Lecture Outline

I. What is Biodiversity?

A. Biodiversity defines all the distinctive populations and species living today.

B. Biodiversity Can Be Measured and Analyzed at Several Levels:
1. Genetic diversity—the total genetic information contained within all individuals of a species.
2. Species diversity—the variety of life-forms on Earth
   a. The red panda and Indian river dolphin have few close relatives.
   b. Therefore, they are species-poor lineages. (**Fig. 55.1**)
3. Ecosystem diversity—refers to the variety of biotic communities in a region, along with the abiotic components.

C. Why Is Biodiversity Important?
1. Direct benefits of biodiversity: providing goods and services
   a. Research programs collectively known as bioprospecting focus on assessing bacteria, archaea, plants, and fungi as novel sources of drugs or ingredients in consumer products.
   b. Agricultural scientists are preserving diverse strains of crop plants in seed banks and continue to use wild relatives of domesticated species in breeding programs aimed at improving crop traits.
   c. Strategies for cleaning up oil spills, abandoned mines, and contaminated industrial sites are incorporating bioremediation—the use of bacteria, archaea, and plants to metabolize pollutants and render them harmless.
2. Indirect benefits of biodiversity: ecosystem services
   a. Ecosystem services are processes that increase the quality of the abiotic environment.
   b. Economists are attempting to quantify the dollar value of ecosystem services as a way of justifying the cost of preserving natural areas, and biologists continue to document how the loss of biodiversity is affecting the quality of the abiotic environment

II. How Do Biologists Study Biodiversity?

A. Quantifying Genetic Diversity
1. Researchers are trying to quantify levels of genetic diversity.
2. They are surveying entire communities or ecosystems rather than individual species.

B. Estimating the Total Number of Species Living Today
1. Taxon-specific surveys
   a. Example: Terry Erwin and J. C. Scott used insecticidal fog to knock down species from the top of a rain forest tree called *Luehea seemannii*. They identified over 900 different species of beetles among individuals that fell.

b. If each of the 50,000 tropical tree species harbors the same number of arthropod specialists, then the world total of arthropod species would exceed 30 million. Based on these types of studies, biologists estimate there are over 100 million species.

2. All-taxon surveys
   a. To obtain a more direct estimate of total species numbers, the first effort to find and catalog *all* forms of life present at a single site is now under way. The location is the Great Smoky Mountains National Park in the southeastern United States.
   b. A consortium of biologists and research organizations initiated this all-taxon survey in 1999. When it is complete, in 2015, biologists will have a much better database to use in estimating the extent of biodiversity. (**Fig. 55.2**)

C. Steps in Understanding Biodiversity
   1. Name the species.
   2. Ask which other species are related to it.
      a. Example: Physicians in Australia administer antivenoms to snakebite victims based on phylogenetic position of the snake in question.
      b. Each antivenom is effective against poisons from closely related snakes. (**Fig. 55.3**)
   3. Assess the species' geographic range.
   4. Understand the species' ecology, or how it interacts with other organisms and the physical environment.

D. Biodiversity and Ecosystem Function
   1. The redundancy hypothesis of ecosystem function holds that many species perform similar roles in an ecosystem, such as primary producer or decomposer. If so, then a minimal level of diversity is required for an ecosystem to function properly.
   2. In contrast, the rivet hypothesis describes an ecosystem as being like an airplane wing held together by rivets. An ecosystem's function may be compromised if certain species are lost.
   3. Example: David Tilman and colleagues classified 32 grassland plant species into five categories. They compared the productivity of plots with different mixes of species numbers and functional groups, and found that both the number and type of species present had important effects. (**Fig. 55.4**)

III. Threats to Biodiversity

A. Humans Have Affected Biodiversity throughout History
   1. Fossil evidence on islands in the South Pacific suggests that about 2000 bird species were wiped out as people colonized this area between about A.D. 400 and 1600.

2. When European settlers arrived on Easter Island in 1722, about 1000 people lived there. The island was treeless. Soil samples analyzed confirmed that the island was once a lush forest. (**Fig. 55.5**)

B. Current Threats to Biodiversity
   1. As a growing human population consumes Earth's resources to fulfill its needs and desires, biodiversity is being degraded or destroyed at the genetic, species, and ecosystem levels. (**Fig. 55.6a**)
   2. Invasive species—exotic species that are introduced to a new area, spread rapidly, and eliminate native species—are implicated in the demise of one-third to one-half of all species currently listed as endangered or threatened in the United States. (**Fig. 55.6b**)
   3. We cause habitat destruction by logging and burning forests, damming rivers, dredging and trawling the oceans, plowing prairies, grazing livestock, filling in wetlands, and excavating and extracting minerals to build housing developments, golf courses, shopping centers, office complexes, airports, and roads. (**Fig. 55.6e**)
   4. This turns large, contiguous areas of natural habitats into small, isolated fragments. (**Fig. 55.6f**)
   5. Habitat fragmentation concerns biologists because:
      a. Habitats can be too small to support some species.
      b. It reduces the ability for some animals to disperse.
      c. It creates a large amount of vulnerable edge habitat.
   6. Example: A wide distribution of plot sizes allowed a research team to monitor changes inside forest fragments of different sizes and to compare these changes to conditions in unfragmented forest. (**Fig. 55.7**)
   7. Biologists are also beginning to document population declines due to domino effects—impacts on other species resulting from the loss of a different species. (**Fig. 55.6g**)

C. How Can Biologists Predict Future Extinction Rates?
   1. Species-area relationships measure rates of habitat destruction to projected rates of species loss.
   2. Researchers compared satellite images of the Amazon Basin from 1978 and 1988. Their analysis showed that 5000 km^2 were deforested in the Amazon each year during this decade. (**Fig. 55.8**)
   3. Researchers have used species-area curves to analyze the number of bird species found on islands in the Bismarck Archipelago near New Guinea. (**Fig. 55.9**)
   4. Biologists want to understand how many species are currently threatened so they can estimate how many will go extinct in the near future.
   5. The "red list" compiled by the International Union for the Conservation of Nature tracks species that are extremely rare or whose populations are in steep decline.

IV. Conserving Biodiversity: Biology, Sociobiology, Economics, and Politics

A. The Role of Governmental and Private Agencies
1. One of the most important biological goals in conservation work is to establish a baseline, or reference point, that provides a standard for evaluating changes in diversity of alleles, species, and ecosystems.
2. International agreements
a. The Convention on Biological Diversity (CBD) was the first global agreement on the conservation and sustainable use of biological diversity and has now been formally ratified in over 175 countries.
b. The CBD has three main goals:
(1) Conserve biodiversity.
(2) Promote sustainable use of biodiversity.
(3) Share commercial benefits of biodiversity equitably, especially with respect to genetic diversity.
3. National agencies
a. The U.S. Department of the Interior has several agencies that are charged with managing biological resources, including the Bureau of Land Management, the Fish & Wildlife Service, and the National Park Service.
b. In the ocean realm, the National Marine Fisheries Service, under the U.S. Department of Commerce, is charged with managing and conserving marine organisms.
4. Nongovernmental organizations
a. NGOs play a vital role in drawing public attention to specific conservation issues and generating grassroots awareness and support.
b. Some of the largest and most familiar NGOs involved in biodiversity conservation are Conservation International, The Nature Conservancy, and the World Wildlife Fund.

B. Conservation Strategies
1. In situ conservation: protected areas
a. In situ conservation is usually achieved by governments protecting designated areas from development. In theory, it allows wild populations to continue to evolve and to be used by indigenous people who depend on them for food, fuel, or medicine.
2. Ex situ conservation: zoos, aquaria, and botanical gardens
a. These locations can serve to propagate species in captivity for possible reintroduction into the wild.
b. They also play a key role in educating the general public about the importance of biodiversity and the need to conserve it. People have to care about biodiversity before they will work to protect it.

C. Looking to the Future

1. The conservation community's common goal was sustainable development, or economic progress for local communities based on using certain species or resources carefully enough that they could regenerate and not decline over time.
2. This concept has recently been expanded to adaptive management, which recognizes that the design, management, and monitoring of conservation programs are inseparable.
3. Example: In southeast Arizona and southwest Mexico, a group of ranchers have reintroduced fire to the area via prescribed burns that remove encroaching woody shrubs and encourage growth of native grasses. (**Fig. 55.10**)
4. Example: In the tropics, one of the most successful restoration projects is that of the dry forest at the Area de Conservación Guanacaste in northwestern Costa Rica. In just 15 years, the conservationists' efforts have succeeded in transforming a vast swath of marginal ranching land into an increasingly popular tourist destination and water source for neighboring farms and ranches. (**Fig. 55.11**)