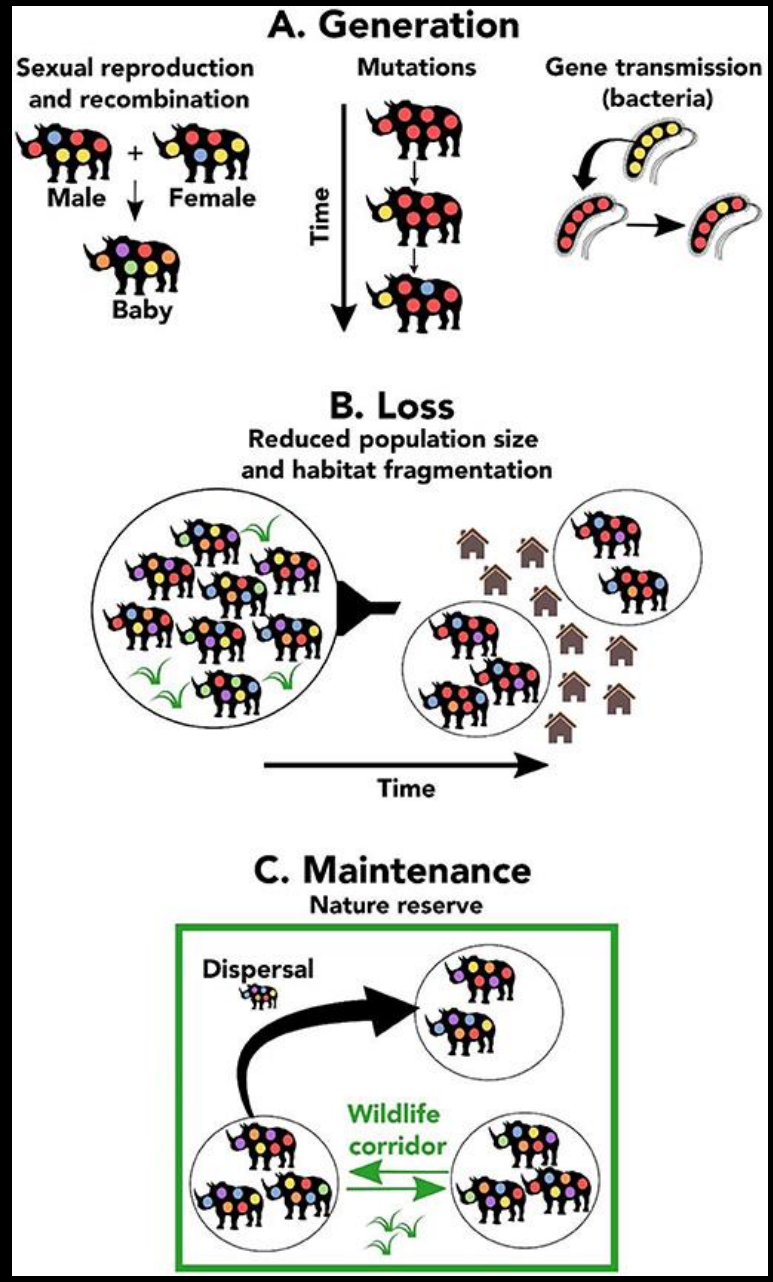
Levels of Biodiversity

Genetic diversity refers to any variation in the nucleotides, genes, chromosomes, or whole genomes of organisms. Genetic diversity is responsible for variation between individuals, populations and species.

Levels of Biodiversity

Genetic diversity among organisms exists at the following different levels:

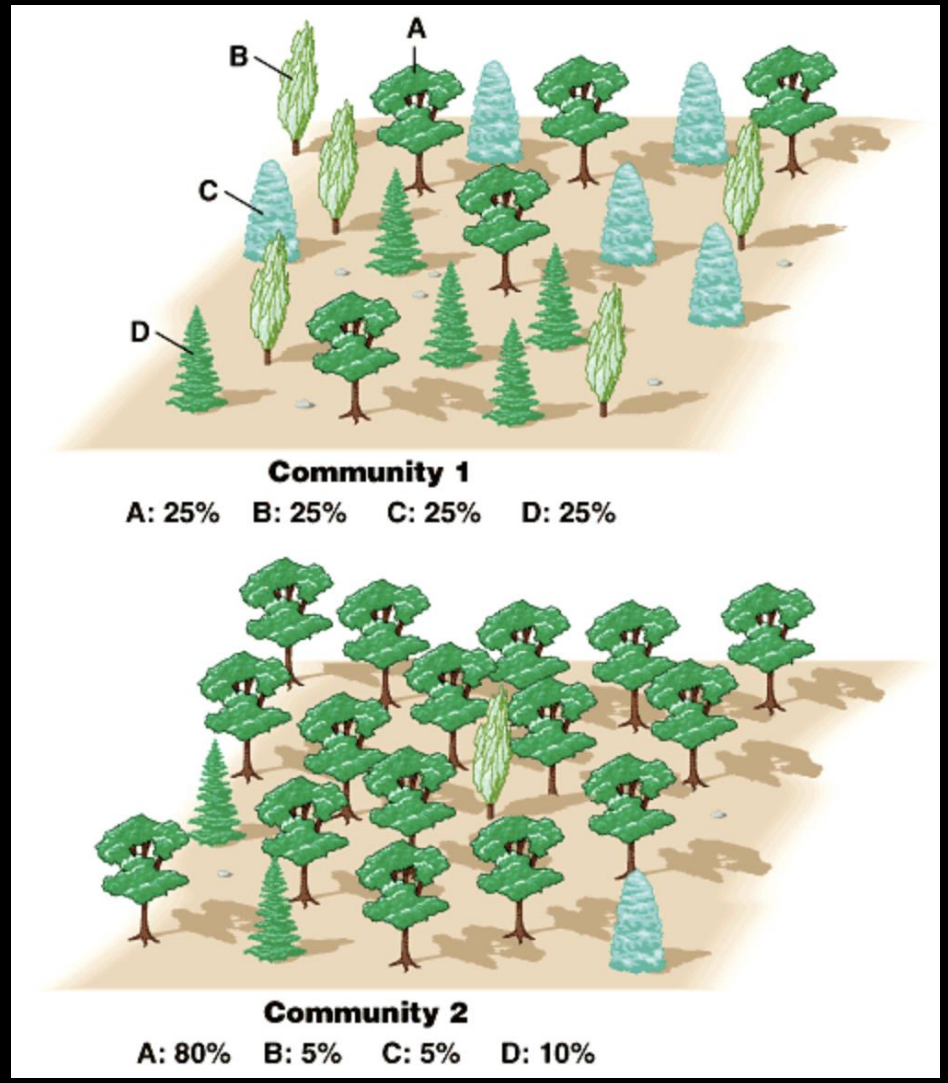
- within a single individual (e.g., different alleles of the same gene)
- between different individuals of a single population (e.g., gene mutations causing changes in some individuals within a population)
- between different populations of a single species (population diversity)
- between different species (species diversity)



Levels of Biodiversity

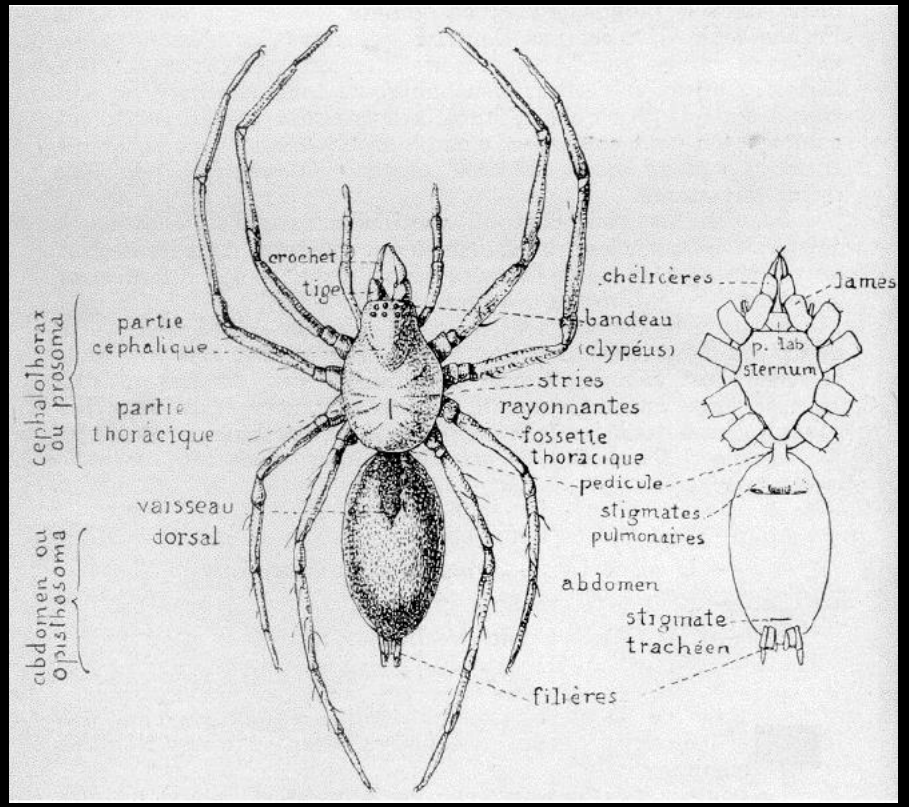
Species diversity is the number of different species in a particular area weighted by some measure of abundance such as number of individuals or biomass.

Species richness is the number of different species in a particular area.



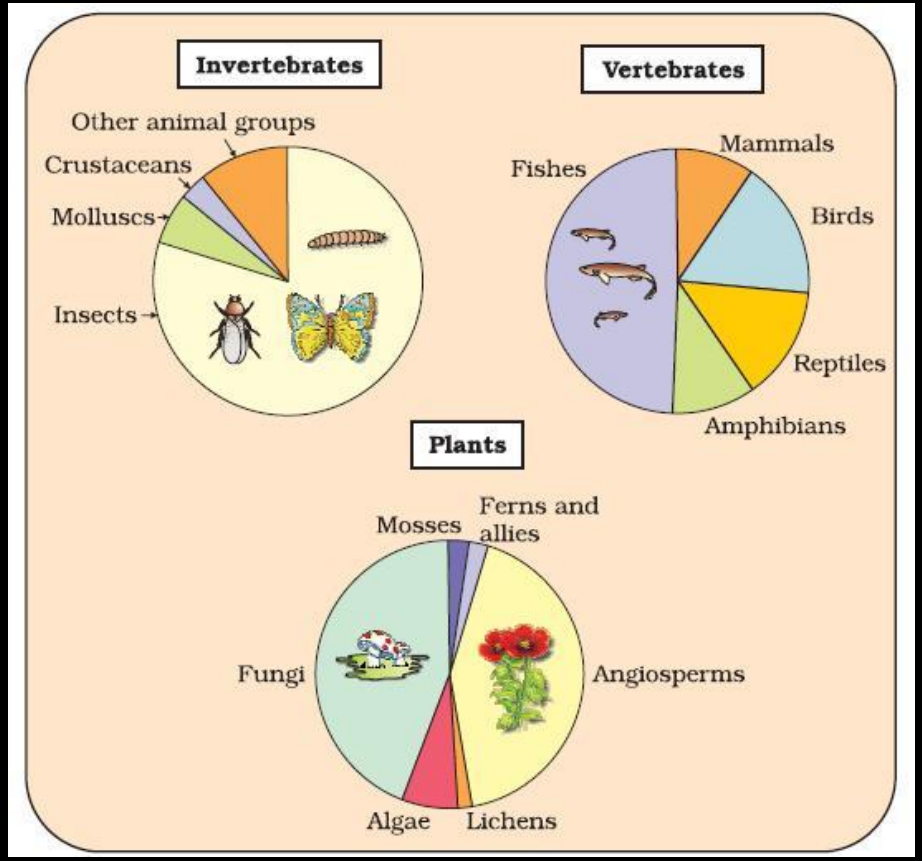
PRACTICUM: A Comparison of Spider Communities

This practicum helps you to learn how life forms are classified and how biological diversity varies at different taxonomic levels.



Levels of Biodiversity

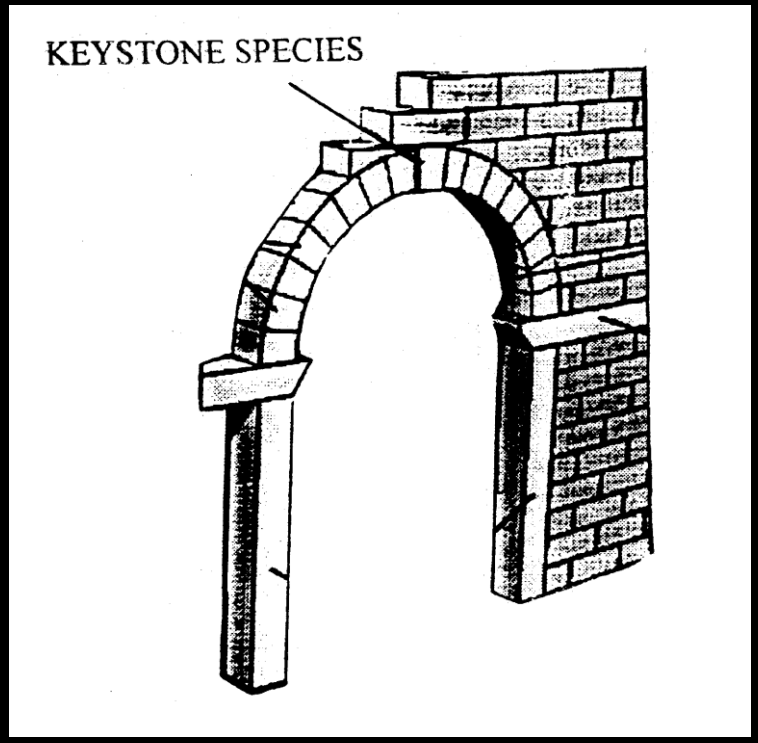
How many species are there on Earth?
Global biodiversity is frequently expressed as the total number of species currently living on Earth. Almost 2 million species have been discovered and scientifically described. These species represent only a small fraction of the total number of species on Earth today. Many additional species have yet to be discovered. Scientists estimate that the total number of species on Earth could range from 13-20 million.



Levels of Biodiversity

A keystone species is an organism that helps define an entire ecosystem. Without its keystone species, the ecosystem would be dramatically different or cease to exist altogether.

Keystone species have low functional redundancy. This means that if the species were to disappear from the ecosystem, no other species would be able to fill its ecological niche.



Levels of Biodiversity

Any organism, from plants to fungi, may be a keystone species; they are not always the largest or most abundant species in an ecosystem. A keystone species is often, but not always, a predator. Just a few predators can control the distribution and population of large numbers of prey species. Herbivores can also be keystone species. Their consumption of plants helps control the physical and biological aspects of an ecosystem.

Levels of Biodiversity

Umbrella species have large habitat needs, and the requirements of that habitat impact many other species living there. Most umbrella species are migratory, and their range may include different habitat types. The identification of an umbrella species can be an important aspect for conservation. The minimum range of an umbrella species is often the basis for establishing the size of a protected area.

Levels of Biodiversity

A flagship species acts as a symbol for an environmental habitat, movement, campaign, or issue. Flagship species are often "charismatic megafauna" – large animals with popular appeal due to their appearance or cultural significance. Flagship species may or may not be keystone or indicator species.

Levels of Biodiversity

An endemic species lives only in a certain region and its distribution is restricted to that region.

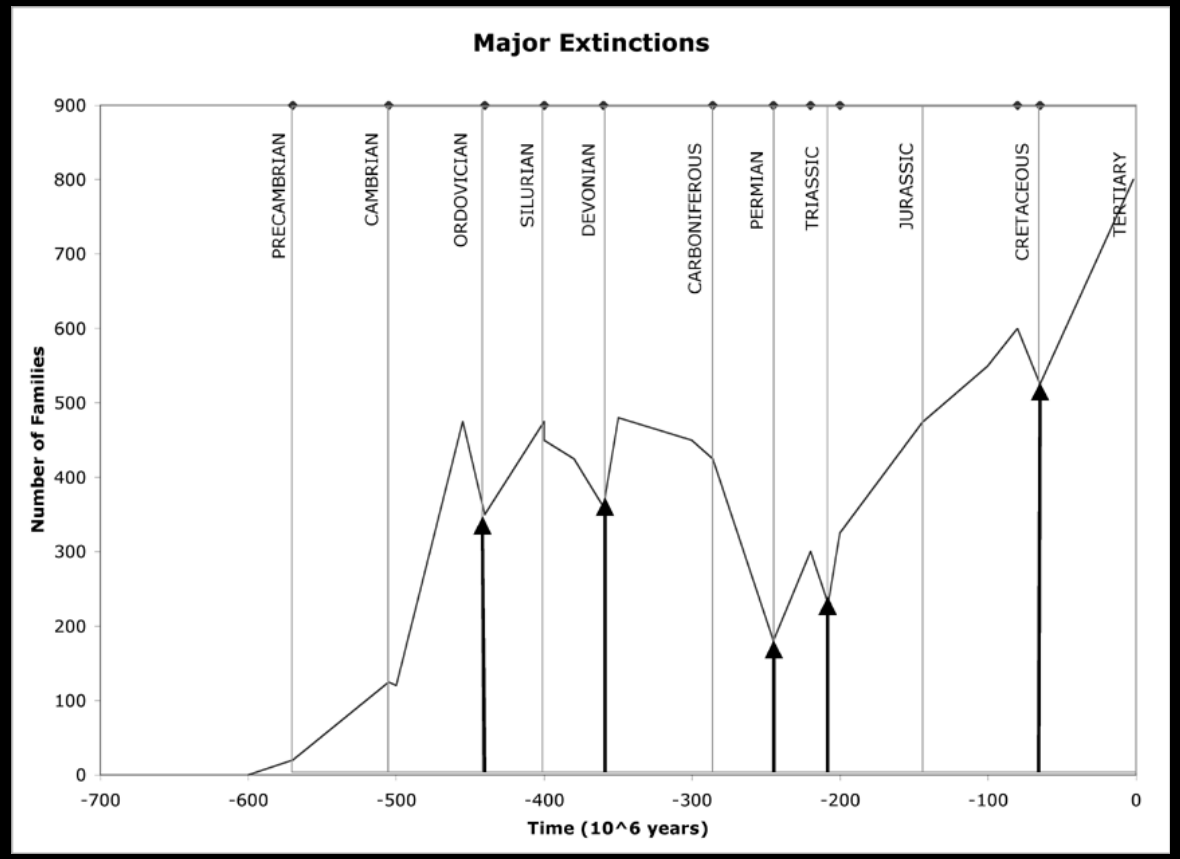
Endemism contributes to the uniqueness and special importance of the biodiversity in particular areas.

Some areas of the world have particularly high levels of endemism, e.g., islands.

Extinction: Past and Present Rates of Extinction

Extinction is the complete disappearance of a species from Earth. Thus, extinction is the final and irreversible event of species loss. Extinction is an important part of the evolution of life on Earth. The current diversity of species is a product of the processes of extinction and speciation over 3.8 billion years of life. There might be 40 million species alive today, but between 5 and 50 billion species have lived at some time during the history of the Earth. Therefore, an estimated that 99.9% of all the life that has existed on Earth is now extinct.

Extinction: Past and Present Rates of Extinction



Extinction has not occurred at a constant pace through the Earth's history. There have been at least five periods when there has been a sudden increase in the rate of extinction, and the extinctions have included representatives from many different taxonomic groups of plants and animals; these events are called mass extinctions.

Extinction: Past and Present Rates of Extinction

<u>6th Mass Extinction</u>

Homo sapiens (humans) are the present cause of a sixth major extinction in history.

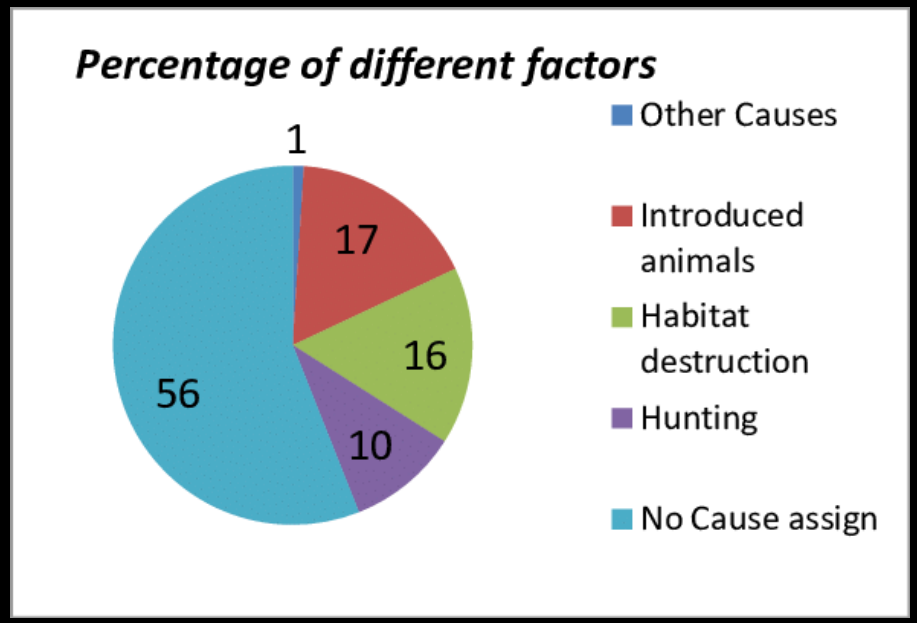
Reasons for extinction:

–human population

–habitat destruction pollution

–global climate change

–over hunting

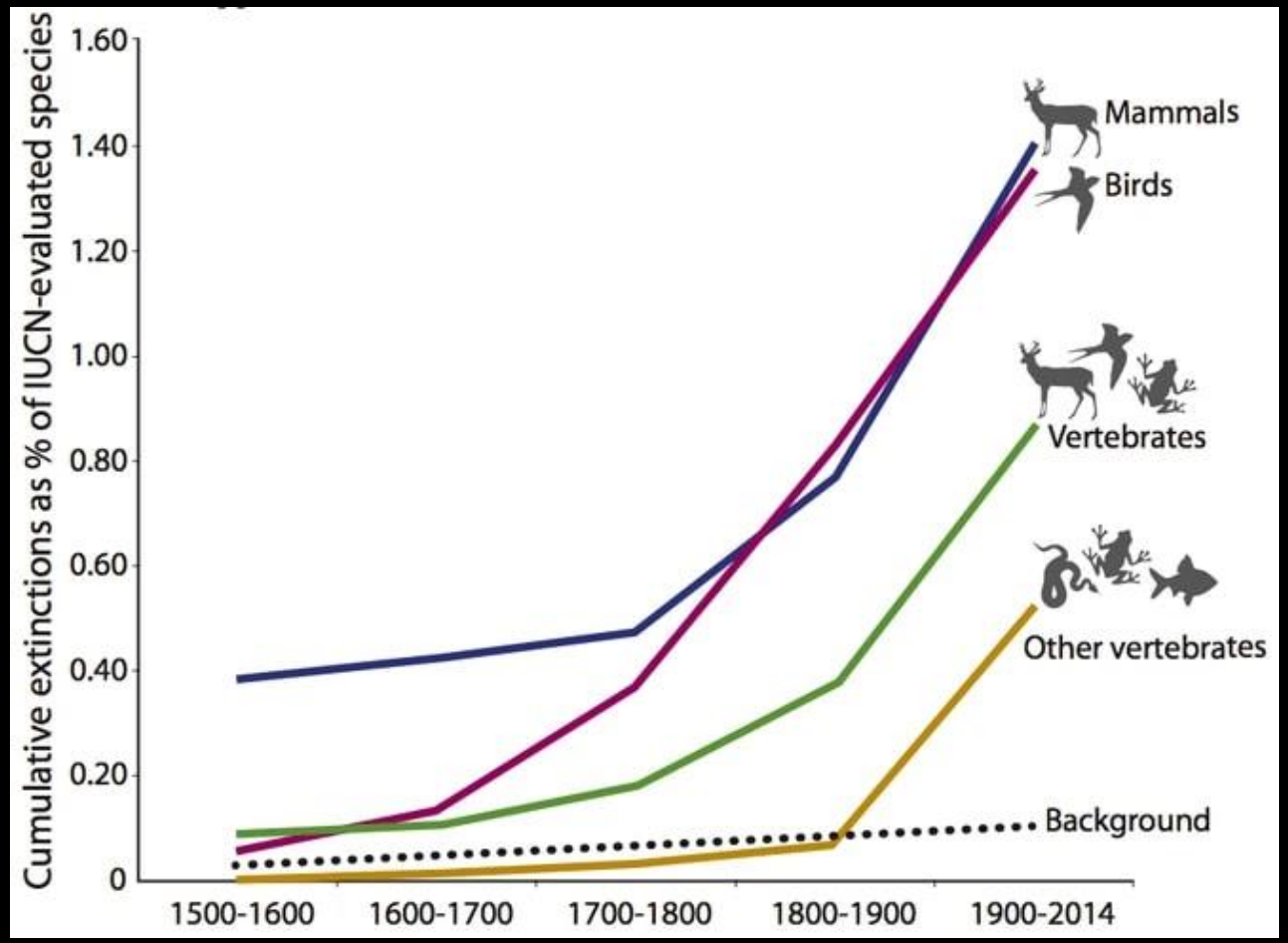


Extinction: Past and Present Rates of Extinction

The 6th Mass Extinction

- Causes – human induced
- Rate – fast!
- Breadth – many taxonomic groups affected

It can be stopped or at least slowed!



Extinction: Impacts of Extinction on Biodiversity

- The distribution of species on Earth is becoming more homogenous.
- The population size or range (or both) of the majority of species across a range of taxonomic groups is declining.
- Humans have increased the species extinction rate by as much as 1,000 times over background rates typical over the planet’s history.
- 10-30% of mammal, bird, and amphibian species are currently threatened with extinction.

Extinction: Characteristics of vulnerable species

A small geographic range makes a species particularly vulnerable to global extinction. Many of the threats to species are geographically restricted, so species with large ranges will survive somewhere even if they are locally eliminated. Species with small ranges do not have this “reserve.” Species with small geographic ranges tend to have low population densities.

Extinction: Characteristics of vulnerable species

Large animals, by virtue of their low population densities, are at increased risk of extinction. Moreover, an animal species that produces few offspring each year and that suffers a major loss in numbers from human activity will need more time to recover than a species with high reproductive rates.

Extinction: Characteristics of vulnerable species

Vulnerability is a function of intrinsic *rate of reproduction* (the larger the individual, the slower it reproduces) and the *social/commercial value* of the species to humans as a resource (e.g., ivory from rhinos and elephants, medicinal properties, etc.).

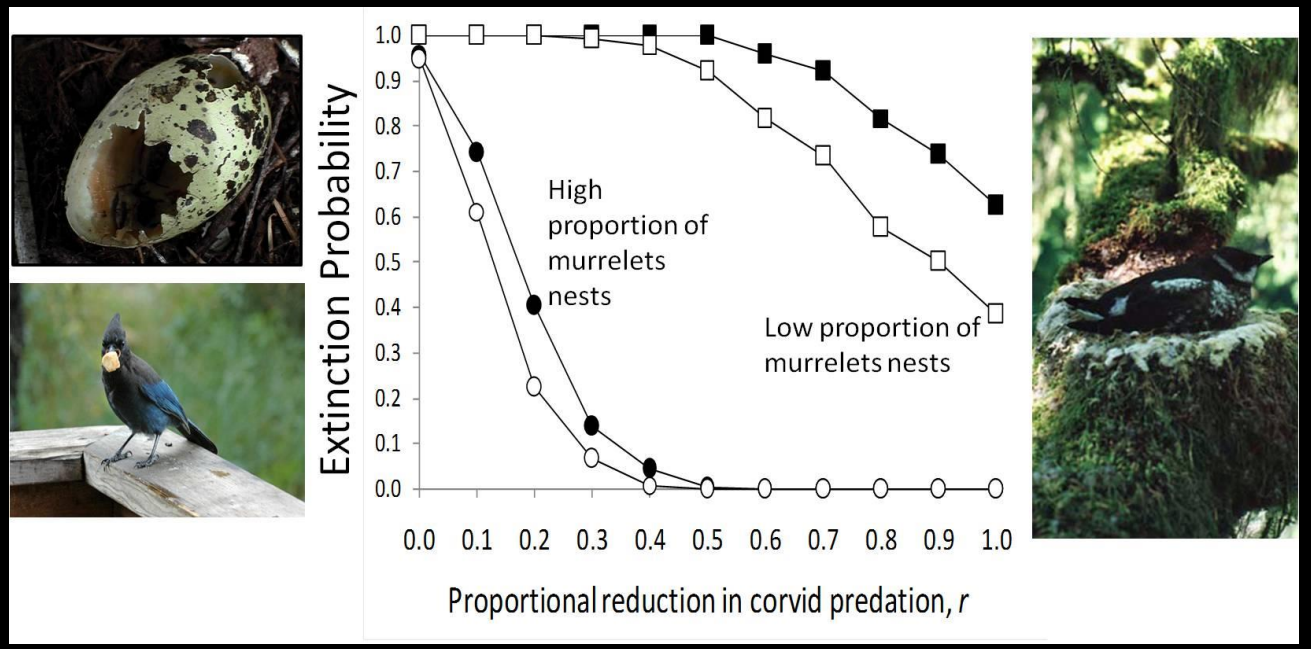
Extinction: Population Viability

Factors that contribute to the likeliness of extinction include:

1. Population decline
2. Small range and fragmentation
3. Population fragmentation
4. Very small or restricted population

Extinction: Population Viability

The minimum viable population is the population size below which the probability of extinction is increased, or the minimum number of interacting local populations necessary for long-term persistence of a population.



Where is the world's biodiversity?

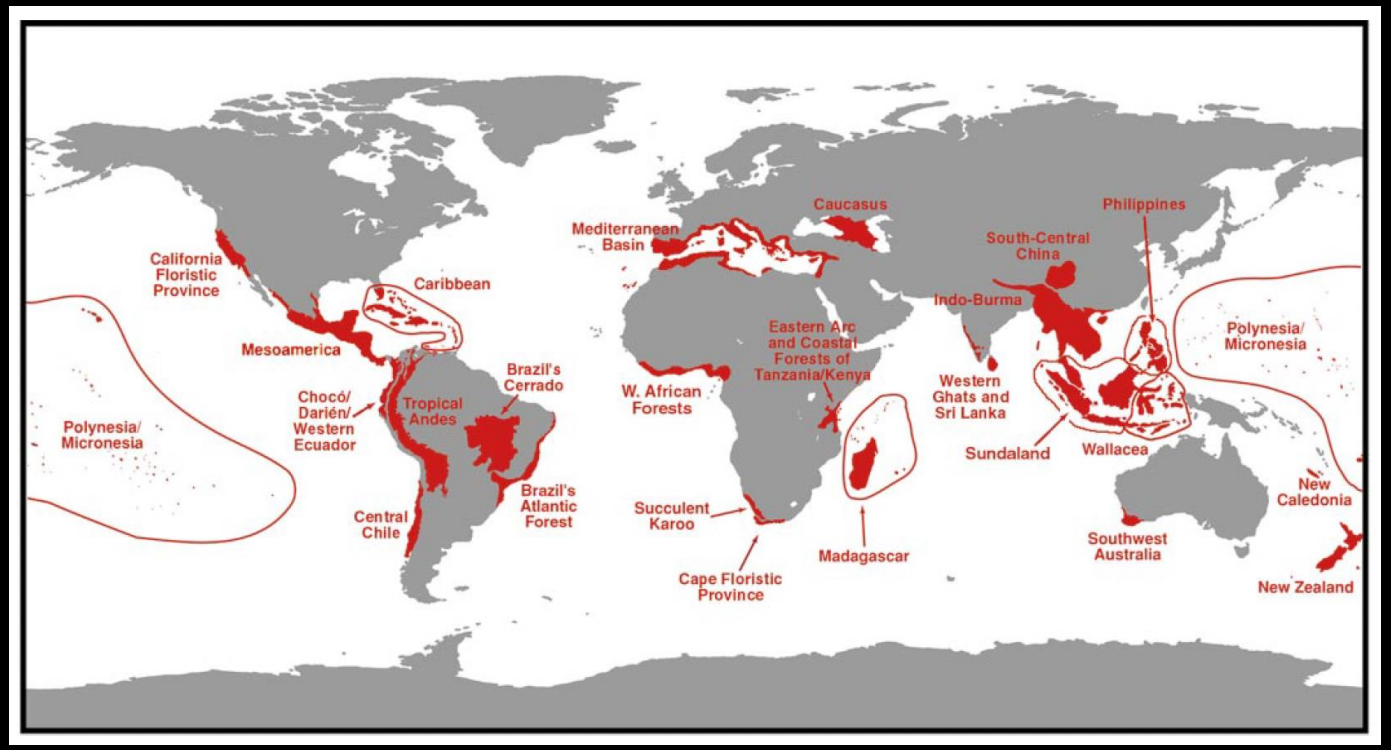
Biodiversity is not distributed evenly across the planet.

Species diversity for most taxa is lowest near the poles, and increases toward the tropics, reaching a peak in tropical rain forests (may contain more than ½ the species on Earth).

Fundamentals of Biodiversity: Readings

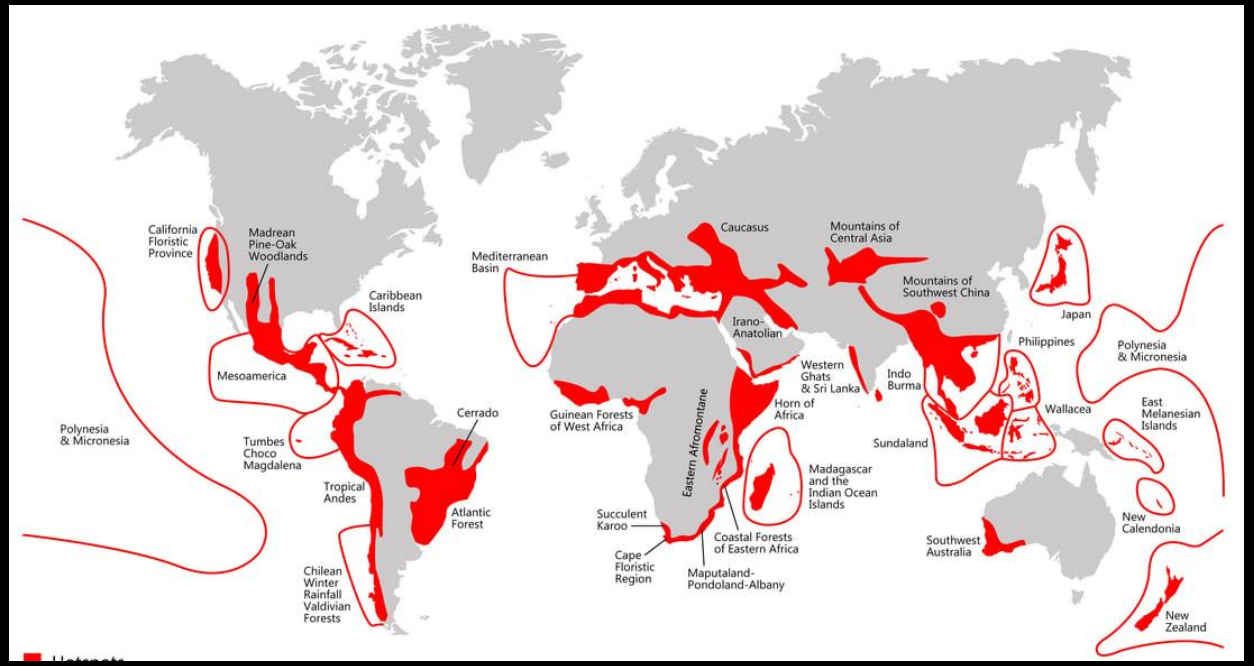
Myers et al (2000)
"Biodiversity Hotspots for Conservation"

Taylor, SJ (2005)
"African Biodiversity Hotspots"



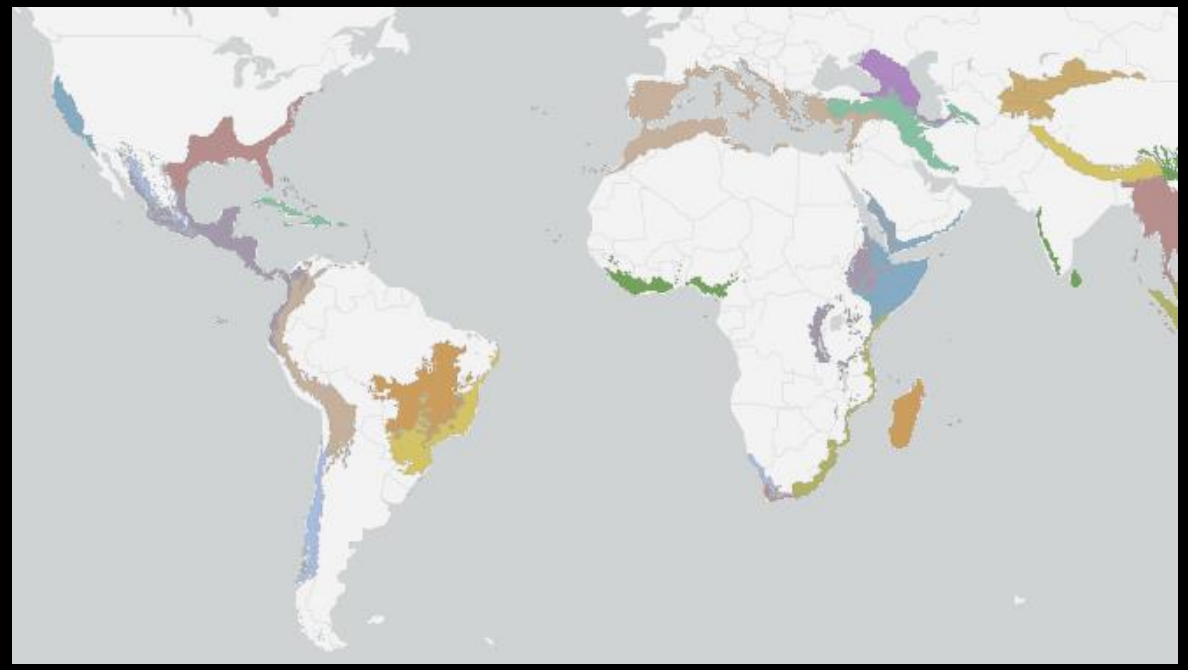
Levels of Biodiversity

Biodiversity hotspots are areas that have large numbers of species and endemic species not found anywhere else. Conservation efforts in biodiversity hotspots can protect or restore a relatively large part of the total biodiversity worldwide.



Levels of Biodiversity

Most biodiversity hotspots are in tropical regions, including the Amazon Basin, Central America, the Caribbean Islands, Western Africa, Madagascar, Western India and Southeast Asia.



Practicum: Africa's Biodiversity Hotspots

You will in small groups to design a poster that describes the important features of an African hotspot.

Biodiversity in Liberia

Liberia contains the highest remaining portion (42%) of the Upper Guinean Rainforest including plants with high rates of endemism. Liberia has over 600 bird species, 75 reptile species, 150 mammal species, etc.

READING

USAID (2018), “Liberia tropical forest biodiversity analysis”

Biodiversity in Liberia

Liberia is home to at least 2200 species of vascular plants, of which 4.7% are endemic. 1.3% of Liberia is protected under IUCN categories I-V.

Biodiversity in Liberia

Liberia’s forests shelter populations of endangered pygmy hippopotamuses, western chimpanzees, red colobus monkeys, and a number of other threatened or endangered species.

Biodiversity in Liberia

Coastal areas contain small but important tracts of mangrove forest, which protect the coast from erosion and provide spawning grounds for marine species.

Biodiversity in Liberia

Wetlands throughout the country include habitats for many bird species, both resident and migratory.

PRACTICUM: Exploring biodiversity in Bomi County

You will work in groups to identify the elements of local ecosystems and species diversity in Bomi County and the conservation threats that these ecosystems face.

Why conserve biodiversity?

Humans depend upon biodiversity in many ways, both to satisfy basic needs like food and medicine, and to enrich our lives culturally or spiritually.

Despite its importance, determining the value or worth of biodiversity is complex and often a cause for debate. This is largely due to that fact that the worth placed on biodiversity is a reflection of underlying human values, and these values vary dramatically both among societies and individuals.

Why conserve biodiversity?

Values are central to conservation decisions. When we measure biodiversity or set conservation priorities, we must decide which species, populations, or ecosystems to study, monitor, manage, or conserve, and these choices depend upon what we currently value.

Values are also the basis of arguments used to justify the conservation of species or ecosystems, for example whether a particular area is valuable for recreation, logging, or fishing.

Why conserve biodiversity?

Values are also dynamic: they change over time and vary according to specific situations. The value of biodiversity is often divided into two main categories:

- Intrinsic value, also known as inherent value
- Utilitarian value, also known as instrumental, extrinsic, or use value

Why conserve biodiversity?

If one accepts the idea that biodiversity has intrinsic value, then regardless of its use to humans or to other species, a species should be conserved.

- Intrinsic value is a central tenet of many religions. For example, many of the world's largest religions, including Christianity, Judaism, Islam, Buddhism, and Hinduism, consider everything on earth to be inherently sacred, or sacred as a result of being created by a divine being, and thus, humans are responsible to care for and respect these creations.

Why conserve biodiversity?

Utilitarian values consist of goods and values…

Goods:

- foods, medicine, fiber, genetic diversity, etc.

- Services:
  - carbon regulation, decomposition, photosynthesis, nitrogen fixation, homeostatic regulation, pest control, pollination

Why conserve biodiversity?

Utilitarian values: Food

Biodiversity played a central role in the development of agriculture, providing the original source of all crops and domesticated animals. We still depend on biodiversity to maintain healthy, sustainable agricultural systems.

Of all the plants that we depend on, none are more important than the grass family, the Gramineae. The grass family includes the world's principal staples: wheat, rice and corn (maize).

Why conserve biodiversity?

Utilitarian values: Food

For many rural peoples in developing countries, wild species are still an important source of food and income, including green leafy plants, fruits, fungi, nuts, and meat.

- The world's marine fisheries are dominated by wild-caught fish, representing 85.8 percent of the 100.2 million tons produced in 2000, according to the UN Food and Agriculture Organization.

Why conserve biodiversity?

Utilitarian values: Goods

Originating plant or animal	Product/End use
Cork oak (Quercus suber)	Cork
Pará rubber tree (Hevea brasiliensis)	Rubber
Lac insect (Laccifer spp.)	shellac
Carnauba palm (Copernicia cerifera)	carnauba wax
Cochineal insect (Dactylopius coccus)	carmine dye*

Why conserve biodiversity?

<u>Utilitarian Values: Medicine</u>

About 80% of the people in developing countries use plants as a primary source of medicine.

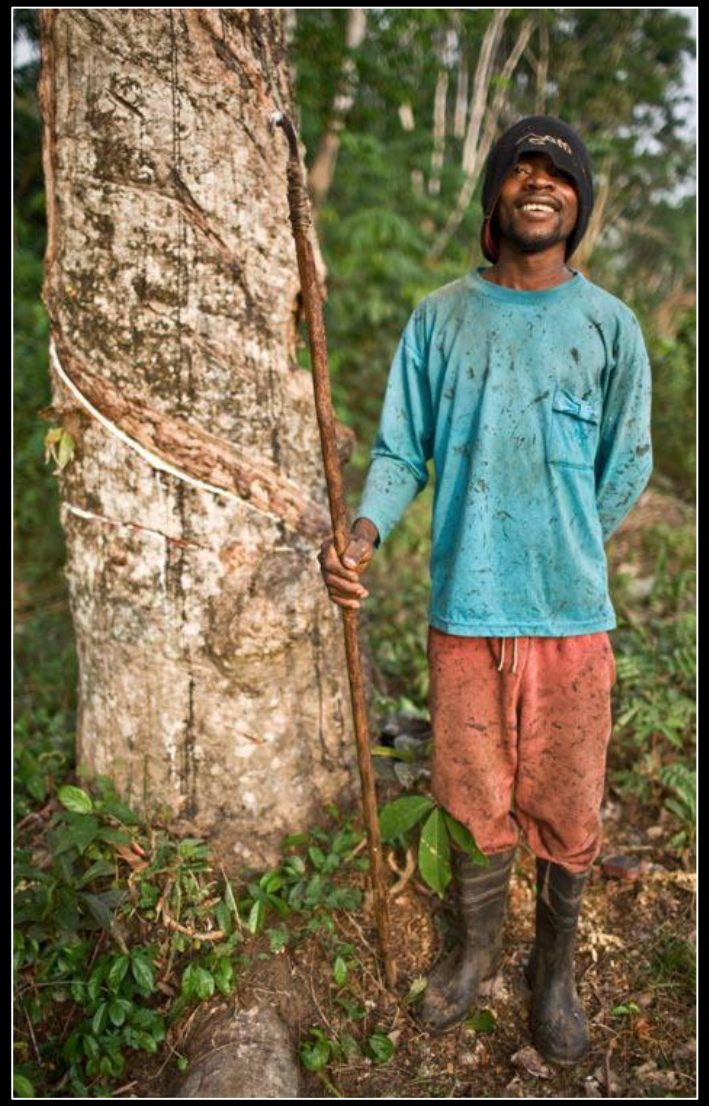
- More than ½ of the 150 most-prescribed drugs have their origins in biodiversity.

Why conserve biodiversity?

<u>Utilitarian Values: Building Materials and Fuel</u>

For rural populations, wood is an important source of energy for cooking and heating. According to the World Resources Institute, more than 50% of all harvested wood is used as fuel, burned either directly or after being converted to charcoal.

- Fuelwood, charcoal, and other fuel from wood are the major sources of energy for households in low-income countries such as Liberia.
- Charcoal is used in a variety industrial activities as well as for domestic heating purposes.



Why conserve biodiversity?

<u>Utilitarian Values: Building Materials and Fuel</u>

Forests provide jobs for more than 13 million people across the world. In addition, 300 million people live in forests, including 60 million indigenous people.

Industries dependent of forest products include: paper industry, cardboard, matches, plywood, shipping, etc.

Why Conserve Biodiversity?

Utilitarian Values: Fibers

Fibers extracted from plants and animals are used to produce textiles and cloth. While synthetic fibers, such as polyester, that are manufactured from petroleum products are increasingly common, cotton (*Gossypium* sp.) is still the single most important textile fiber in the world, and accounts for over 40% of total world fiber production.

Why conserve biodiversity?

Utilitarian Values: Spiritual

Biodiverse ecosystems provide meaning to human existence (e.g., biophilia, recreation, ecotourism)

Why Conserve Biodiversity?

Ecosystem services are benefits people obtain from ecosystems. These services can be classified into four types:

- Provisioning services, which are the products people obtain from ecosystems;
- Regulating services, which are the benefits people obtain from the regulation of ecosystem processes;
- Cultural services, which are the nonmaterial benefits people obtain from ecosystems
- Supporting services, which are the natural processes that maintain the other services.

Why Conserve Biodiversity?

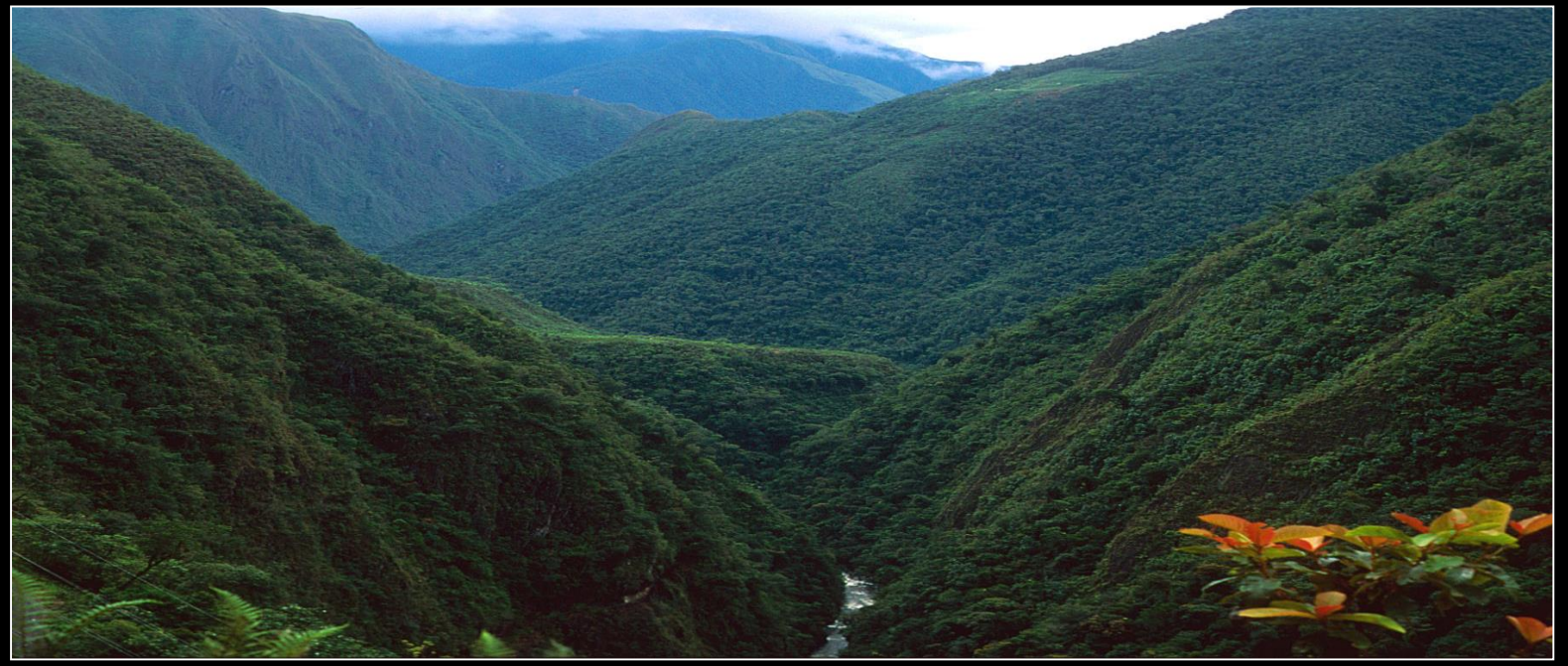
Forests provide a wide variety of ecosystem services that are critical to human welfare. These include:

- Absorbing harmful greenhouse gasses that produce climate change.
- Providing clean water for drinking, bathing, and other household needs.
- Protecting watersheds and reducing or slowing the amount of erosion and chemicals that reach waterways.
- Serving as a buffer in natural disasters like flood and rainfalls.
- Providing habitat to more than half of the world’s land-based species.

Why Conserve Biodiversity?

Services: Climate Regulation

Forests and other vegetation modify the climate by affecting sun reflectance, water vapor release, wind patterns and moisture loss.



Why Conserve Biodiversity?

Services: Soil and Water Conservation

Ecosystems filter excess nutrients and traps sediments that would otherwise impact neighboring marine and aquatic areas

Other services

- Minimize damage from waves and floods
- Serve as a nursery for juvenile commercial fish.
- Provide habitat for many birds, fish, and shellfish .

Coastal wetlands and mangroves

Why Conserve Biodiversity?

Services: Nutrient Cycling

- Nutrient cycling and soil renewal are critical for biodiversity.
- For example, nitrogen is essential for plant growth, and an insufficient quantity of it limits plant production.
- While nitrogen is abundant in the atmosphere, only a few organisms (nitrogen-fixing bacteria) can use it in this form. Nitrogen-fixing bacteria extract nitrogen from the air, and transform it into ammonia that can be absorbed by most plants.
- Microorganisms also help detoxify waste, changing waste products into forms less harmful to the environment.

Why Conserve Biodiversity?

Services: Pollination

- An estimated 90% of flowering plants depend on pollinators such as wasps, birds, bats, and bees to reproduce.
- 30% of human crops depend on free services of pollinators.

Source: Spector© AMNH-CBC

Why Conserve Biodiversity?

Services: Information

- Biomimicry
- Applied Biology
- Medical Models
- Education and Scientific Research

Why conserve biodiversity?

Services: Spiritual and Cultural Values

The survival of natural areas and species are important to different cultures around the world. Thousands of cultural groups in the world, each have distinct traditions and knowledge relating to the natural world.

Why conserve biodiversity?

Services: Aesthetics and Recreation

Recreational uses of biodiversity - fishing, hunting, and various non-consumptive uses, such as bird-watching - also contribute to the economy. One of the most rapidly growing values of biodiversity in wild ecosystems is ecotourism.