

# THE BIOSPHERE

## INTRODUCTION

The **biosphere** is the region of the earth that encompasses all living organisms: plants, animals and bacteria. It is a feature that distinguishes the earth from the other planets in the solar system. "Bio" means life, and the term biosphere was first coined by a Russian scientist (Vladimir Vernadsky) in the 1920s. Another term sometimes used is **ecosphere** ("eco" meaning home). The biosphere includes the outer region of the earth (the **lithosphere**) and the lower region of the atmosphere (the **troposphere**). It also includes the **hydrosphere**, the region of lakes, oceans, streams, ice and clouds comprising the earth's water resources.

Traditionally, the biosphere is considered to extend from the bottom of the oceans to the highest mountaintops, a layer with an average thickness of about 20 kilometers. Scientists now know that some forms of microbes live at great depths, sometimes several thousand meters into the earth's crust. Nonetheless, the biosphere is a very tiny region on the scale of the whole earth, analogous to the thickness of the skin on an apple. The bulk of living organisms actually live within a smaller fraction of the biosphere, from about 500 meters below the ocean's surface to about 6 kilometers above sea level.

Dynamic interactions occur between the biotic region (biosphere) and the abiotic regions (atmosphere, lithosphere and hydrosphere) of the earth. Energy, water, gases and nutrients are exchanged between the regions on various spatial and time scales. Such exchanges depend upon, and can be altered by, the environments of the regions. For example, the chemical processes of early life on earth (e.g. photosynthesis, respiration, carbonate formation) transformed the reducing ancient atmosphere into the oxidizing (free oxygen) environment of today. The interactive processes between the biosphere and the abiotic regions work to maintain a kind of planetary equilibrium. These processes, as well as those that might disrupt this equilibrium, involve a range of scientific and socioeconomic issues.

The study of the relationships of living organisms with one another and with their environment is the science known as **ecology**. The word ecology comes from the Greek words *oikos* and *logos*, and literally means "study of the home." The ecology of the earth can be studied at various levels: an **individual** (organism), a **population**, a **community**, an **ecosystem**, a **biome** or the entire **biosphere**. The variety of living organisms that inhabit an environment is a measure of its **biodiversity**.

## POPULATIONS AND COMMUNITIES

A number of individuals of the same species in a given area constitute a **population**. The number typically ranges anywhere from a few individuals to several thousand individuals. Bacterial populations can number in the millions. Populations live in a place or environment called a **habitat**. All of the populations of species in a given region together make up a **community**. In an area of tropical grassland, a community might be made up of grasses, shrubs, insects, rodents and various species of hoofed mammals.

The populations and communities found in a particular environment are determined by abiotic and biotic **limiting factors**. These are the factors that most affect the success of populations. Abiotic limiting factors involve the physical and chemical characteristics of the environment. Some of these factors include: amounts of sunlight, annual rainfall, available nutrients, oxygen levels and temperature. For example, the amount of annual rainfall may determine whether a region is a grassland or forest, which in turn, affects the types of animals living there.

Each population in a community has a **range of tolerance** for an abiotic limiting factor. There are also certain maximum and minimum requirements known as **tolerance limits**, above and below which no member of a population is able to survive. The range of an abiotic factor that results in the largest population of a species is known as the **optimum range** for that factor. Some populations may have a narrow range of tolerance for one factor. For example, a freshwater fish species may have a narrow tolerance range for dissolved oxygen in the water. If the lake in which that fish species lives undergoes eutrophication, the species will die. This fish species can therefore act as an

**indicator species**, because its presence or absence is a strict indicator of the condition of the lake with regard to dissolved oxygen content.

Biotic limiting factors involve interactions between different populations, such as competition for food and habitat. For example, an increase in the population of a meat-eating predator might result in a decrease in the population of its plant-eating prey, which in turn might result in an increase in the plant population the prey feeds on. Sometimes, the presence of a certain species may significantly affect the community make up. Such a species is known as a **keystone species**. For example, a beaver builds a dam on a stream and causes the meadow behind it to flood. A starfish keeps mussels from dominating a rocky beach, thereby allowing many other species to exist there.

## BIOMES

The biosphere can be divided into relatively large regions called **biomes**. A biome has a distinct climate and certain living organisms (especially vegetation) characteristic to the region and may contain many ecosystems. The key factors determining climate are average annual precipitation and temperature. These factors, in turn, depend on the geography of the region, such as the latitude and elevation of the region, and mountainous barriers. The major types of biomes include: **aquatic, desert, forest, grassland** and **tundra**. Biomes have no distinct boundaries. Instead, there is a transition zone called an **ecotone**, which contains a variety of plants and animals. For example, an ecotone might be a transition region between a grassland and a desert, with species from both. Water covers a major portion of the earth's surface, so aquatic biomes contain a rich diversity of plants and animals.

**Aquatic biomes** can be subdivided into two basic types: **freshwater** and **marine**. Freshwater has a low salt concentration, usually less than 1 percent, and occurs in several types of regions: ponds and lakes, streams and rivers, and wetlands. **Ponds and lakes** range in size, and small ponds may be seasonal. They sometimes have limited species diversity due to isolation from other water environments. They can get their water from precipitation, surface runoff, rivers, and springs. **Streams and rivers** are bodies of flowing water moving in one general direction (i.e., downstream). Streams and rivers start at their upstream headwaters, which could be springs, snowmelt or even lakes. They continue downstream to their mouths, which may be another stream, river, lake or ocean. The environment of a stream or river may change along its length, ranging from clear, cool water near the head, to warm, sediment-rich water near the mouth. The greatest diversity of living organisms usually occurs in the middle region.

Wetlands are places of still water that support aquatic plants, such as cattails, pond lilies and cypress trees. Types of wetlands include marshes, swamps and bogs. **Wetlands** have the highest diversity of species with many species of birds, fur-bearing mammals, amphibians and reptiles. Some wetlands, such as salt marshes, are not freshwater regions.

**Marine regions** cover nearly three-fourths of the earth's surface. Marine bodies are salty, having approximately 35 grams of dissolved salt per liter of water (3.5 percent). **Oceans** are very large marine bodies that dominate the earth's surface and hold the largest ecosystems. They contain a rich diversity of living organisms. Ocean regions can be separated into four major zones: **intertidal, pelagic, benthic** and **abyssal**. The intertidal zone is where the ocean meets the land. Sometimes, it is submerged and at other times exposed, depending upon waves and tides. The pelagic zone includes the open ocean further away from land. The benthic zone is the region below the pelagic zone, but not including the very deepest parts of the ocean. The bottom of this zone consists of sediments.

The deepest parts of the ocean are known as the abyssal zone. This zone is very cold (near freezing temperatures), and under great pressure from the overlying mass of water. Mid-ocean ridges occur on the ocean floor in abyssal zones.

**Coral reefs** are found in the warm, clear, shallow waters of tropical oceans around islands or along continental coastlines. They are mostly formed from calcium carbonate produced by living coral. Reefs provide food and shelter for other organisms and protect shorelines from erosion. Estuaries are partially enclosed areas where fresh water and silt from streams or rivers mix with salty

ocean water. They represent a transition from land to sea and from freshwater to saltwater. Estuaries are biologically very productive areas and provide homes for a wide variety of plants, birds and animals.

Deserts are dry areas where evaporation usually exceeds precipitation. Rainfall is low -- less than 25 centimeters per year -- and can be highly variable and seasonal. The low humidity results in temperature extremes between day and night. Deserts can be hot or cold. **Hot deserts** (e.g. the Sonoran) are very hot in the summer and have relatively high temperatures throughout the year and have seasonal rainfall. **Cold deserts** (e.g. the Gobi) are characterized by cold winters and low but year-round precipitation. Deserts have relatively little vegetation and the substrate consists mostly of sand, gravel or rocks. The transition regions between deserts and grasslands are sometimes called **semiarid deserts** (e.g. the Great Basin of the western United States).

Grasslands cover regions where moderate rainfall is sufficient for the growth of grasses, but not enough for stands of trees. There are two main types of grasslands: **tropical grasslands** (savannas) and **temperate grasslands**. Tropical grasslands occur in warm climates such as Africa and very limited regions of Australia. They have a few scattered trees and shrubs, but their distinct rainy and dry seasons prevent the formation of tropical forests. Lower rainfall, more variable winter-through-summer temperatures and a near lack of trees characterize temperate grasslands. Prairies are temperate grasslands at fairly high elevation. They may be dominated by long or short grass species. The vast prairies originally covering central North America, or the Great Plains, were the result of favorable climate conditions created by their high elevation and proximity to the Rocky Mountains. Because temperate grasslands are treeless, relatively flat and have rich soil, most have been replaced by farmland.

Forests are dominated by trees and can be divided into three types: **tropical forests**, **temperate forests** and **boreal forests**. Tropical forests are always warm and wet and are found at lower latitudes. Their annual precipitation is very high, although some regions may have distinct wet and dry seasons. Tropical forests have the highest biodiversity of this biome. Temperate forests occur at mid-latitudes (i.e., North America), and therefore have distinct seasons. Summers are warm and winters are cold. The temperate forests have suffered considerable alteration by humans, who have cleared much of the forest land for fuel, building materials and agricultural use. Boreal forests are located in higher latitudes, like Siberia, where they are known as "taiga." They have very long, cold winters and a short summer season when most of the precipitation occurs.

Boreal forests represent the largest biome on the continents. Very low temperatures, little precipitation and low biodiversity characterize tundra. Its vegetation is very simple, with virtually no trees. The tundra can be divided into two different types: **arctic tundra** and **alpine tundra**. The arctic alpine occurs in polar regions. It has a very short summer growing season. Water collects in ponds and bogs, and the ground has a subsurface layer of permanently frozen soil known as permafrost. Alpine tundra is found at high elevations in tall mountains. The temperatures are not as low as in the arctic tundra, and it has a longer summer growing season.