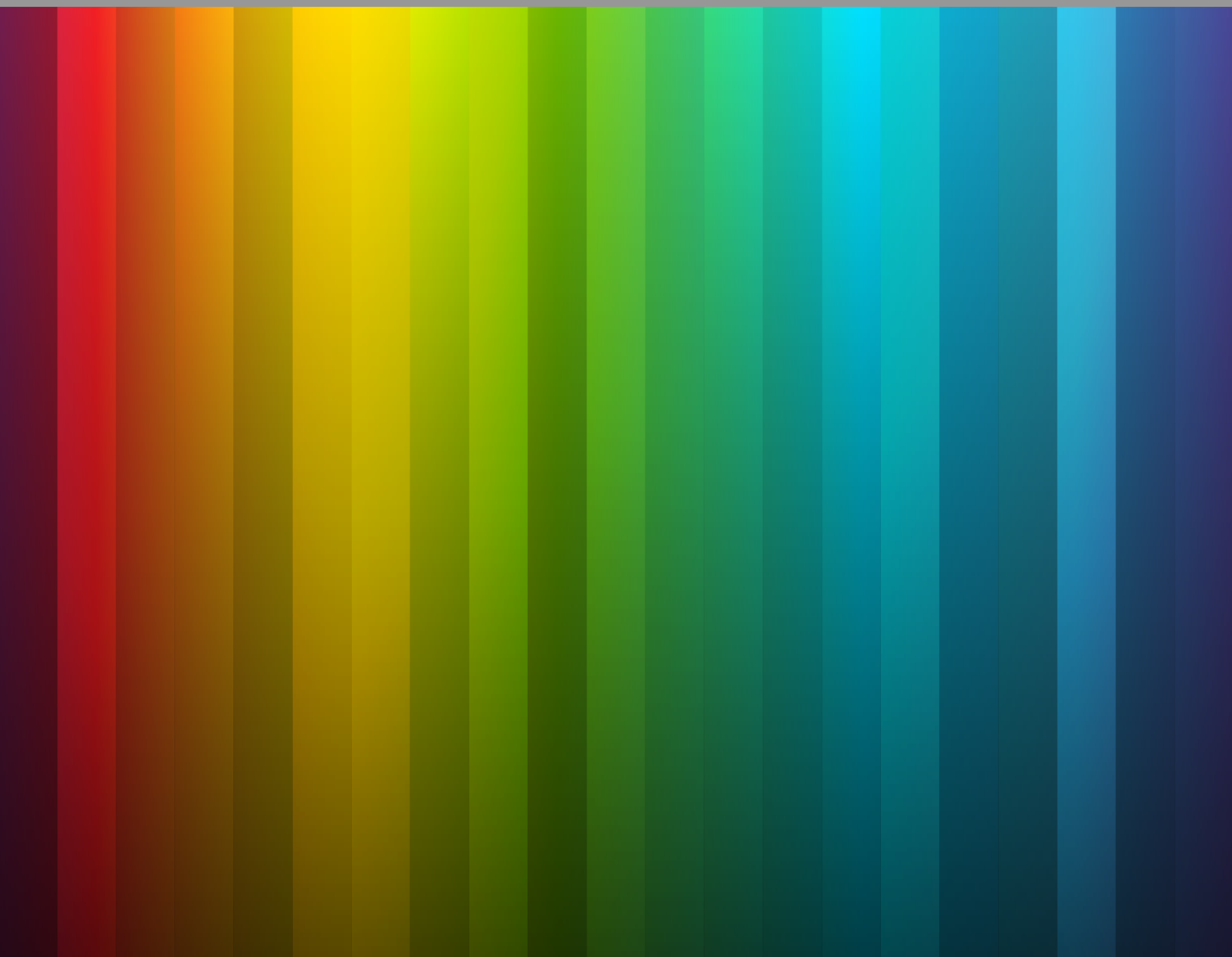


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# The Biosphere and Biomes

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# CONCEPT 1

## What are Biomes?

- Define biome and describe how they are classified.
- Explain what determines the differences among biomes.
- Distinguish terrestrial biomes from aquatic biomes.



### Where was this picture taken?

This scene is from Anza-Borrego California Desert Park. However, deserts exist around the globe. You might find a similar picture of a desert in Africa. The desert is one type of biome.

### What are Biomes?

Tropical rainforests and deserts are two familiar types of biomes. A **biome** is an area with similar populations of organisms. This can easily be seen with a community of plants and animals. Remember that a **community** is all of the populations of different species that live in the same area and interact with one another. Different biomes, such as a forest (**Figure 1.1**) or a desert, obviously have different communities of plants and animals. How are the plants and animals different in the rainforest than those in the desert? Why do you think they are so different?

The differences in the biomes are due to differences in the **abiotic factors**, especially climate. **Climate** is the typical weather in an area over a long period of time. The climate includes the amount of rainfall and the average temperature in the region. Obviously, the climate in the desert is much different than the climate in the rainforest. As a result, different types of plants and animals live in each biome.

There are into two major groups of biomes:

1. **Terrestrial biomes**, which are land-based, such as deserts and forests.
2. **Aquatic biomes**, which are water-based, such as ponds and lakes.

The abiotic factors, such as the amount of rainfall and the temperature, are going to influence other abiotic factors, such as the quality of the soil. This, in turn, is going to influence the plants that migrate into the ecosystem and thrive




---

**FIGURE 1.1**

Tropical rainforest landscape in Hawaii. Notice how the plants are different from those in the desert.

---

in that biome. Recall that **migration** is the movement of an organism into or out of a population. It can also refer to a whole new species moving into a **habitat**. The type of plants that live in a biome are going to attract a certain type of animal to that habitat. It is the interaction of the abiotic and biotic factors that describe a biome and ecosystem. In aquatic biomes, abiotic factors such as salt, sunlight and temperature play significant roles.

For example, a hot dry biome is going to be completely different from a moderate wet biome. The soil quality will be different. Together, these will result in different plants being able to occupy each biome. Different plants will attract different animals (herbivores) to eat these plants. These animals, in turn, will attract different (carnivores) animals to eat the herbivores. So it is the abiotic factors that determine the biotic factors of an ecosystem, and together these define the biome.

## Summary

- A biome is an area with similar climate that includes similar communities of plants and animals.
- Climate influences the types of plants and animals that inhabit a specific biome.

## Explore More

Use the resources below to answer the questions that follow.

- **Biomes** at <http://www.youtube.com/watch?v=ag5ATGEplbU> (7:50)




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**MEDIA**

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1. Where do tundra biomes primarily occur? How much precipitation do these areas see annually?
2. What areas are best known for having Taiga biomes? What is the temperature range this biome experiences?

3. What is a behavioral adaptation that animals in desert biomes display?
4. List three characteristics of the rainforest.
5. How do the animals of a grassland adapt? Give two examples of animals of the grassland.

### Review

1. What is a biome?
2. What causes differences in the biomes?
3. Give two examples of terrestrial biomes.
4. What influence does the soil quality have on a biome?

---

### References

1. Flickr:daveynin. [This tropical rainforest has different plants than those found in a desert](#) . CC BY 2.0

## CONCEPT

## 2

# Climate Effects on Biomes

## Learning Objectives

- Define climate.
- Describe the role of climate in a biome.
- List the major temperature zones.
- Describe how climate affects plant growth and biodiversity.
- Give examples of adaptations organisms have due to climate.



## What do temperature, wind, and rain, have in common?

They are all part of climate, the statistical summary of temperature, humidity, atmospheric pressure, wind, rainfall, other meteorological measurements in a given region over long periods. In other words, is it dry or wet, hot or cold, or humid? And it is these abiotic factors that help determine the nature of a biome.

## Terrestrial Biomes

If you look at the two pictures in **Figure 2.1**, you will see very few similarities. The picture on the left shows a desert in Africa. The picture on the right shows a rainforest in Australia. The desert doesn't have any visible plants, whereas the rainforest is densely packed with trees. What explains these differences?

**Terrestrial biomes** include all the land areas on Earth where organisms live. The distinguishing features of terrestrial biomes are determined mainly by climate. Terrestrial biomes include tundras, temperate forests and grasslands, chaparral, temperate and tropical deserts, and tropical forests and grasslands.



**FIGURE 2.1**

Sahara Desert in northern Africa (left). Rainforest in northeastern Australia (right). Two very different biomes are pictured here. A biome is a group of similar ecosystems with the same general abiotic factors and primary producers. Both are found at roughly the same distance from the equator.

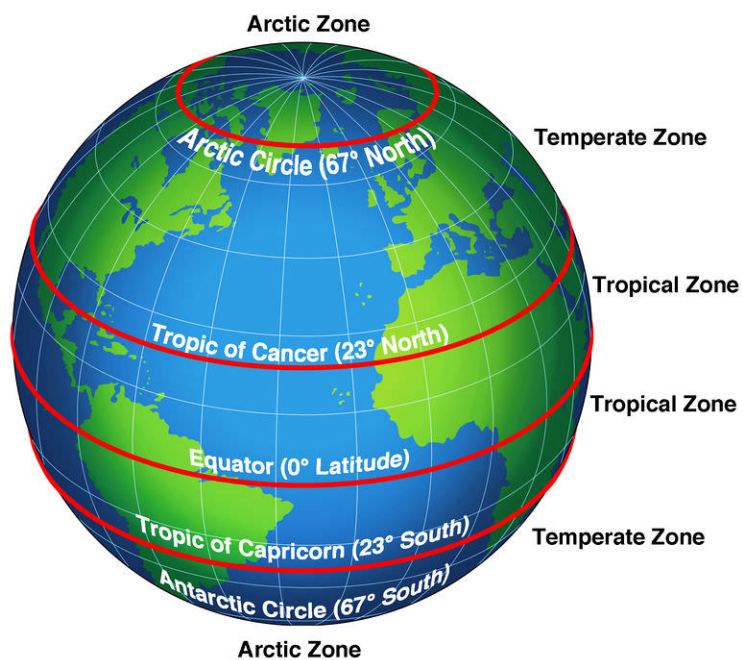
## Terrestrial Biomes and Climate

**Climate** is the average weather in an area over a long period of time. **Weather** refers to the conditions of the atmosphere from day to day. Climate is generally described in terms of temperature and moisture.

Temperature falls from the equator to the poles. Therefore, major temperature zones are based on **latitude**. They include tropical, temperate, and arctic zones (see **Figure 2.2**). However, other factors besides latitude may also influence temperature. For example, land near the ocean may have cooler summers and warmer winters than land farther inland. This is because water gains and loses heat more slowly than does land, and the water temperature influences the temperature on the coast. Temperature also falls from lower to higher altitudes. That's why tropical zone mountain tops may be capped with snow.

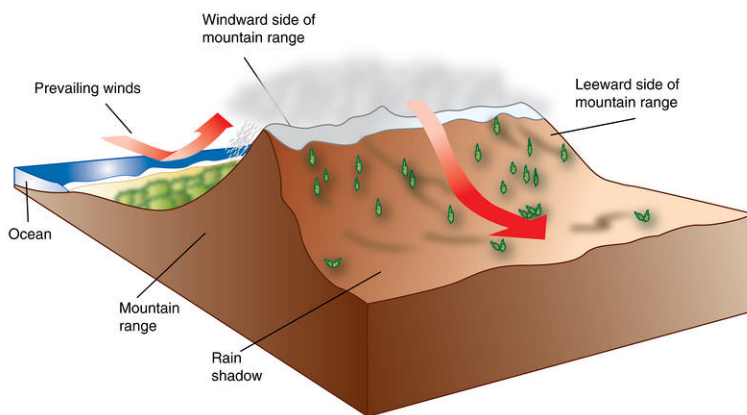
In terms of moisture, climates can be classified as arid (dry), semi-arid, humid (wet), or semi-humid. The amount of moisture depends on both precipitation and evaporation. Precipitation increases moisture. Evaporation decreases moisture.

- The global pattern of precipitation is influenced by movements of air masses. For example, there is a global belt of dry air masses and low precipitation at about 30° N and 30° S latitude.
- Precipitation is also influenced by temperature. Warm air can hold more moisture than cold air, so tropical areas receive more rainfall than other parts of the world.
- Nearness to the ocean and mountain ranges may also influence the amount of precipitation an area receives. This is explained in **Figure 2.3**.
- Evaporation of moisture is greatest where it is hot and sunny. Therefore, cold climates with low precipitation may not be as dry as warm climates with the same amount of precipitation.
- Moist air from the ocean rises up over the mountain range.
- As the air rises, it cools and its water vapor condenses. Precipitation falls on the windward side of the mountain range.
- The air is dry when it reaches the leeward side of the mountain range, so there is little precipitation there. This creates a “rain shadow.”



**FIGURE 2.2**

Temperature zones are based on latitude. What temperature zone do you live in?



**FIGURE 2.3**

This diagram shows how precipitation is affected by the ocean and a mountain range.



**MEDIA**

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## Climate and Plant Growth

Plants are the major producers in terrestrial biomes. They have five basic needs: air, warmth, sunlight, water, and nutrients. How well these needs are met in a given location depends on the growing season and soil quality, both of which are determined mainly by climate.

- The **growing season** is the period of time each year when it is warm and wet enough for plants to grow. The growing season may last all year in a hot, wet climate but just a few months in a cooler or drier climate.
- Plants grow best in soil that contains plenty of nutrients and organic matter. Both are added to soil when plant litter and dead organisms decompose. Decomposition occurs too slowly in cold climates and too quickly in hot, wet climates for nutrients and organic matter to accumulate. Temperate climates usually have the best soil for plant growth.

## Climate and Biodiversity

Because climate determines plant growth, it also influences the number and variety of other organisms in a terrestrial biome. **Biodiversity** generally increases from the poles to the equator. It is also usually greater in more humid climates. This is apparent from the desert and rainforest biomes pictured in **Figure 2.1**.

## Climate and Adaptations

Organisms evolve adaptations that help them survive in the climate of the biome where they live. For example, in biomes with arid climates, plants may have special tissues for storing water (see **Figure 2.4**). The desert animals pictured in **Figure 2.5** also have adaptations for a dry climate.

In biomes with cold climates, plants may adapt by becoming dormant during the coldest part of the year. **Dormancy** is a state in which a plant slows down cellular activities and may shed its leaves. Animals also adapt to cold temperatures. One way is with insulation in the form of fur and fat. This is how the polar bears in **Figure 2.6** stay warm.

## Summary

- Terrestrial biomes are determined mainly by climate.
- Climate influences plant growth, biodiversity, and adaptations of land organisms.

## Review

1. What is climate? How does it differ from weather?
2. What is a rain shadow?
3. What is a growing season? How does climate influence plant growth?
4. Describe the relationship between climate and biodiversity.
5. Compare the data for Seattle and Denver in **Table 2.1**. Seattle is farther north than Denver. Why is Seattle warmer?



**FIGURE 2.4**

The aloe plant on the left stores water in its large, hollow leaves. The cactus plant on the right stores water in its stout, barrel-shaped stems.

**TABLE 2.1:** Seattle vs Denver

City, State	Latitude (°N)	Altitude (ft above sea level)	Location (relative to ocean)	Average Low Temperature in January (°F)
Seattle, Washington	48	429	Coastal	33
Denver, Colorado	41	5183	Interior	15



**FIGURE 2.5**

The Gila monster's fat tail is an adaptation to its dry climate. It serves as a storage depot for water. The kangaroo rat has very efficient kidneys. They produce concentrated urine, thus reducing the amount of water lost from the body.

**FIGURE 2.6**

Thick fur and a layer of blubber keep polar bears warm in their Arctic ecosystem. Why do you think their fur is white? Why might it be an adaptation in an Arctic biome?

## References

1. Desert: Flickr:wonker; Rainforest: User:Tim35/Wikipedia. [A desert and a rainforest are different biomes, even though both are roughly at the same distance from the equator](#) . Desert: CC BY 2.0; Rainforest: Public Domain
2. Laura Guerin, using globe graphic courtesy of the Defense Institute of Security Assistance Management. [Temperature zones are based on latitude](#) . CC BY-NC 3.0 (globe graphic available in the Public Domain)
3. CK-12 Foundation. [This diagram shows how precipitation is affected by the ocean and a mountain range](#) . CC BY-NC 3.0
4. Aloe: Rae Allen; Cactus: Amante Darmanin. [Aloe and cactus have special tissues for storing waters](#) . CC

BY 2.0

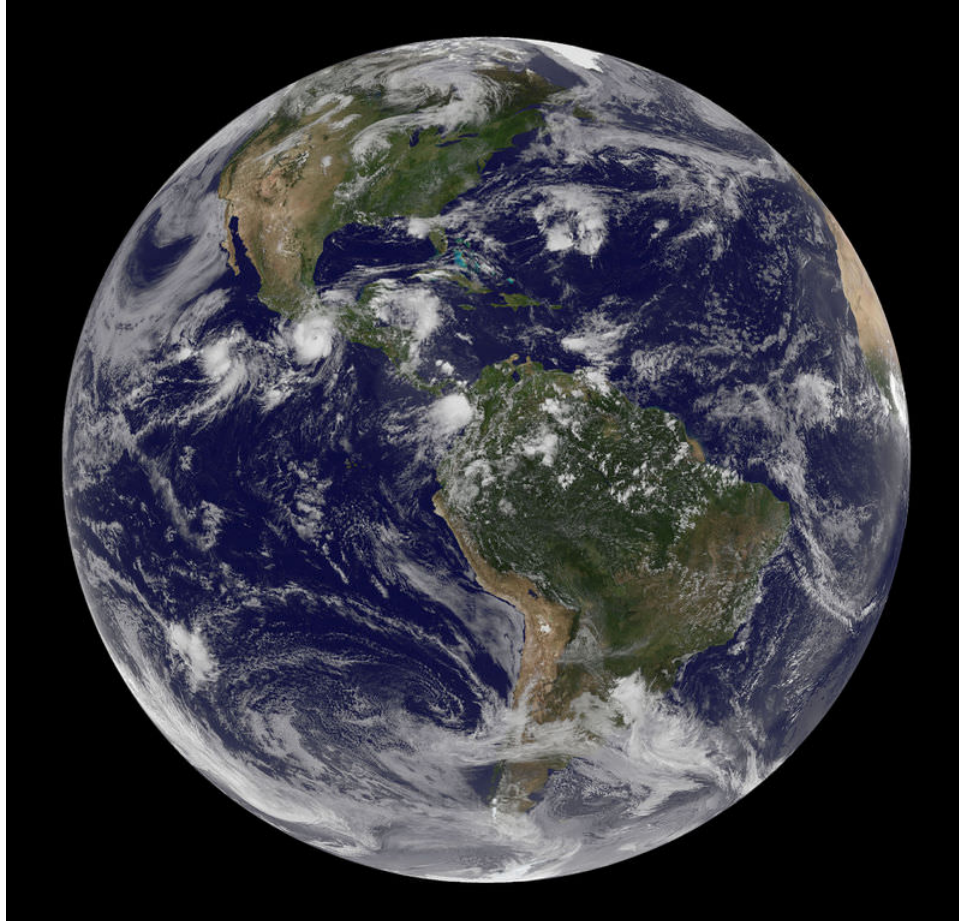
5. Gila monster: David Mark; Kangaroo rat: U.S. Fish and Wildlife Service. [Gila monster and a kangaroo rat have adaptations to survive in the dry climate](#) . Public Domain
6. U.S. Fish and Wildlife Service. [Polar bears have insulation in the form of fur and fat in order to stay warm in their Arctic ecosystem](#) . Public Domain

## CONCEPT

## 3

# The Biosphere

- Describe the biosphere and its importance in ecology.
- Distinguish the lithosphere from the hydrosphere and from the atmosphere.
- Discuss the Gaia hypothesis.



## Is Earth a living organism?

Most scientists agree that the Earth itself is not a living thing. However, the Earth does have some aspects of life. Some scientists argue that the Earth maintains homeostasis, a stable state, just like a living organisms.

## The Biosphere

The highest level of ecological organization is the **biosphere**. It is the part of Earth, including the air, land, surface rocks, and water, where life is found. Parts of the lithosphere, hydrosphere, and atmosphere make up the biosphere. The **lithosphere** is the outermost layer of the Earth's crust; essentially land is part of the lithosphere. The **hydrosphere** is composed of all the areas that contain water, which can be found on, under, and over the surface of Earth. The **atmosphere** is the layer of gas that surrounds the planet. The biosphere includes the area from about 11,000 meters below sea level to 15,000 meters above sea level. It overlaps with the lithosphere, hydrosphere, and atmosphere. Land plants and animals are found on the lithosphere, freshwater and marine plants and animals are found in the hydrosphere, and birds and other flying animals are found in the atmosphere. Of course, there are countless bacteria, protists, and fungi that are also found in the biosphere.

## Is the Biosphere Living?

The **Gaia hypothesis** states that the biosphere is its own living organism. The hypothesis suggests that the Earth is self-regulating and tends to achieve a stable state, known as **homeostasis**. For example the composition of our atmosphere stays fairly consistent, providing the ideal conditions for life. When carbon dioxide levels increase in the atmosphere, plants grow more quickly. As their growth continues, they remove more carbon dioxide from the atmosphere. In this way, the amount of carbon dioxide stays fairly constant without human intervention.

For a better understanding of how the biosphere works and various dysfunctions related to human activity, scientists have simulated the biosphere in small-scale models. Biosphere 2 (**Figure 3.1**) is a laboratory in Arizona that contains 3.15 acres of closed ecosystems. Ecosystems of Biosphere 2 are an ocean ecosystem with a coral reef, mangrove wetlands, a tropical rainforest, a savannah grassland and a fog desert. See <http://www.b2science.org/> for additional information.

Additional biosphere projects include BIOS-3, a closed ecosystem in Siberia, and Biosphere J, located in Japan.



**FIGURE 3.1**

Biosphere 2, in Arizona, contains 3.15 acres of closed ecosystem and is a small-scale model of the biosphere.

## Summary

- The biosphere is the part of the Earth, including the air, land, surface rocks, and water, where you can find life.
- The Gaia hypothesis states that the biosphere is its own living organism

## Explore More

Use the resource below to answer the questions that follow.

- **Biosphere** at <http://www.eoearth.org/view/article/150667/>

1. What is the biosphere?
2. What is the ecological definition of the biosphere?
3. What is the result of humans releasing carbon dioxide back into the atmosphere?
4. What is the Anthropocene?



## Review

1. What is the biosphere?
2. Distinguish between the lithosphere, atmosphere and hydrosphere.
3. Give an example of how Earth is self-regulating.

---

## References

1. Karen (Flickr: DrStarbuck). [Biosphere 2 is a laboratory that contains acres of various ecosystems](#) . CC BY 2.0

## CONCEPT

## 4

# Classification of Biomes - Advanced

## Learning Objectives

- State how terrestrial biomes are classified and distributed around the globe.



### Forest vs. desert. What explains these differences?

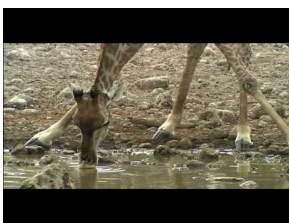
If you look at these two pictures, you will see very few similarities. The picture on the left shows a desert in Africa. The picture on the right shows a rainforest in Australia. The desert doesn't have any visible plants, whereas the rainforest is densely packed with trees. Do they have different climates? Does one get more rain than the other?

## Classification of Terrestrial Biomes

**Terrestrial biomes** include all land areas on Earth where organisms live. The major **biomes** cover large regions and are found on more than one continent. They are generally classified on the basis of climatic factors and the types of plants that are the primary **producers**.

Scientists have created several different systems for classifying terrestrial biomes. Biomes in most classification systems include tundra, boreal forest, temperate forest, temperate grassland, chaparral, tropical forest, tropical grassland, and desert. The worldwide distribution of these biomes is shown in **Figure 4.1**.

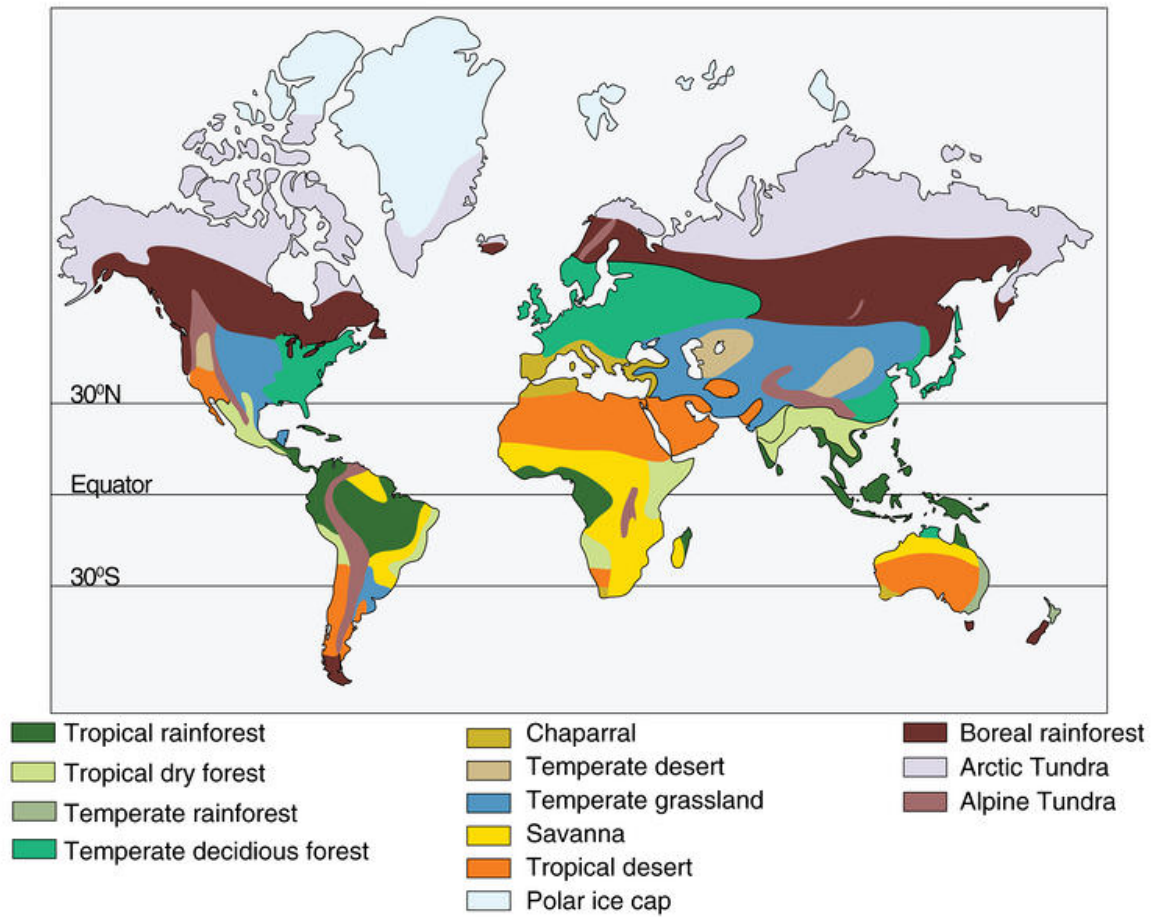
The distribution of biomes shown in **Figure 4.1** reflects global patterns of temperature and moisture. It also reflects conditions in earlier times. Many areas have been disturbed by human actions, some more so than others. For example, most tundra biomes have been changed very little by human actions, but many forests have been completely cleared. Some biomes, including tropical rainforests, cannot be replaced once they have been destroyed. **Figure 4.2** summarizes important features of most of the biomes shown in **Figure 4.1**. Refer to both figures as you read about these terrestrial biomes throughout this lesson.



### MEDIA

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**FIGURE 4.1**

Distribution of Earth's major terrestrial biomes.

---

## Summary

- The concept map below shows how the terrestrial biomes described in this lesson are related.



Alpine tundra in the Alps Mountains of Switzerland in Europe



Arctic tundra on the northern coast of Alaska in the United States

## Tundra

**Other names:** Arctic tundra (high latitudes)  
Alpine tundra (high altitudes)

**Climate:** Arctic, arid  
**Growing season:** Very short  
**Soil quality:** Very poor

**Biodiversity:** Very low

**Plants:** Mosses, grasses, and lichens; few herbaceous plants; no trees.

**Animals:** Insects; birds (summer only); no amphibians or reptiles; mammals such as rodents, arctic hares, arctic foxes, polar bears, caribou (summer only); mountain goats and chinchillas (alpine tundra only)



Boreal forest in central (inland) Alaska, United States

## Boreal Forest

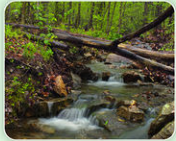
**Other names:** Taiga, northern conifer forest

**Climate:** Subarctic, semi-arid  
**Growing season:** Short  
**Soil quality:** Poor

**Biodiversity:** Low

**Plants:** Conifers such as cedar, spruce, pine, and fir; mosses and lichens

**Animals:** Insects; birds (mainly in summer); no amphibians or reptiles; mammals such as rodents, rabbits, minks, raccoons, bears, and moose; caribou (winter only)



Temperate deciduous forest in Pennsylvania, eastern United States

## Temperate Deciduous Forest

**Other names:** Temperate hardwood forest, temperate broadleaf forest

**Climate:** Temperate, semi-humid  
**Growing season:** Medium  
**Soil quality:** Good

**Biodiversity:** High

**Plants:** Broadleaf deciduous trees such as beech, maple, oak, and hickory; ferns, mosses, and shrubs; many herbaceous plants

**Animals:** Insects, amphibians, reptiles, and birds; mammals such as mice, chipmunks, squirrels, raccoons, foxes, deer, black bears, bobcats, and wolves



Temperate grassland in Nebraska, midwestern United States

## Temperate Grassland

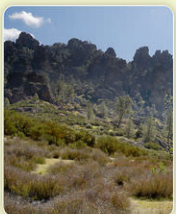
**Other names:** Prairie, outback, pampa, steppe

**Climate:** Temperate, semi-arid  
**Growing season:** Medium  
**Soil quality:** Excellent

**Biodiversity:** Medium-high

**Plants:** Grasses; other herbaceous plants; no trees

**Animals:** Invertebrates such as worms and insects; amphibians, reptiles, and birds; mammals such as mice, prairie dogs, rabbits, foxes, wolves, coyotes, bison, and antelope; kangaroo (only in Australia)



Chaparral in southern California, United States

## Chaparral

**Other names:** Mediterranean scrub forest

**Climate:** Temperate, semi-arid  
**Growing season:** Medium  
**Soil quality:** Poor

**Biodiversity:** Low-medium

**Plants:** Shrubs and small trees such as scrub oak and scrub pine

**Animals:** Insects, reptiles, and birds; mammals such as rodents and deer



## Desert

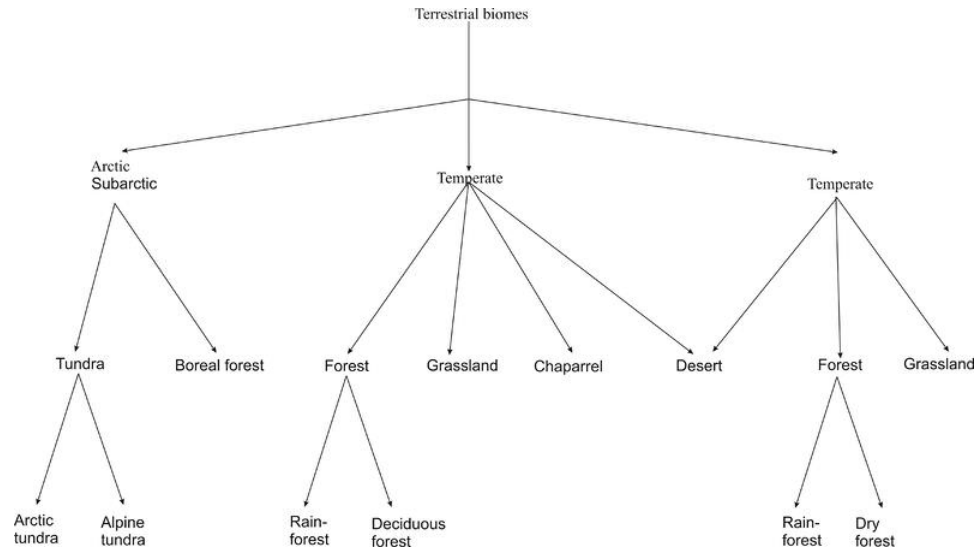
**Climate:** Temperate or tropical, arid  
**Growing season:** Varies  
**Soil quality:** Very poor

**Biodiversity:** None-low

**Plants:** Plants adapted to dryness, such as cacti, sagebrush, and mesquite; virtually no

FIGURE 4.2

A summary of the terrestrial biomes.



- Terrestrial biomes are generally classified on the basis of climatic factors and the types of plants that are the primary producers.

## Review

1. Why is the classifications of biomes important?
2. Describe the classification of terrestrial biomes.
3. Compare the abiotic factors that differentiate temperate deciduous forests from chaparral.
4. What might explain the disparity in biodiversity between tropical rainforests and tropical grassland?

## References

1. CK-12 Foundation. [CK-12 Foundation](#) . CC BY-NC 3.0
2. Fawcett5; National Oceanic and Atmospheric Administration; Nicholas A. Tonelli ; Brian Kell; Miguel Vieira; Ju Dadalto; Flickr: lana.japan; Shankar S.. [http://commons.wikimedia.org/wiki/File:Tundra\\_coastal\\_vegetation\\_Alaska.jpg](http://commons.wikimedia.org/wiki/File:Tundra_coastal_vegetation_Alaska.jpg); [http://commons.wikimedia.org/wiki/File:Picea\\_mariana\\_taiga.jpg](http://commons.wikimedia.org/wiki/File:Picea_mariana_taiga.jpg); [http://www.flickr.com/photos/nicholas\\_t/6958582046/](http://www.flickr.com/photos/nicholas_t/6958582046/); [http://commons.wikimedia.org/wiki/File:Oglala\\_National\\_Grassland.jpg](http://commons.wikimedia.org/wiki/File:Oglala_National_Grassland.jpg); <http://www.flickr.com/photos/miguelvieira/3384303160/>; <http://www.flickr.com/photos/black-bird/2584138571/>; <http://www.flickr.com/photos/13007595@N05/2697183159/>; <http://www.flickr.com/photos/shankaronline/7513383356/> . Public Domain, Public Domain, CC-BY 2.0, Public Domain, CC-BY 2.0, CC-BY 2.0, CC-BY 2.0, CC-BY 2.0

**CONCEPT 5****Arctic and Subarctic Biomes - Advanced****Learning Objectives**

- Outline abiotic and biotic factors in tundra and boreal forest biomes.

**FIGURE 5.1****What type of bird likes the cold and does not need trees to live in?**

Penguins live in the arctic, where it is too cold for trees to grow. Penguins have special adaptations to allow them to thrive in their habitats. And thrive they do, with some penguin colonies having over a million penguins. And yes, penguins are birds.

**Arctic and Subarctic Biomes**

Arctic and subarctic biomes are found near the north and south poles or at high altitudes in other climate zones. The biomes include tundra and boreal forests. Both have cold, dry climates and poor soil. They can support only limited plant growth and have low biodiversity.

**Tundra**

**Tundra** is an arctic biome where it is too cold for trees to grow. Outside of the polar ice caps, tundra has the coldest temperatures on Earth. There are two types of tundra: arctic tundra, which is also found in Antarctica, and alpine tundra, which is found only at high altitudes.

- **Arctic tundra** occurs north of the arctic circle and south of the antarctic circle. It covers much of Alaska and vast areas of northern Canada and Russia. It is also found along the northern coast of Antarctica.
- **Alpine tundra** occurs in mountains around the world at any latitude, but only above the tree line. The **tree line** is the edge of the zone at which trees are able to survive. Alpine tundra is found in the Rocky Mountains in the United States and in several other mountain ranges around the world.



Both types of tundra receive very low precipitation, but little of it evaporates because of the cold. Arctic tundra has **permafrost**, which is soil that is frozen year-round. The top layer of soil thaws in the summer, but deeper layers do not. As a result, water cannot soak into the ground. This leaves the soil soggy and creates many bogs, lakes, and streams. Alpine tundra does not have permafrost, except at very high altitudes. Therefore, alpine tundra soil tends to be dry rather than soggy.

Global warming poses a serious threat to Arctic tundra biomes because it is causing the permafrost to melt. When permafrost melts, it not only changes the tundra. It also releases large amounts of methane and carbon dioxide into the atmosphere. Both are greenhouse gases, which contribute to greater global warming.

The most common vegetation in tundra is mosses and **lichens**. They can grow in very little soil and become dormant during the winter. Tundra is too cold for amphibians or reptiles, which cannot regulate their own body heat. Insects such as mosquitoes can survive the winter as pupae and are very numerous in summer. In addition, many species of birds and large herds of caribou migrate to arctic tundra each summer. However, few birds and mammals live there year-round. Those that remain have adapted to the extreme cold. Polar bears are an example. They have very thick fur to insulate them from the cold. In alpine tundra, animals must adapt to rugged terrain as well as to cold. Alpine animals include mountain goats, which not only have wool to keep them warm but are also sure-footed and agile.

## Boreal Forests



FIGURE 5.2

Snowy forest

A **boreal forest** is a subarctic biome covered with conifers. Conifers are cone-bearing, needle-leaved evergreen trees such as spruces. Boreal forests are found only in the northern hemisphere. They occur just south of the arctic circle in Alaska, Canada, northern Europe, and Russia (where they are called taiga). They also occur in extreme northern regions of Minnesota, New York State, New Hampshire, and Maine.

Boreal forests have harsh continental climates, with very cold winters and relatively warm summers. The growing season is also short. Precipitation is quite low, but there is little evaporation. Most of the precipitation falls in the summer when plants are growing, so there is enough moisture for dense plant growth. A thick carpet of evergreen needles on the forest floor causes the soil to be too acidic for most other plants.

Conifers have adapted to the difficult conditions in several ways. They have shallow roots that suit them for the thin soil. They have needles instead of leaves, which reduce water loss during the long, dry winters. The needles are also very dark green in color, which maximizes absorption of sunlight for photosynthesis. Although boreal forests are dense with conifers, there are only a few different species of trees. Vegetation on the forest floor consists mostly of mosses and lichens. Animals found in boreal forests include insects, birds, and mammals such as rabbits, foxes, and brown bears. Caribou also spend their winters there. Like tundra, the boreal forest is too cold for amphibians or reptiles.

## Summary

- Arctic and subarctic biomes are found near the north and south poles or at high altitudes.
- Arctic and subarctic biomes include tundra and boreal forests.

## Review

1. Identify the two types of tundra and where they are found.
2. Why does global warming pose a serious threat to arctic tundras?
3. How are conifers adapted for boreal forests?

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## References

1. Christopher Michel. <https://www.flickr.com/photos/cmichel67/11240231654> . CC BY 2.0
2. Andrey. <https://www.flickr.com/photos/akras/5482136430> . CC BY 2.0



## CONCEPT

## 6

# Temperate Biomes - Advanced

## Learning Objectives

- Describe climatic factors and organisms of temperate zone biomes.

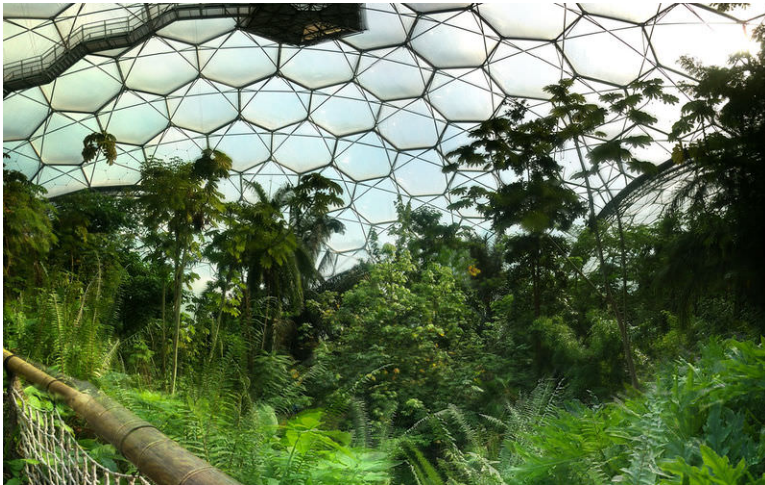


FIGURE 6.1

### What's a temperate biome?

Temperate biomes are between the tropics and the polar regions. The changes in these regions between summer and winter are generally moderate, rather than having extreme differences. This allows for numerous types of habitats, including forests and grasslands.

### Temperate Biomes

Temperate biomes cover most of the continental United States and Europe. They also cover large parts of Asia. Types of temperate biomes include forests, grasslands, and chaparral.

### Temperate Forests

There are two types of temperate forests: temperate deciduous forests and temperate rainforests. Both types have a temperate climate and good soil. A temperate climate is a moderate climate that is neither extremely hot nor extremely cold. A temperate climate can be either continental or coastal. Continental temperate climates are found inland, and they tend to have cold winters, hot summers, and moderate precipitation. Coastal temperate climates are found near the ocean, and they tend to have mild winters, cool summers, and high precipitation.

- **Temperate deciduous forests** are found in areas with continental temperate climates, such as the eastern United States and Canada and throughout much of Europe. These forests consist mainly of deciduous trees, such as maples and oaks, which lose their leaves in the fall. There are many other species of plants as well. Animals include insects, amphibians, reptiles, and birds. Mammals are also common, including rabbits and wolves.

- **Temperate rainforests** are found in areas with coastal temperate climates, such as the northwestern coast of North America and certain coastal regions of other continents. These forests consist mainly of evergreen trees, such as hemlocks and firs. Mosses, lichens, and ferns grow on the forest floor. There are also many epiphytic plants. Animals include insects, amphibians, reptiles, and birds. There are also many mammals, such as squirrels and deer.

**Epiphytes** are plants that grow on other plants. They use the other plants for support, not nutrients, and generally do not harm the plants they grow on. They grow high in the branches of trees where there is more sunlight available for photosynthesis.

## Temperate Grasslands

**Temperate grasslands** are temperate biomes that consist mainly of grasses. They are found in the midwestern region of North America and in inland areas of most other continents. The climate is continental, and precipitation is relatively low. However, the majority of the precipitation falls during the growing season when plants need it the most.

Biomes are often referred to by local names. For example, a temperate grassland biome is known as prairie in North America, outback in Australia, pampa in South America, and steppe in central Asia.

The soil of temperate grasslands is the richest, deepest soil on Earth. It is densely covered with thick grasses that decompose to add large amounts of organic matter and nutrients to the soil. Grasses also have thick mats of roots that hold the soil in place and prevent erosion. The low rainfall does not leach many nutrients from the soil, but it does lead to frequent fires. The fires help prevent woody vegetation from moving in if a grassland is disturbed. This is because grasses can grow back after a fire, whereas most woody plants cannot.

The rich, deep soil supports high productivity. This is why the temperate grassland of the US midwest is known as the *Breadbasket of America*. Grass plants are closely spaced and can support many herbivore consumers. These range from grasshoppers to deer. Many worms and other invertebrates (animals without a backbone) consume organic matter in the soil. Grassland animals also include carnivores such as foxes and coyotes.

## Chaparral

**Chaparral** is a shrub forest biome dominated by densely-growing evergreen shrubs or small trees, such as scrub oak. There are few other species of plants. Chaparral is found mainly in central and southern California and around the Mediterranean Sea. The climate, called a Mediterranean climate, has mild wet winters and hot dry summers. Fires are frequent because of the summer dryness, and the soil is relatively poor.

The majority of chaparral trees and plants are adapted to the dry summers. For example:

- Trees are short, which reduces their need for water.
- Many plants are dormant during the dry season, which also reduces water needs.
- The leaves of some plants have waxy coatings, which reduce water loss.

Most chaparral plants are adapted to frequent fires, as well. For example:

- Many plants can grow back quickly from the roots after burning to the ground.
- Some plants produce seeds that need fire in order to germinate.
- Many plants have thick underground stems that can survive fires.

The densely growing trees make it difficult for very large animals to penetrate the chaparral, so most chaparral animals are small. They include insects, birds, reptiles, and rodents. The largest animals are deer, which browse on the leaves of chaparral trees.

## Summary

- Temperate biomes include forests, grasslands, and chaparral.
- Temperate deciduous forests are found in areas with continental temperate climates and temperate rainforests are found in areas with coastal temperate climates.
- Temperate grasslands are temperate biomes that consist mainly of grasses.
- Chaparral is a shrub forest biome dominated by densely-growing evergreen shrubs or small trees

## Review

1. Name two temperate biomes and the main type of plant found in each biome.
2. Describe an epiphyte.
3. Assume a new species of lizard has been discovered in the northern hemisphere. It lives in an area of dense evergreen forest, where mosses and lichens grow on the forest floor. Identify the biome in which the lizard was found and explain your answer.
4. In which biome are you most likely to find foxes and coyotes?
5. Compare and contrast two types of temperate forests.

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## References

1. David Fisher. [https://www.flickr.com/photos/dave\\_fisher/5529970563](https://www.flickr.com/photos/dave_fisher/5529970563) . CC BY 2.0

## CONCEPT

## 7

## Desert Biomes - Advanced

## Learning Objectives

- List abiotic factors in deserts and adaptations of desert organisms.



FIGURE 7.1

**Does a desert have plants?**

All ecosystems have some sort of plant life, even the Sahara desert. Plants are obviously needed as the producers in the desert, attracting animal life to the ecosystem.

**Deserts**

A **desert** is a biome that receives no more than 25 centimeters (10 inches) of precipitation per year. Deserts are found in both temperate and tropical areas. The largest deserts are found at about 30° north or south latitude due to the dry air masses over these latitudes. As it turns out, deserts play an important role in the overall health of the whole planet. Without deserts, there would not be any rainforests.

**MEDIA**

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Deserts also occur in rain shadows. A **rain shadow** is a dry region on the leeward side of a mountain range. Examples of rain shadow deserts include Death Valley and the Mojave Desert, both partly in California. The dry

air in deserts leads to extreme temperature variations from day to night. Without water vapor in the air, there are no clouds to block sunlight during the day or hold in heat at night.

Desert soil is usually very poor. They tend to be sandy or rocky and lack organic content. Because of the low precipitation, minerals are not leached out and may become too concentrated for plants to tolerate. Plant cover is very sparse, so most of the soil is exposed and easily eroded by wind. The occasional rain tends to be brief but heavy, causing runoff and more erosion.

Most desert plants have evolved adaptations to the extreme dryness. For example:

- Many plants have special water-storing tissues in leaves, stems, or roots.
- Some plants have very long taproots that can reach down to the water table.
- Some plants have wide-spreading roots that can absorb water over a large area.
- Plants may have small, spiny leaves that help reduce water loss.

Most desert animals have adaptations to the extreme heat and bright sunlight. For example:

- Many small animals stay underground in burrows during the day and come out only at night.
- Most animals that are active in daytime spend as much time as possible in the shade of rocks or plants.
- Some animals have very large ears or other appendages, which help them lose heat to the environment, keeping them cooler.
- Many animals are light in color, which helps them reflect sunlight and stay cooler.

## Summary

- Deserts are biomes that receive little precipitation; no more than 25 centimeters (10 inches) per year.
- Most desert plants and animals have evolved adaptations to the extreme dryness.

## Review

1. If you were to design a well-adapted desert animal, what traits would you give it to help it survive in its desert environment?
2. Discuss the adaptations of desert plants and animals.
3. What makes a biome a desert? Can deserts occur in cold temperatures?
4. Why is there extreme temperature variation in deserts?
5. What is the soil quality usually like in deserts?

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## References

1. TREEAID. <https://www.flickr.com/photos/53871588@N05/5630241115> . CC BY 2.0

## CONCEPT

## 8

# Tropical Biomes - Advanced

## Learning Objectives

- Identify abiotic factors and organisms in tropical biomes.
- Distinguish between three types of tropical biomes: tropical rainforests, tropical dry forests, and tropical grasslands.



FIGURE 8.1

## What are the tropics?

Many people identify the tropics with islands like Hawaii. The tropical biomes are close to the equator, creating biomes unique to their areas. Tropical biomes include their own version of forests and grasslands.

## Tropical Biomes

Tropical biomes receive more sunlight than any other biomes on Earth. They also have high temperatures year-round. In addition to deserts, tropical biomes include forests and grasslands.

## Tropical Forests

There are two types of tropical forests: tropical rainforests and tropical dry forests. Both occur near the equator, so they have plenty of sunlight and warmth year-round. However, they differ in the amount and timing of the precipitation they receive.

- **Tropical rainforests** receive more precipitation than any other biome. They are found near the equator in Central and South America and Africa. The soil is thin and poor, partly because the lush plant growth uses up nutrients before they can accumulate in the soil. **Biodiversity** of animals as well as plants is greater than in all other biomes combined. Most plants are tall, broadleaf evergreen trees. They form a dense canopy over the forest, so little sunlight reaches the forest floor. The many vines and **epiphytes** reach sunlight by growing on trees. Numerous animal species also live in trees, including monkeys, sloths, and leopards.



- **Tropical dry forests** occur in tropical areas where most of the precipitation falls during a single wet season. As a result, there is a pronounced dry season. Tropical dry forests are found in parts of Central and South America, Africa, and India. Trees and other plants are widely spaced because there is not enough water for denser growth. The plants also have adaptations to help them cope with seasonal drought. For example, many go dormant during the dry season, which reduces their need for water. Animals that live in tropical dry forests include arboreal animals such as monkeys and ground-dwelling animals such as rodents.



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## Tropical Grasslands

**Tropical grasslands** are tropical biomes with relatively low rainfall where the primary **producers** are grasses. Tropical grasslands are found mainly in Africa, where they are called **savannas**. They have high temperatures year-round, but relatively low precipitation. Moreover, most of the precipitation falls during a single wet season, leaving the rest of the year very dry. The soil is also poor.

In addition to grasses, there are scattered clumps of trees in most tropical grasslands. The trees are drought-adapted species such as acacia, which have narrow leaves that reduce water loss. Acacia trees also have thorns that discourage browsing by **herbivores**. Africa savannas are well known for their huge herds of herbivores, including zebra, giraffe, and wildebeest. They are also well known for their large carnivores—such as lions, cheetahs, and hyenas—that prey on the herbivores.



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## Summary

- Tropical biomes receive more sunlight than any other biomes on Earth.
- Tropical rainforests receive more precipitation than any other biome; they are found near the equator.
- Tropical dry forests occur in tropical areas where most of the precipitation falls during a single wet season.
- Tropical grasslands are tropical biomes with relatively low rainfall where the primary producers are grasses.

## Review

1. In which biome are you most likely to find grasses, zebras, and lions?
2. If the tropics receive more sunlight year-round than any other biome, why are some plants in tropical rainforests adapted to low levels of sunlight?
3. Compare the two types of tropical forests.
4. Compare and contrast a tropical grassland and tropical dry forest.

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## References

1. Patrick McNally. <https://www.flickr.com/photos/patrickmcnally/5979069144> . CC BY 2.0



# CONCEPT 9 Aquatic Biomes - Advanced

## Learning Objectives

- Describe how aquatic biomes are divided into zones, and list types of aquatic organisms.



### Do aquatic ecosystems need sunlight?

Of course. The sunlight - in part - allows the diversity of life seen in this ecosystem. If the available sunlight was less, could this ecosystem still thrive? Maybe, but the ecosystem would probably be very different. Sunlight, of course, is necessary for photosynthesis, which brings energy into an ecosystem. So, the availability of that sunlight has a direct impact on the productivity and biodiversity of aquatic ecosystems.

### What Are Aquatic Biomes?

Terrestrial organisms are generally limited by temperature and moisture. Therefore, terrestrial biomes are defined in terms of these abiotic factors. In contrast, most organisms that live in the water do not have to deal with extremes of temperature or moisture. Instead, their main limiting factors are the availability of sunlight and the concentration of dissolved nutrients in the water.

Aquatic biomes are biomes found in water. Water covers 70 percent of Earth's surface, so aquatic biomes are a major component of the biosphere. However, they have less total biomass than terrestrial biomes. Aquatic biomes can occur in either salt water or freshwater. About 98 percent of Earth's water is salty, and only 2 percent is fresh. The primary saltwater biome is the ocean. Major freshwater biomes include lakes and rivers.

### Aquatic Zones

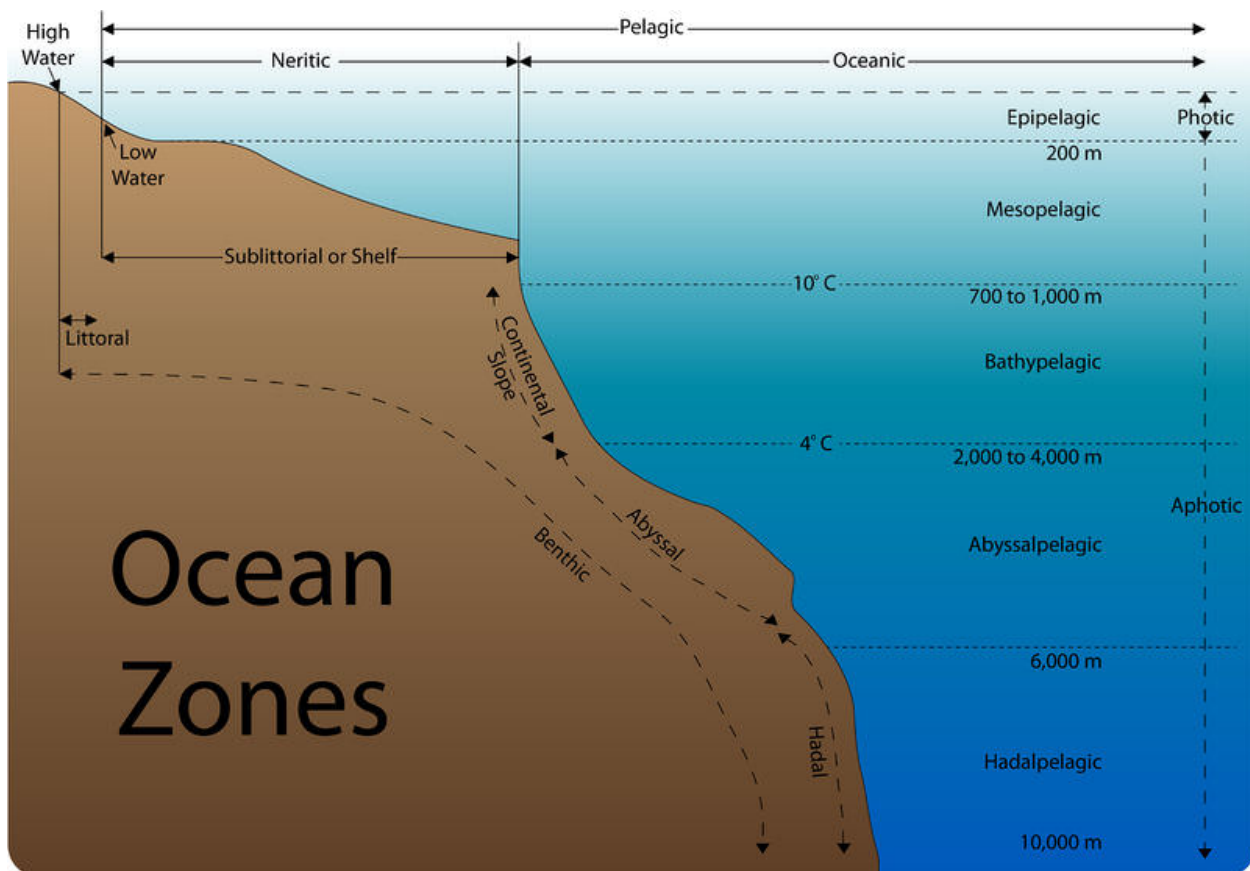
In large bodies of standing water (including the ocean and lakes), the water can be divided into zones based on the amount of sunlight it receives. There is enough sunlight for photosynthesis only in - at most - the top 200 meters

of water. Water down to this depth is called the **photic zone**. Deeper water, where too little sunlight penetrates for photosynthesis, is called the **aphotic zone**.

Surface water dissolves oxygen from the air, so there is generally plenty of oxygen in the photic zone to support organisms. Water near shore usually contains more dissolved nutrients than water farther from the shore. This is because most dissolved nutrients enter a body of water from land, carried by runoff or rivers that empty into the body of water. When aquatic organisms die, they sink to the bottom, where decomposers release the nutrients they contain. As a result, deep water may contain more nutrients than surface water.

Deep ocean water may be forced to the surface by currents in a process called **upwelling**. When this happens, dissolved nutrients are brought to the surface from the deep ocean. The nutrients can support large populations of producers and consumers, including many species of fish. As a result, areas of upwelling are important for commercial fishing.

With these variations in sunlight, oxygen, and nutrients, different parts of the ocean or a lake have different types and numbers of organisms. Therefore, life in a lake or the ocean is generally divided into zones. The zones correlate mainly with the amount of sunlight and nutrients available to producers. **Figure 9.1** shows ocean zones. Lakes have similar zones.



**FIGURE 9.1**

The ocean is divided into many different zones, depending on distance from shore and depth of water. The pelagic zone is divided into neritic and oceanic zones based on distance from shore. Into what additional zones is the pelagic zone divided on the basis of water depth? What additional zones make up the benthic zone?

- The **littoral zone** is the shallow water near the shore. In the ocean, the littoral zone is also called the intertidal zone.
- The **pelagic zone** is the main body of open water farther out from shore. It is divided into additional zones based on water depth. In the ocean, the part of the pelagic zone over the continental shelf is called the **neritic zone**, and the rest of the pelagic zone is called the **oceanic zone**.
- The **benthic zone** is the bottom surface of a body of water. In the ocean, the benthic zone is divided into additional zones based on depth below sea level.

## Aquatic Organisms



### What is this? Plant or animal?

It is actually the Yellow Christmas tree worm. These animals are colorful, and can be red, orange, yellow, blue, and white. The Christmas tree worm lives on tropical coral reefs throughout the world. The Christmas tree worm's plumes are used for feeding and respiration. These worms use their plumes to catch plankton and other small particles passing in the water. Cilia then pass the food to the worm's mouth.

Aquatic organisms are classified into three basic categories: plankton, nekton, and benthos. Organisms in these three categories vary in where they live and how they move.

- **Plankton** are aquatic organisms that live in the water itself and cannot propel themselves through water. They include both phytoplankton and zooplankton. Phytoplankton are bacteria and algae that use sunlight to make food by photosynthesis. Zooplankton are tiny animals that feed on phytoplankton.
- **Nekton** are aquatic animals that live in the water and can propel themselves by swimming or other means. Nekton include invertebrates such as shrimp and vertebrates such as fish.
- **Benthos** are aquatic organisms that live on the surface below a body of water. They live in or on the sediments at the bottom. Benthos include sponges, clams, and sea stars (see **Figure 9.2**).

**FIGURE 9.2**

This sea star, or starfish, is an example of a benthic organism. The tiny white projections on the bottom surface of the sea star allow it anchor to, or slowly crawl over, the bottom surface of the ocean.

## Studying Aquatic Animals

Oceans cover more than 70 percent of our planet, yet they are some of the least explored regions on Earth. How much of the sea life in the oceans do we understand? Whatever the answer, there is still plenty left to explore and study. Who better to unlock the mysteries of the ocean than marine animals themselves? Marine scientists have been tagging and tracking sharks, leatherback turtles, and other sea life to learn more about marine ecosystems. Through the Tagging of Pacific Predators program (TOPP), scientists hope to assess and explain the migration routes, ecosystems, and diversity of our oceans' species.

Beginning in the year 2000, scientists from the National Oceanic and Atmospheric Administration, Stanford University, and the University of California, Santa Cruz combined to form TOPP. As part of TOPP, researchers attach satellite tags to elephant seals, white sharks, giant leatherback turtles, bluefin tuna, swordfish, and other marine animals. The tags collect information, such as how deep each animal dives, the levels of ambient light (to help determine an animal's location), and interior and exterior body temperature. Some tags also collect information about the temperature, salinity, and depth of the water surrounding an animal to help scientists identify ocean currents. The tags send the data to a satellite, which in turn sends the data the scientists. They use this information to create maps of migration patterns and discover new information about different marine ecosystems. The information collected by TOPP offers rare insights into the lives of marine animals. Without TOPP, that information would otherwise remain unknown. With TOPP, scientists are developing a working knowledge of the particular migration routes animals take, as well as the locations of popular breeding grounds and the environmental dangers faced by different species. TOPP has shed light on how we can better protect the leatherback turtle and other endangered species.



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## Summary

- Aquatic biomes are divided into zones based on factors such as water depth and amount of sunlight available for photosynthesis.
- Aquatic organisms include plankton, nekton, and benthos.

## Review

1. In a large body of standing water, what is the photic zone?
2. Why is moving water a major challenge for organisms in the littoral zone of the ocean?
3. Compare and contrast plankton, nekton, and benthos.
4. Which areas of the ocean usually has more nutrients?

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## References

1. Jodi So. [CK-12 Foundation](#) . CC BY-NC 3.0
2. Mike Murphy. <http://commons.wikimedia.org/wiki/File:Starfish.jpg> . Public Domain



CONCEPT **10**

# Aquatic Organisms

## Learning Objectives

- Distinguish between plankton, nekton, and benthos.
- Define phytoplankton and zooplankton.



## What is this? Plant or animal?

It is actually the Yellow Christmas tree worm. These animals are colorful, and can be red, orange, yellow, blue, and white. The Christmas tree worm lives on tropical coral reefs throughout the world. The Christmas tree worm's plumes are used for feeding and respiration. These worms use their plumes to catch plankton and other small particles passing in the water. Cilia then pass the food to the worm's mouth.

## Aquatic Organisms

Aquatic organisms generally fall into three broad groups: plankton, nekton, and benthos. They vary in how they move and where they live.

1. **Plankton** are tiny aquatic organisms that cannot move on their own. They live in the photic zone. They include phytoplankton and zooplankton. **Phytoplankton** are bacteria and algae that use sunlight to make food. **Zooplankton** are tiny animals that feed on phytoplankton.
2. **Nekton** are aquatic animals that can move on their own by "swimming" through the water. They may live in the photic or aphotic zone. They feed on plankton or other nekton. Examples of nekton include fish and shrimp.
3. **Benthos** are aquatic organisms that crawl in sediments at the bottom of a body of water. Many are decomposers. Benthos include sponges, clams, and anglerfish like the one in **Figure 10.1**. How has this fish adapted to a life in the dark?

**FIGURE 10.1**

Anglerfish. This anglerfish lives between 1000 and 4000 meters below sea level. No sunlight penetrates to this depth. The rod-like structure on its face has a glow-in-the-dark tip. It is covered with microorganisms that give off their own light. The fish wiggles the structure like a worm to attract prey. In the darkness, only the rod-like worm is visible.

### KQED: Studying Aquatic Animals

Oceans cover more than 70 percent of our planet, yet they are some of the least explored regions on Earth. Who better to unlock the mysteries of the ocean than marine animals themselves? Marine scientists have been tagging and tracking sharks, leatherback turtles, and other sea life to learn more about marine ecosystems. Through the Tagging of Pacific Predators program (TOPP), scientists hope to assess and explain the migration routes, ecosystems, and diversity of our oceans' species.

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### Summary

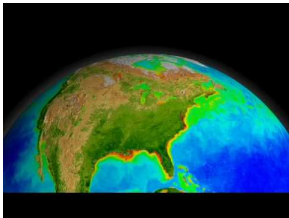
- Aquatic organisms are either plankton, nekton, or benthos.

### Review

1. Compare plankton, nekton, and benthos.

2. Give an example of plankton, nekton, and benthos.
3. What are phytoplankton and zooplankton?

## Resources



### MEDIA

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## References

1. August Brauer. [An anglerfish is an organism that falls into the benthos group](#) . Public Domain



# CONCEPT 11 Marine Biomes - Advanced

## Learning Objectives

- Identify marine biomes, and state which biomes have the highest biodiversity.



### Would you expect this protected area of the ocean would have its own ecosystem?

Probably. This remote lagoon, located in Indonesia, is surrounded by limestone islands, and protects a vibrant and diverse coral reef. This is one of the most diverse areas on Earth for marine life.

## Marine Biomes

**Marine biomes** are aquatic biomes found in the salt water of the ocean. Major marine biomes are neritic, oceanic, and benthic biomes. Other marine biomes include intertidal zones, estuaries, and coral reefs.

### Neritic Biomes

**Neritic biomes** occur in ocean water over the continental shelf. They extend from the low-tide water line to the edge of the continental shelf. The water here is shallow, so there is enough sunlight for photosynthesis. The water is also rich in nutrients, which are washed into the water from the nearby land. Because of these favorable conditions, large populations of phytoplankton live in neritic biomes. They produce enough food to support many other organisms, including both zooplankton and nekton. As a result, neritic biomes have relatively great biomass and biodiversity. They are occupied by many species of invertebrates and fish. In fact, most of the world's major saltwater fishing areas are in neritic biomes.

## Oceanic Biomes

**Oceanic biomes** occur in the open ocean beyond the continental shelf. There are lower concentrations of dissolved nutrients away from shore, so the oceanic zone has a lower density of organisms than the neritic zone. The oceanic zone is divided into additional zones based on water depth.

- The **epipelagic zone** is the top 200 meters of water, or the depth to which enough sunlight can penetrate for photosynthesis. Most open ocean organisms are concentrated in this zone, including both plankton and nekton.
- The **mesopelagic zone** is between 200 and 1,000 meters below sea level. Some sunlight penetrates to this depth but not enough for photosynthesis. Organisms in this zone consume food drifting down from the epipelagic zone, or they prey upon other organisms in their own zone. Some organisms are detritivores, which consume dead organisms and organic debris that also drift down through the water.
- The **bathypelagic zone** is between 1,000 and 4,000 meters below sea level. No sunlight penetrates below 1,000 meters, so this zone is completely dark. Most organisms in this zone either consume dead organisms drifting down from above or prey upon other animals in their own zone. There are fewer organisms and less biomass here than in higher zones. Some animals are bioluminescent, which means they can give off light (see **Figure 11.1**). This is an adaptation to the total darkness.
- The **abyssopelagic zone** is between 4,000 and 6,000 meters below sea level. The **hadopelagic zone** is found in the water of deep ocean trenches below 6,000 meters. Both of these zones are similar to the bathypelagic zone in being completely dark. They have even lower biomass and species diversity.



**FIGURE 11.1**

The anglerfish lives in the bathypelagic zone. The rod-like structure protruding from the anglerfish's face is tipped with bioluminescent microorganisms. The structure wiggles like a worm to attract prey. Only the "worm" is visible to prey in the total darkness of this zone.

## Benthic Biomes

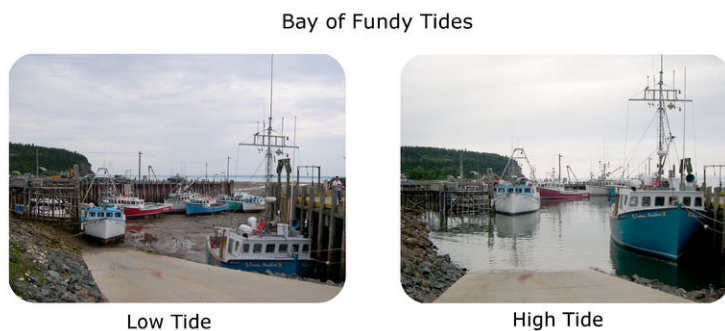
**Benthic biomes** occur on the bottom of the ocean where benthos live. Some benthos, including sponges, are sessile, or unable to move, and live attached to the ocean floor. Other benthos, including clams, burrow into sediments on

the ocean floor. The benthic zone can be divided into additional zones based on how far below sea level the ocean floor is.

- The **sublittoral zone** is the part of the ocean floor that makes up the continental shelf near the shoreline. The water is shallow enough for sunlight to penetrate down to the ocean floor. Therefore, photosynthetic producers such as seaweed can grow on the ocean floor in this zone. The littoral zone is rich in marine life.
- The **bathyal zone** is the part of the ocean floor that makes up the continental slope. It ranges from about 1,000 to 4,000 meters below sea level. The bathyal zone contains no producers because it is too far below the surface for sunlight to penetrate. Although consumers and decomposers live in this zone, there are fewer organisms here than in the sublittoral zone.
- The **abyssal zone** is the part of the ocean floor in the deep open ocean. It varies from about 4,000 to 6,000 meters below sea level. Organisms that live on the ocean floor in this zone must be able to withstand extreme water pressure, continuous cold, and scarcity of nutrients. Many of the organisms sift through sediments on the ocean floor for food or dead organisms.
- The **hadal zone** is the ocean floor below 6,000 meters in deep ocean trenches. The only places where organisms are known to live in this zone are at hydrothermal vents, where invertebrates such as tubeworms and clams are found. They depend on microscopic archaea organisms for food. These tiny chemosynthetic producers obtain energy from chemicals leaving the vents.

## Intertidal Zone

The **intertidal zone** is a narrow strip along the coastline that falls between high- and low-tide water lines. It is also called the littoral zone. A dominant feature of this zone is the regular movement of the tides in and out. In most areas, this occurs twice a day. Due to the tides, this zone alternates between being under water at high tide and being exposed to the air at low tide. An intertidal zone is pictured in **Figure 11.2**.



**FIGURE 11.2**

These pictures show the Bay of Fundy off the northeastern coast of Maine in North America. The picture on the left shows the bay at low tide, and the picture on the right shows the bay at high tide. The area exposed to air at low tide and covered by water at high tide is the intertidal zone.

The high tide repeatedly brings in coastal water with its rich load of dissolved nutrients. There is also plenty of sunlight for photosynthesis. In addition, the shallow water keeps large predators, such as whales and big fish, out of the intertidal zone. As a result, the intertidal zone has a high density of living things. Seaweeds and algae are numerous, and they support many consumer species, either directly or indirectly, including barnacles, sea stars, and crabs.

Other conditions in the intertidal zone are less favorable. For example, there are frequent shifts from a water to an air environment. There are also repeated changes in temperature and salinity (salt concentration). These changing conditions pose serious challenges to marine organisms. The moving water poses yet another challenge. Organisms must have some way to prevent being washed out to sea with the tides. Barnacles, like those in **Figure 11.3**, cement themselves to rocks. Seaweeds have rootlike structures, called holdfasts, which anchor them to rocks. Crabs burrow underground to avoid being washed out with the tides.


**FIGURE 11.3**

Barnacles secrete a cement-like substance that anchors them to rocks.

## Other Marine Biomes

The intertidal zone has high biodiversity. However, it is not the marine biome with the highest biodiversity. That distinction goes to estuaries and coral reefs. They have the highest biodiversity of all marine biomes.

- An **estuary** is a bay where a river empties into the ocean. It is usually semi-enclosed, making it a protected environment. The water is rich in dissolved nutrients from the river and shallow enough for sunlight to penetrate for photosynthesis. As a result, estuaries are full of marine life. **Figure 11.4** shows an estuary on the California coast near San Francisco.
- A **coral reef** is an underwater limestone structure produced by tiny invertebrate animals called corals. Coral reefs are found only in shallow, tropical ocean water. Corals secrete calcium carbonate (limestone) to form an external skeleton. Corals live in colonies, and the skeletal material gradually accumulates to form a reef. Coral reefs are rich with marine organisms, including more than 4,000 species of tropical fish. **Figure 11.5** shows a coral reef in the Hawaiian Islands.

## Summary

- Marine biomes include neritic, oceanic, and benthic biomes. Intertidal zones, estuaries, and coral reefs are marine biomes with the highest biodiversity.

## Review

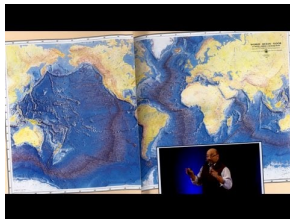
1. State why the oceanic zone has a lower concentration of nutrients than the neritic zone.
2. A new species of bioluminescent fish has been discovered in the ocean. Which oceanic zone is most likely the home of this fish? Explain your answer.
3. What are the four benthic biomes? Which zone is rich in life?
4. How have species adapted to the intertidal zone?



**FIGURE 11.4**

This satellite photo shows the San Francisco Estuary on the California coast. This is the largest estuary on the lower west coast of North America. Two rivers, the Sacramento and the San Joaquin, flow into the estuary (upper right corner of photo). The estuary is almost completely enclosed by land but still connected to the ocean.

## Explore More



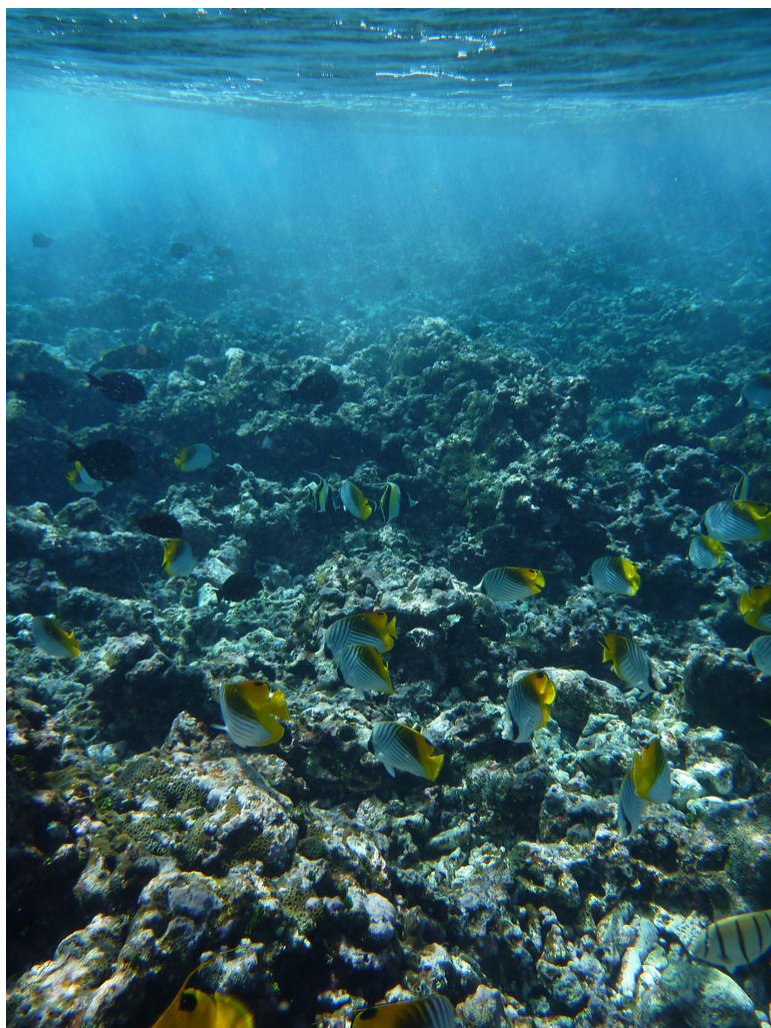
### MEDIA

Click image to the left or use the URL below.

URL: <http://www.ck12.org/flx/render/embeddedobject/187105>

## References

1. August Brauer. [http://commons.wikimedia.org/wiki/File:Humpback\\_anglerfish.png](http://commons.wikimedia.org/wiki/File:Humpback_anglerfish.png) . Public Domain
2. Dylan Kereluk. Left: [http://commons.wikimedia.org/wiki/File:Bay\\_of\\_Fundy\\_-\\_Tide\\_Out.jpg](http://commons.wikimedia.org/wiki/File:Bay_of_Fundy_-_Tide_Out.jpg); Right: [http://commons.wikimedia.org/wiki/File:Bay\\_of\\_Fundy\\_-\\_Tide\\_In.jpg](http://commons.wikimedia.org/wiki/File:Bay_of_Fundy_-_Tide_In.jpg) . CC BY 2.0
3. Mo Riza. <http://www.flickr.com/photos/modomatic/2394983702/> . CC BY 2.0
4. U.S. Geological Survey. <http://commons.wikimedia.org/wiki/File:BayareaUSGS.jpg> . Public Domain
5. FWS Volunteer Sarah Youngren. <https://www.flickr.com/photos/usfwspacific/5489630149/> . CC BY 2.0



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**FIGURE 11.5**

Colorful fish swim in warm, shallow ocean water near a coral reef off the Hawaiian Islands.

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## CONCEPT

## 12

## Freshwater and Wetlands Biomes

## Learning Objectives

- Define and describe a freshwater biome.
- Outline the characteristics of a wetland.

**What may be the most biologically diverse type of ecosystem?**

These are wetland marshes in Delaware. Notice the abundance of vegetation mixed with the water. And of course, where there are plants, there are animals. Wetlands are considered the most biologically diverse of all ecosystems. Plant life found in wetlands includes mangrove, water lilies, cattails, black spruce, cypress, and many others. Animal life includes many different amphibians, reptiles, birds, insects, and mammals.

**Freshwater Biomes**

**Freshwater biomes** have water that contains little or no salt. They include standing and running freshwater biomes. Standing freshwater biomes include ponds and lakes. Lakes are generally bigger and deeper than ponds. Some of the water in lakes is in the aphotic zone, where there is too little sunlight for photosynthesis. Plankton and plants, such as the duckweed in **Figure 12.1**, are the primary producers in standing freshwater biomes.

Running freshwater biomes include streams and rivers. Rivers are usually larger than streams. Streams may start with runoff or water seeping out of a spring. The water runs downhill and joins other running water to become a stream. A stream may flow into a river that empties into a lake or the ocean. Running water is better able to dissolve oxygen and nutrients than standing water. However, the moving water is a challenge to many living things. Algae and plants, such as the cattails in **Figure 12.1**, are the primary producers in running water biomes.

# Freshwater Producers



Duckweed in a pond



Cattails in a stream

## FIGURE 12.1

The pond on the left has a thick mat of duckweed plants. They cover the surface of the water and use sunlight for photosynthesis. The cattails on the right grow along a stream bed. They have tough, slender leaves that can withstand moving water.



## MEDIA

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## Wetlands

A **wetland** is an area that is saturated with water or covered by water for at least one season of the year. The water may be freshwater or salt water. Wetlands are extremely important biomes for several reasons:

- They store excess water from floods.
- They slow down runoff and help prevent erosion.
- They remove excess nutrients from runoff before it empties into rivers or lakes.
- They provide a unique habitat that certain communities of plants need to survive.
- They provide a safe, lush habitat for many species of animals, so they have high biodiversity.



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### **KQED: San Francisco Bay: A Unique Estuary**

An **estuary** is a partly enclosed coastal body of water with one or more rivers or streams flowing into it, and with a free connection to the ocean. Estuaries can be thought of as the most biologically productive regions on Earth, with very high biodiversity. Estuaries are zones where land and sea come together, and where fresh and salt water meet.

The San Francisco Bay is one of the great estuaries of the world.



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**MEDIA**

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### **Science Friday: Poop and Paddle: An Eco-Friendly Floating Toilet**

How do wetlands filter water? In this video by Science Friday, inventor Adam Katzman describes how his toilet-boat converts human waste into cattails and clean water.



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**MEDIA**

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## Summary

- Freshwater biomes include standing water and running water biomes.
- Wetlands are extremely important biomes. They may have freshwater or salt water.

## Review

1. Describe a freshwater biome.
2. Define a wetland.
3. Why do wetlands have high biodiversity?
4. A developer wants to extend a golf course into a wetland. Outline environmental arguments you could make against this plan.

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## References

1. Duckweed: Jonathan Jordan; Cattails: User:JoJan/Wikimedia Commons. [Duckweed and cattails are respectively the primary producers in standing and running freshwater biomes](#) . Duckweed: CC BY 2.0; Cattails: CC BY 3.0

