Life on Earth

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CHAPTER 1 Life on Earth

CHAPTER OUTLINE

Introduction

The only known life in the universe. So far.

It's possible, maybe even likely, that there is life elsewhere in the universe, but if there is life we haven't found it yet. What makes Earth unique in the solar system is not only that it has life but that it has such an incredible diversity of life forms. The origin of life, the evolution of a variety of life forms, and the evolution of life that can read this sentence is certainly unique in the universe.

1.1 Biological Communities

- Identify and define the component parts of biological communities and ecosystems.

How is a community of people like a community of organisms?

Different species have different jobs within their community. Some are the farmers, some are traders, some are the janitors, and others have different roles.

Biological Communities

A **population** consists of all individuals of a single **species** that exist together at a given place and time. A species is a single type of organism that can interbreed and produce fertile offspring. All of the populations living together in the same area make up a **community**.

Ecosystems

An **ecosystem** is made up of the living organisms in a community and the nonliving things, the physical and chemical factors, that they interact with. The living organisms within an ecosystem are its **biotic** factors (**Figure** 1.1). Living things include bacteria, algae, fungi, plants, and animals, including invertebrates, animals without backbones, and vertebrates, animals with backbones.

FIGURE 1.1
(a) The horsetail Equisetum is a primitive plant. (b) Insects are among the many different types of invertebrates. (c) A giraffe is an example of a vertebrate.

Physical and chemical features are **abiotic** factors. Abiotic factors include resources living organisms need, such as light, oxygen, water, carbon dioxide, good soil, and nitrogen, phosphorous, and other nutrients. Nutrients cycle through different parts of the ecosystem and can enter or leave the ecosystem at many points. Abiotic factors also include environmental features that are not materials or living things, such as living space and the right temperature range. Energy moves through an ecosystem in one direction.

Niches

Organisms must make a living, just like a lawyer or a ballet dancer. This means that each individual organism must acquire enough food energy to live and reproduce. A species' way of making a living is called its **niche**. An example of a niche is making a living as a top carnivore, an animal that eats other animals, but is not eaten by any other animals (**Figure** 1.2). Every species fills a niche, and niches are almost always filled in an ecosystem.

Habitat

An organism's **habitat** is where it lives (**Figure** 1.3). The important characteristics of a habitat include climate, the availability of food, water, and other resources, and other factors, such as weather.

Summary

- All of the individuals of a species that exist together at a given place and time make up a population. A community is made up of all of the populations in an area.
- The living and nonliving factors that living organisms need plus the communities of organisms themselves make up an ecosystem.
- A habitat is where an organism lives and a niche is what it does to make a living.

FIGURE 1.2
The top carnivore niche is filled by lions on the savanna.

FIGURE 1.3
Birds living in a saguaro cactus. A habitat may be a hole in a cactus or the underside of a fern in a rainforest. It may be rocks and the nearby sea.

Explore More

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=JPHqUxxyLsY

1. What are the two primary parts of an ecosystem?
2. What are the biotic parts?
3. What are the abiotic parts?
4. How big is an ecosystem?
5. Where does the energy to run an ecosystem come from?

How does that energy move through an ecosystem?

1. What is a habitat? What is included in it?
2. What is a niche? What is included in it?

Explore More Answers

1. biotic and abiotic factors
2. All the living things like plants, animals, decomposers and microbes.
3. The nonliving parts of the ecosystem like temperature, soil, water, etc.
4. It can be almost any size from large to small.
5. Mostly it comes from sunlight used by producers.
6. by a food web
7. A habitat is where an organism lives. It includes nutrition, shelter, water, and other things.
8. A niche is an organism's special role in an ecosystem. It includes how it eats, how it behaves, where it lives.

Review

1. Define species, population, community, niche, habitat, biotic factor, and abiotic factor.
2. Diagram how the words listed above relate to each other.
3. Choose a type of wild organism that you're familiar with and list the biotic and abiotic factors that it needs to live.

Review Answers

1. species: a single type of organisms that can interbreed and produce fertile offspring; population: all individuals of a single species that exist together at a given place and time; community: all populations living in the same area; niche: how a species makes a living; habitat: where an organism lives; biotic factor: living things; abiotic factors: things in an ecosystem that are not living
2. Answers will vary.
3. Answers will vary.

1.2 Roles in an Ecosystem

- Define and describe the common roles and relationships of organisms in an ecosystem.

What roles do coral reef organisms have?

Corals are not rocks or plants, but little animals that live in a carbonate shell they create. They have a symbiotic relationship with zooxanthellae, tiny photosynthesizing organisms. The zooxanthellae provide food for the coral and the coral provides a safe home for the zooxanthellae. Together they form the base of a complex ecosystem.

Roles in Ecosystems

There are many different types of ecosystems. Climate conditions determine which ecosystems are found in a particular location. A biome encompasses all of the ecosystems that have similar climate and organisms.

Different organisms live in different types of ecosystems because they are adapted to different conditions. Lizards thrive in deserts, but no reptiles are found in any polar ecosystems. Amphibians can't live too far from the water.

Large animals generally do better in cold climates than in hot climates.

Despite this, every ecosystem has the same general roles that living creatures fill. It's just the organisms that fill those niches that are different. For example, every ecosystem must have some organisms that produce food in the form of chemical energy. These organisms are primarily algae in the oceans, plants on land, and bacteria at hydrothermal vents.

Producers and Consumers

The organisms that produce food are extremely important in every ecosystem. Organisms that produce their own food are called **producers**. There are two ways of producing food energy:

- Photosynthesis: plants on land, phytoplankton in the surface ocean, and some other organisms.
- Chemosynthesis: bacteria at hydrothermal vents.

Organisms that use the food energy that was created by producers are named **consumers**. There are many types of consumers:

- **Herbivores** eat producers directly. These animals break down the plant structures to get the materials and energy they need.
- **Carnivores** eat animals; they can eat herbivores or other carnivores.
- **Omnivores** eat plants and animals as well as fungi, bacteria, and organisms from the other kingdoms.

FIGURE 1.4

A llama grazes near Machu Picchu, Peru

Feeding Relationships

There are many types of feeding relationships (**Figure** 1.5) between organisms. A **predator** is an animal that kills and eats another animal, known as its **prey**. **Scavengers** are animals, such as vultures and hyenas, that eat organisms that are already dead. **Decomposers** break apart dead organisms or the waste material of living organisms, returning the nutrients to the ecosystem.

FIGURE 1.5

(a) Predator and prey; (b) Scavengers; (c) Bacteria and fungi, acting as decomposers.

Relationships Between Species

Species have different types of relationships with each other. **Competition** occurs between species that try to use the same resources. When there is too much competition, one species may move or adapt so that it uses slightly different resources. It may live at the tops of trees and eat leaves that are somewhat higher on bushes, for example. If the competition does not end, one species will die out. Each niche can only be inhabited by one species.

Some relationships between species are beneficial to at least one of the two interacting species. These relationships are known as **symbiosis** and there are three types:

- In **mutualism**, the relationship benefits both species. Most plant-pollinator relationships are mutually beneficial. What does each get from the relationship?
- In **commensalism**, one organism benefits and the other is not harmed.
- In **parasitism**, the parasite species benefits and the host is harmed. Parasites do not usually kill their hosts because a dead host is no longer useful to the parasite. Humans host parasites, such as the flatworms that cause schistosomiasis.

Choose which type of relationship is described by each of the images and captions below (**Figure** 1.6).

Summary

- Herbivores eat plants, carnivores eat meat, and omnivores eat both.
- Predators are animals that eat a prey animal. Scavengers eat organisms that are already dead. Decomposers break down dead plants and animals into component parts, including nutrients.

FIGURE 1.6

(a) The pollinator gets food; the plant's pollen gets caught in the bird's feathers so it is spread to far away flowers. (b) The barnacles receive protection and get to move to new locations; the whale is not harmed. (c) These tiny mites are parasitic and consume the insect called a harvestman.

- Relationships between species can be one of competition or one of symbiosis, in which one or both species benefits. Mutualism, commensalism, and parasitism are the three types of symbiotic relationships.

Explore More

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=LgXXmz_c3mM

1. What is the science of ecology?
2. What are biotic factors? What are three examples?
3. What are abiotic factors? What are three examples?
4. What is an individual? Give an example.
5. What is a population? Give an example.
6. What is a community? Give an example.
7. What is a population? Give an example.
8. What is an ecosystem? Give an example.
9. What is a biome? Give an example.
10. What is a biosphere? Give an example.
11. What is a niche? What is a habitat?
12. What is the role of producers in an ecosystem?
13. What are consumers? What are three examples?
14. What do decomposers do? Why are they so important?
15. What is symbiosis? What is mutualism? What is commensalism?

Explore More Answers

1. The study of the interaction of organisms with their environment.
2. Living factors; e.g. redwood trees, owls, bacteria

3. Nonliving factors; e.g. fog, sunlight, soil
4. One organism; an elk
5. A group of organisms in a particular area; a herd of elk
6. All the organisms in an area; The elk plus all the wolves and owls and plants they interact with.
7. A population is xxx.
8. The community plus the abiotic factors; the organisms plus the rocks, air, water, etc that the organisms interact with.
9. Regions of earth that have similar climate, but the ecosystems within a biome are similar.
10. The part of Earth that supports life.
11. A niche is an organism's role like a decomposer or predator. A habitat is its home; e.g. a log.
12. Producers make their own food and are the base of the food web.
13. Consumers eat the food produced by producers; e.g. herbivores (plant eaters), carnivores (meat eaters) and omnivores (meat and plants)
14. They break down dead organisms and waste products; they recycle material so that nutrients get back into the soil.
15. Symbiosis is organisms living together. In mutualism both organisms benefit. In commensalism one organisms is neutral and one benefits. In parasitism one organism benefits and the other has a detriment.

Review

1. Compare and contrast the two different ways of producing food energy, photosynthesis and chemosynthesis.
2. After a producer produces food energy, follow its path until it ends up being used by another producer.
3. What kind of symbiotic relationship do zooxanthellae and corals have?

Review Answers

1. In photosynthesis organisms use energy from the sun to make food energy. Chemosynthesis is done by bacteria deep within the ocean at hydrothermal vents.
2. Producer is eaten by an herbivore, which is eaten by a carnivore, which is eaten by another carnivore, eventually that animal is decomposed and the nutrients are returned to the soil to be used by another producer.
3. Zooxanthellae are tiny photosynthesizing organisms that provide food for the coral while the coral provide shelter for the zooxanthellae. This is mutualism.

1.3 Flow of Energy in Ecosystems

- Define trophic levels.
- Compare and contrast food chains and webs.
- Explain how energy flows through ecosystems.

What is the source of energy for almost all ecosystems?

The Sun supports most of Earth's ecosystems. Plants create chemical energy from abiotic factors that include solar energy. Chemosynthesizing bacteria create usable chemical energy from unusable chemical energy. The food energy created by producers is passed to consumers, scavengers, and decomposers.

Trophic Levels

Energy flows through an ecosystem in only one direction. Energy is passed from organisms at one **trophic level** or energy level to organisms in the next trophic level. Which organisms do you think are at the first trophic level (**Figure** 1.7)?

Most of the energy at a trophic level –about 90% –is used at that trophic level. Organisms need it for growth, locomotion, heating themselves, and reproduction. So animals at the second trophic level have only about 10% as much energy available to them as do organisms at the first trophic level. Animals at the third level have only 10% as much available to them as those at the second level.

Food Chains

The set of organisms that pass energy from one trophic level to the next is described as the **food chain** (**Figure** 1.8). In this simple depiction, all organisms eat at only one trophic level (**Figure** 1.9).

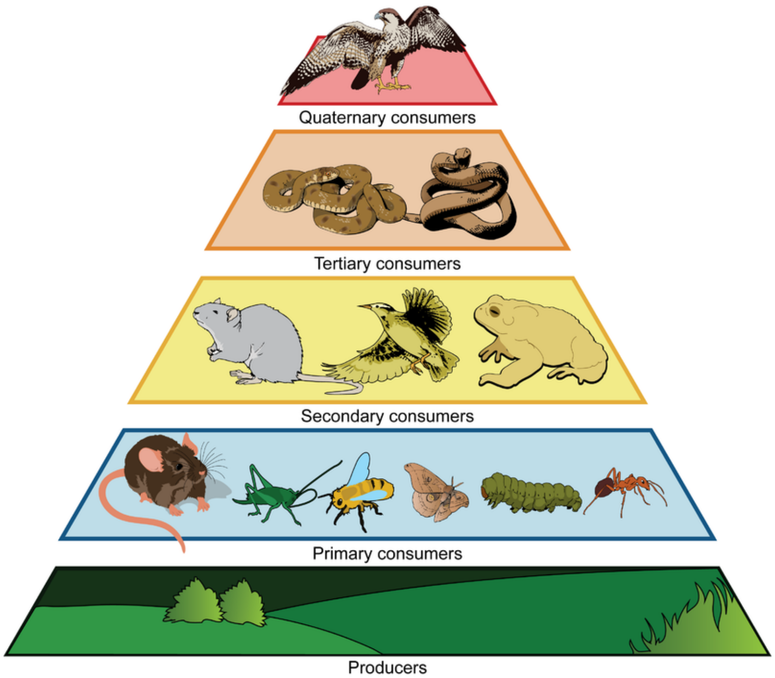

FIGURE 1.7
Producers are always the first trophic level, herbivores the second, the carnivores that eat herbivores the third, and so on.

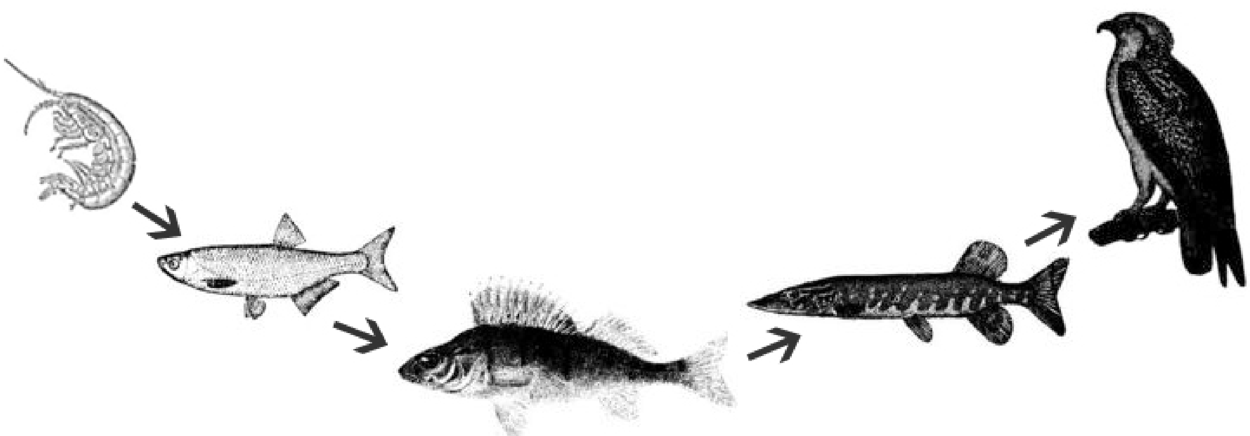

FIGURE 1.8
A simple food chain in a lake. The producers, algae, are not shown. For the predatory bird at the top, how much of the original energy is left?

What are the consequences of the loss of energy at each trophic level? Each trophic level can support fewer organisms.

What does this mean for the range of the osprey (or lion, or other top predator)? A top predator must have a very large range in which to hunt so that it can get enough energy to live.

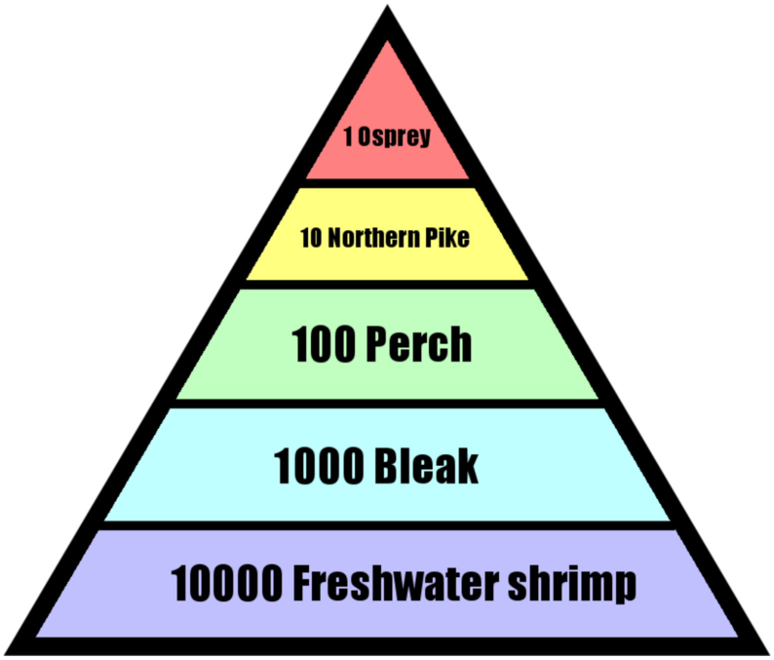

FIGURE 1.9
How many osprey are there relative to the number of shrimp?

Why do most food chains have only four or five trophic levels? There is not enough energy to support organisms in a sixth trophic level. Food chains of ocean animals are longer than those of land-based animals because ocean conditions are more stable.

Why do organisms at higher trophic levels tend to be larger than those at lower levels? The reason for this is simple: a large fish must be able to eat a small fish, but the small fish does not have to be able to eat the large fish (**Figure** 1.10).

FIGURE 1.10
In this image the predators (wolves) are smaller than the prey (bison), which goes against the rule placed above. How does this relationship work? Many wolves are acting together to take down the bison.

Food Webs

What is a more accurate way to depict the passage of energy in an ecosystem? A **food web** (**Figure** 1.11) recognizes that many organisms eat at multiple trophic levels.

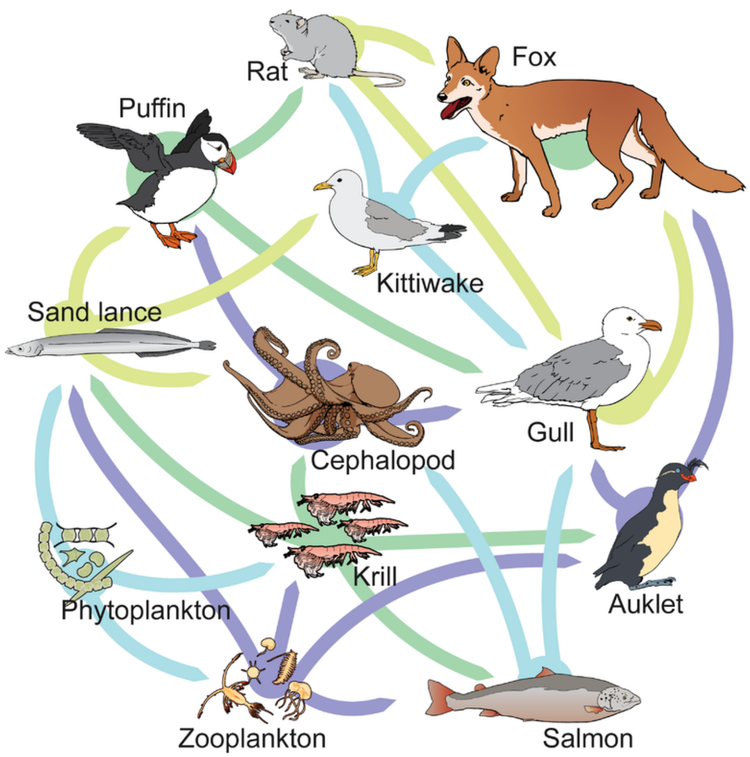

FIGURE 1.11
A food web includes the relationships between producers, consumers, and decomposers.

Even food webs are interconnected. All organisms depend on two global food webs. The base of one is phytoplankton and the other is land plants. How are these two webs interconnected? Birds or bears that live on land may eat fish, which connects the two food webs.

Humans are an important part of both of these food webs; we are at the top of a food web, since nothing eats us. That means that we are top predators.

Summary

- A food chain describes the passage of energy between trophic levels.
- A food web is a set of interconnected and overlapping food chains.
- Food webs are interconnected, such as nearby land and a marine food webs.

Making Connections

MEDIA

Click image to the left for use the URL below.

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Explore More

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=Ot_KmOTYfRA

1. What is an ecosystem? What example does the teacher give?
2. What is primary productivity? What do organisms need for ths?
3. What are trophic levels? What is at level 1? What is at level 2? What is at level 3? What is at level 4?
4. What is a food web?
5. How do populations grow?
6. What is a limiting factor? What are some examples?
7. What is carrying capacity?
8. What does the decline in elk do to the population of wolves in Yellowstone?
9. How will warming conditions change the population of grizzly bears in Yellowstone?

Explore More Answers

1. All of the biotic and abiotic characteristics in an area. Yellowstone National Park and surroundings.
2. Primary productivity is the biomass the producers are producing using energy plus matter. The amount of carbon added.
3. Eating levels; 1: producers; 2: consumers; 3: 2nd level consumers; 4: 3rd level consumers
4. All the food webs that are all interconnected.
5. All growth is exponential.
6. A factor that limits the growth of a population. Space, food, predators, sunlight are all possible limiting factors.
7. The maximum level that an ecosystem can support.
8. There will be less food and so the population will decrease.
9. White bark pine can't live so the acorns won't be available for squirrels to save so the grizzlies can't raid the middens so there will be fewer grizzlies.

Review

1. What does a food chain depict? Why do scientists usually use a food web instead of a food chain?
2. Start with the Sun and describe what happens to energy through the trophic levels. Why does this not go on forever (with many more trophic levels)?
3. What trophic level do you inhabit? Do all humans inhabit the same trophic level? Using energy as the factor, what case can be made for eating vegetarian.

Review Answers

1. A food chain shows the passing of energy from one trophic level to another. Many organisms eat from more than one trophic level so there is a much greater interconnection of food chains.

2. The sun is used by a producer at the first trophic level. The producers are eaten by a consumer at the 2nd trophic level. This continues. At each trophic level only a portion of the energy is passed to the next trophic level because energy is lost to heat and growth and reproduction, among other things. After four or five trophic levels there is not enough energy to be passed and the food web ends.
3. We inhabit multiple trophic levels. Some people are vegetarians who are at the 2nd trophic level. Others eat higher on the food chain. Less energy is wasted by eating lower on the food chain. More people could be supported if everyone ate at the 2nd trophic level.

1.4 Flow of Matter in Ecosystems

- Describe how matter flows through ecosystems.
- Compare and contrast the flow of matter with the flow of energy in ecosystems.

What killed millions of sailors in the 15th through 18th centuries?

Sailors at sea or explorers in polar regions, even Crusaders, who went without fresh food developed scurvy due to the lack of vitamin C in their diets. Without the right nutrients in the right amounts, you can't live —and humans need vitamin C. It wasn't until 1932 that the link between scurvy and a nutrient was made.

Flow of Matter in Ecosystems

The flow of matter in an ecosystem is not like energy flow. Matter enters an ecosystem at any level and leaves at any level. Matter cycles freely between trophic levels and between the ecosystem and the physical environment (**Figure** 1.12).

Nutrients

Nutrients are ions that are crucial to the growth of living organisms. Nutrients such as nitrogen and phosphorous are important for plant cell growth. Animals use silica and calcium to build shells and skeletons. Cells need nitrates and phosphates to create proteins and other biochemicals. From nutrients, organisms make tissues and complex molecules such as carbohydrates, lipids, proteins, and nucleic acids.

What are the sources of nutrients in an ecosystem? Rocks and minerals break down to release nutrients. Some enter the soil and are taken up by plants. Nutrients can be brought in from other regions, carried by wind or water. When one organism eats another organism, it receives all of its nutrients. Nutrients can also cycle out of an ecosystem.

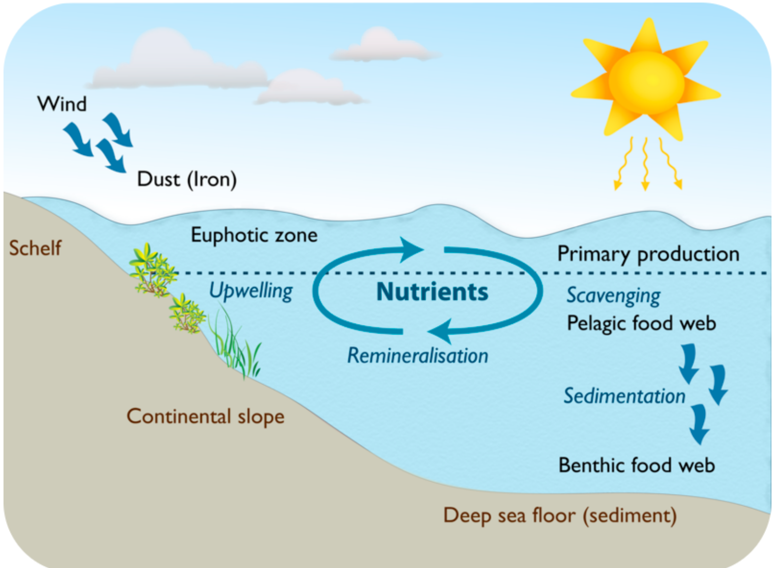


FIGURE 1.12
Nutrients cycle through ocean food webs.

Decaying leaves may be transported out of an ecosystem by a stream. Wind or water carries nutrients out of an ecosystem.

Decomposers play a key role in making nutrients available to organisms. Decomposers break down dead organisms into nutrients and carbon dioxide, which they respire into the air. If dead tissue would remain as it is, eventually nutrients would run out. Without decomposers, life on Earth would have died out long ago.

Summary

- Ions that are crucial to the growth of organisms are known as nutrients.
- Decomposers break down dead organisms into nutrients and gases so that they can be used by other organisms.
- Nutrients can enter or exit an ecosystem at any point and can cycle around the planet.

Explore More

Use this resource to answer the questions that follow.

1. What happens to the energy that goes up the trophic levels?
2. What is the consequence of this energy loss on the ecosystem?
3. What happens to the size of organisms as you go up the food web?
4. What are decomposers needed?
5. What direction does energy go through a food web? What direction does matter go through a food web?

Explore More Answers

1. A lot is lost because it is consumed or lost as heat or used. Less energy is available at higher trophic levels. About 10% gets passed to the next trophic level.
2. There are many more producers than organisms at the higher tropic levels.
3. The organisms get larger or more specialized to capture the food energy they need.
4. They need to recycle the organisms and their wastes into nutrients so they can be used again.

5. Energy goes straight through the trophic levels. Matter gets cycled all the way around and back to the beginning.

Review

1. How does the flow of matter differ from the flow of energy through an ecosystem?
2. How do nutrients enter and exit and ecosystem?
3. What would happen to life on Earth if there were no decomposers?

Review Answers

1. Energy flows in one direction through an ecosystem. It starts with producers and goes up the trophic levels until it is lost.
2. Nutrients enter at many parts of the ecosystem and they are recycled and reused so they cycle through.
3. There would be no life because all the matter would be tied up in dead animals and there would be no nutrients left over for producers to make food energy with.

1.5 Nitrogen Cycle in Ecosystems

- Describe nitrogen's roles as a nutrient.
- Define nitrogen fixation and explain how it occurs.

Lentils, anyone?

Why are legumes important to biological cycles? Nitrogen gas, as found in the atmosphere, is not useful to organisms. Legumes have bacteria in their root nodules that fix nitrogen. Putting legumes into a crop rotation reduces fertilizer costs and makes the soil and the crops healthier.

Nitrogen as a Nutrient

Nitrogen (N_2) is vital for life on Earth as an essential component of organic materials, such as amino acids, chlorophyll, and nucleic acids such as DNA and RNA (**Figure** 1.13). Chlorophyll molecules, essential for photosynthesis, contain nitrogen.

Nitrogen Fixing

Although nitrogen is the most abundant gas in the atmosphere, it is not in a form that plants can use. To be useful, nitrogen must be "fixed," or converted into a more useful form. Although some nitrogen is fixed by lightning or blue-green algae, much is modified by bacteria in the soil. These bacteria combine the nitrogen with oxygen or hydrogen to create nitrates or ammonia (**Figure** 1.14).

Nitrogen-fixing bacteria either live free or in a symbiotic relationship with leguminous plants (peas, beans, peanuts). The symbiotic bacteria use carbohydrates from the plant to produce ammonia that is useful to the plant. Plants use

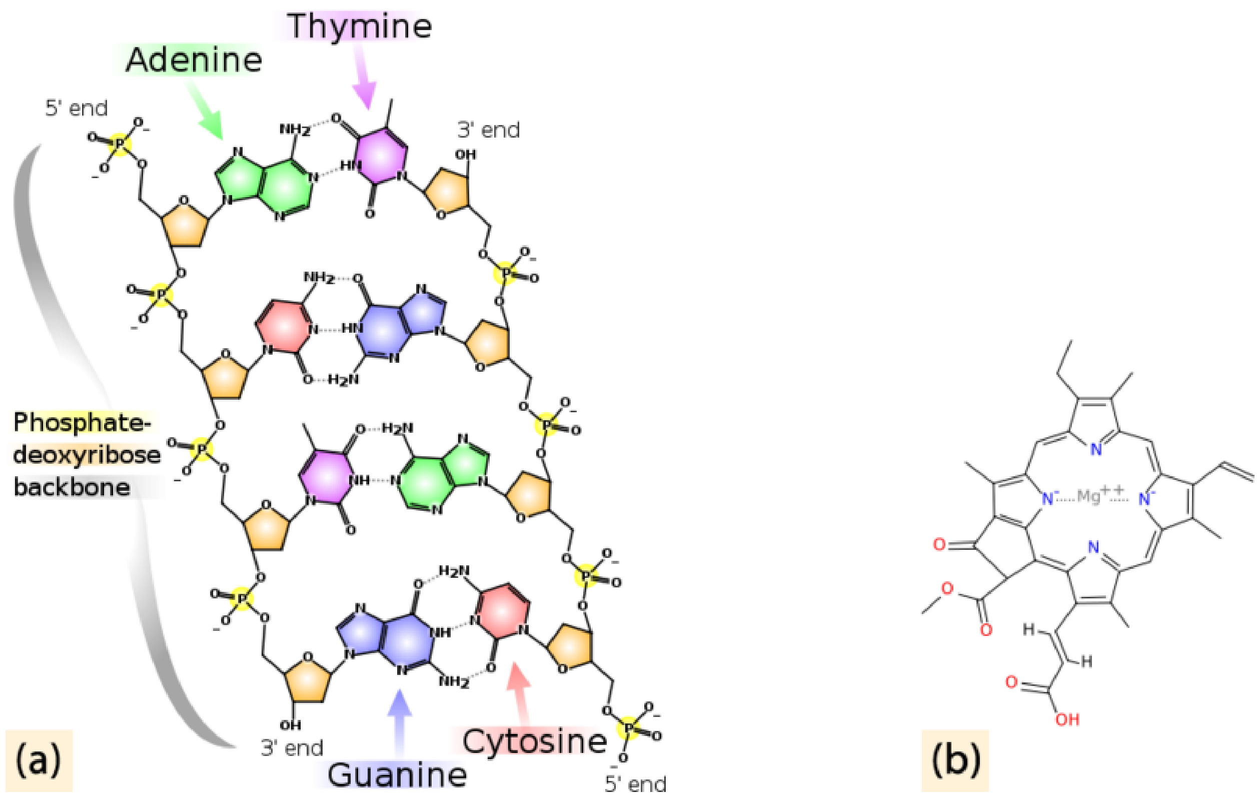


FIGURE 1.13
(a) Nucleic acids contain nitrogen (b) Chlorophyll molecules contain nitrogen

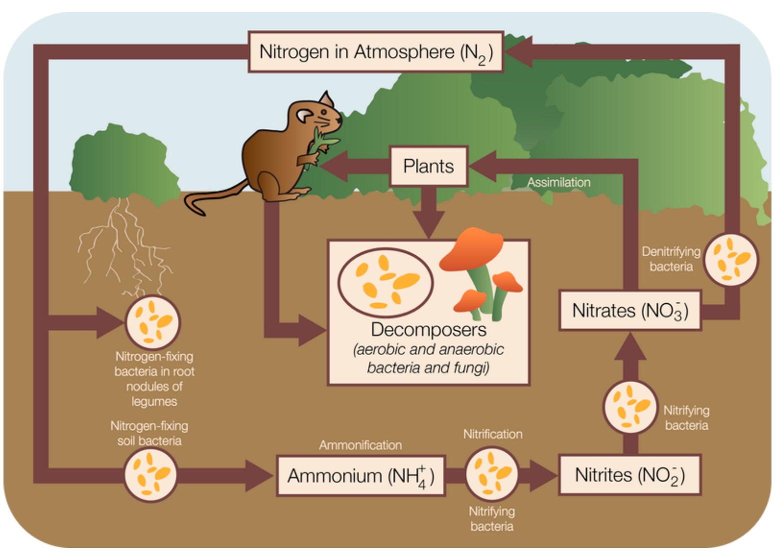


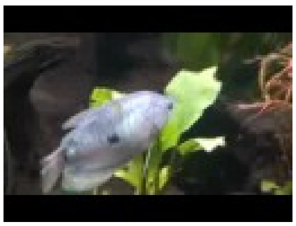
FIGURE 1.14
The nitrogen cycle.

this fixed nitrogen to build amino acids, nucleic acids (DNA, RNA), and chlorophyll. When these legumes die, the fixed nitrogen they contain fertilizes the soil.

Up the Food Chain

Animals eat plant tissue and create animal tissue. After a plant or animal dies or an animal excretes waste, bacteria and some fungi in the soil fix the organic nitrogen and return it to the soil as ammonia. Nitrifying bacteria oxidize the ammonia to nitrites, while other bacteria oxidize the nitrites to nitrates, which can be used by the next generation of plants. In this way, nitrogen does not need to return to a gas. Under conditions when there is no oxygen, some bacteria can reduce nitrates to molecular nitrogen.

This very thorough video on the nitrogen cycle with an aquatic perspective was created by high school students: http://www.youtube.com/watch?v=pdY4I-EaqJA (5:08).



MEDIA

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Summary

- Nitrogen is an essential component of many organic molecules.
- Nitrogen is fixed when it is changed into a form that organisms can use.
- Bacteria and some fungi fix organic nitrogen into ammonia and nitrifying bacteria oxidize it to nitrates.

Explore More

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=leHy-Y_8nRs End at 5:15

1. How much nitrogen are animals? How much phosphorous?
2. What do animals use nitrogen for?
3. Why is nitrogen gas impossible for us to use for the nitrogen we need?
4. Which organisms can change the nitrogen into a form that we can use? What is this process called?
5. Where do these bacteria live? What do they create?
6. What do nitrifying bacteria do?
7. What would life on Earth be like without these two types of bacteria?
8. What else can break nitrogen apart?
9. What do denitrifying bacteria do?

Explore More Answers

1. 3%; 1%
2. Nitrogen is needed for amino acids, which make proteins, and DNA and RNA.
3. Nitrogen gas is two nitrogen atoms held together by three covalent bonds, which are hard to pry apart.
4. Certain bacteria can fix the nitrogen so that it can be used.

5. They associate with the root nodules of legumes. They convert atmospheric nitrogen into ammonia.
6. Take the ammonia and convert it into nitrates and nitrites.
7. There would be much less of it.
8. Lightning and humans.
9. Metabolize nitrogen oxides and turn it back into nitrogen gas.

Review

1. What do soil bacteria do with nitrogen?
2. Why are legumes important as nitrogen fixers?
3. Why do organisms need nitrogen?

Review Answers

1. Bacteria in the soil break apart nitrogen gas and produce ammonia.
2. They provide carbohydrates to the bacteria to produce the ammonia.
3. Nitrogen is an essential component of organic materials such as amino acids, chlorophyll and nucleic acids.

1.6 Fresh Water Ecosystems

- Describe the various types of freshwater ecosystems.

Why did people used to rush to fill in swamps?

People didn't know the value of wetlands. Many are in locations that might be desirable for people to live, like near a shoreline. Mosquitoes, which no one seems to like, breed there. But wetlands serve a number of valuable purposes. They are breeding grounds for many organisms and they protect inland areas from storms. Now wetlands are protected.

Freshwater Ecosystems

Organisms that live in lakes, ponds, streams, springs or wetlands are part of freshwater ecosystems. These ecosystems vary by temperature, pressure (in lakes), the amount of light that penetrates and the type of vegetation that lives there.

Lake Ecosystems

Limnology is the study of bodies of fresh water and the organisms that live there. A lake has zones just like the ocean. The ecosystem of a lake is divided into three distinct zones (**Figure** 1.15):

1. The surface (littoral) zone is the sloped area closest to the edge of the water.
2. The open-water zone (also called the photic or limnetic zone) has abundant sunlight.
3. The deep-water zone (also called the aphotic or profundal zone) has little or no sunlight.

There are several life zones found within a lake:

- In the littoral zone, sunlight promotes plant growth, which provides food and shelter to animals such as snails, insects, and fish.
- In the open-water zone, other plants and fish, such as bass and trout, live.
- The deep-water zone does not have photosynthesis since there is no sunlight. Most deep-water organisms are scavengers, such as crabs and catfish that feed on dead organisms that fall to the bottom of the lake. Fungi and bacteria aid in the decomposition in the deep zone.

Though different creatures live in the oceans, ocean waters also have these same divisions based on sunlight with similar types of creatures that live in each of the zones.

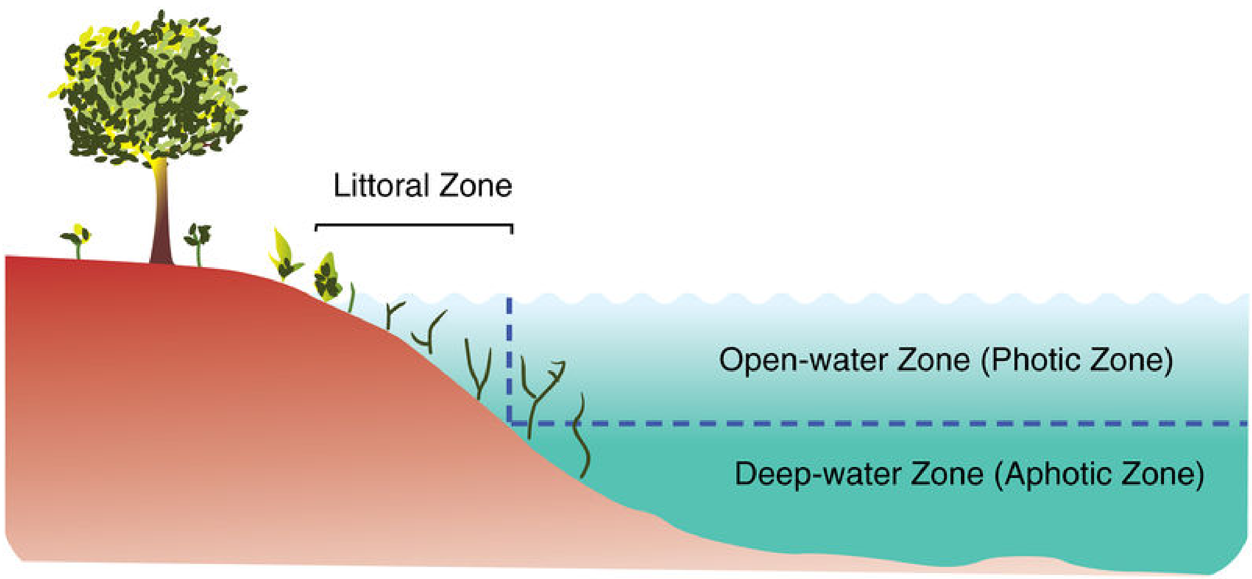


FIGURE 1.15
The three primary zones of a lake are the littoral, open-water, and deep-water zones.

Wetlands

Wetlands are lands that are wet for significant periods of time. They are common where water and land meet. Wetlands can be large flat areas or relatively small and steep areas.

Wetlands are rich and unique ecosystems with many species that rely on both the land and the water for survival. Only specialized plants are able to grow in these conditions. Wetlands tend have a great deal of biological diversity. Wetland ecosystems can also be fragile systems that are sensitive to the amount and quality of water present within them.

Marshes

Marshes are shallow wetlands around lakes, streams, or the ocean where grasses and reeds are common, but trees are not (**Figure** 1.16). Frogs, turtles, muskrats, and many varieties of birds are at home in marshes.

FIGURE 1.16
A salt marsh on Cape Cod in Massachusetts.

Swamps

A **swamp** is a wetland with lush trees and vines found in low-lying areas beside slow-moving rivers (**Figure** 1.17). Like marshes, they are frequently or always inundated with water. Since the water in a swamp moves slowly, oxygen in the water is often scarce. Swamp plants and animals must be adapted for these low-oxygen conditions. Like marshes, swamps can be fresh water, salt water, or a mixture of both.

FIGURE 1.17
A swamp is characterized by trees in still water.

Ecological Role of Wetlands

As mentioned above, wetlands are home to many different species of organisms. Although they make up only 5% of the area of the United States, wetlands contain more than 30% of the plant types. Many endangered species live in wetlands, so wetlands are protected from human use.

Wetlands also play a key biological role by removing pollutants from water. For example, they can trap and use fertilizer that has washed off a farmer's field, and therefore they prevent that fertilizer from contaminating another body of water. Since wetlands naturally purify water, preserving wetlands also helps to maintain clean supplies of water.

Summary

- The conditions that affect lake ecosystems are similar to those that affect marine ecosystems, such as light penetration, temperature and water depth.
- Wetlands are lands that are wet for a significant portion of the year.
- Wetlands are extremely important as an ecosystem and as a filter for pollutants.

Making Connections

MEDIA

Click image to the left for use the URL below.

URL: http://gamma.ck12.org/flx/render/embeddedobject/60976

Explore More

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=-VP5WNZK6JM Stop at 10:40

1. What are the three main kinds of water biomes?
2. What are the two types of freshwater biomes?
3. How does the geology of a region affect the ecology of a river?
4. What grows in slow-moving rivers that won't grow in fast rivers?
5. Why is there plenty of oxygen in a moving river?
6. Why don't most lakes become saline?
7. What are bogs?
8. How are swamps and marshes different from bogs? How are marshes different from swamp?
9. How do living things last through a winter in a lake if the top of the lake freezes?
10. What happens to the lake when the ice melts in the spring?
11. Why is the lake temperature stratified in the summer?
12. How much circulation is in the lake in autumn?
13. What brings nutrients into a lake?
14. What is a young lake with little food called
15. Is a lake that has a lot of plants at the top teeming with life?

Explore More Answers

1. Freshwater, salt water and estuaries, which is in between.
2. Moving and standing.
3. The dirt or rock the river runs through will have an impact as will the topography of the region the river flows through.

4. Grasses and things that need to take hold of the bottom.
5. The turbulence of the water mixes atmospheric gases into it.
6. They don't last long enough to get that much salt buildup.
7. Standing water covered with vegetation.
8. They are not covered with plants. Swamps have more trees; marshes have more grasses.
9. The temperature is cold but constant because the ice insulates the rest of the lake. They lower their metabolism.
10. The top of the lake is colder than the bottom so there is convection. Wind blows the surface. Nutrients are taken up from the bottom.
11. The top is warmer due to the sun and so the lake stays stratified.
12. Convection happens in autumn.
13. Rain brings it in from the lands surrounding the lake.
14. oligotrophic
15. Nutrients and sunlight do not filter down and so the lake is not rich in life.

Review

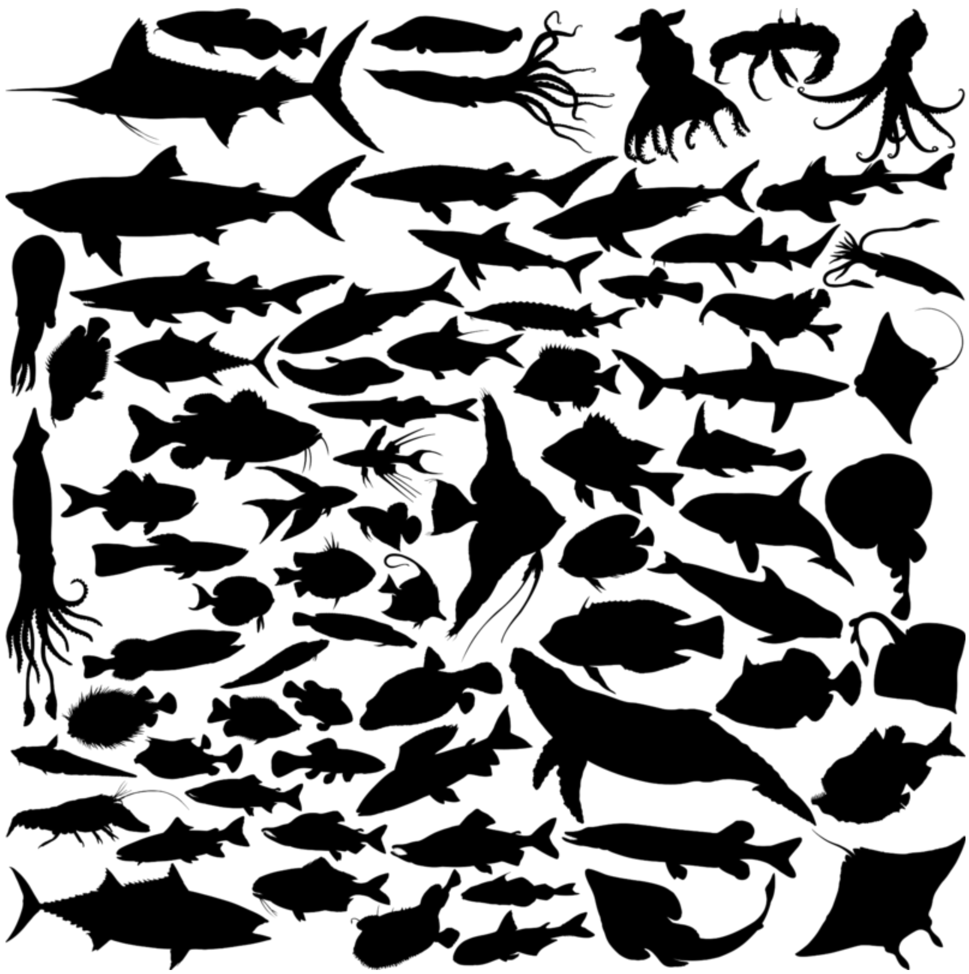
1. Describe how ecological zones in lakes are similar to ecological zones in oceans.
2. For many decades, people drained wetlands. Was this a good idea or a bad idea? Why?
3. How are marshes different from swamps? How are they the same?

Review Answers

1. In large lakes the features are the same. One important distinction is where there is light (the photic zone) and where there is no light (the aphotic zone). There are also zones for the surface on the sloping bank (the littoral zone) and for the open water (photic or limnetic) and for the deep water (aphotic or profundal). Types of life corresponds to these zones.
2. It was a bad idea. Wetlands are the breeding ground for many organisms and they protect inland seas from storms. They contain a lot o biodiversity including many endangered species. They filter and cleanse water.
3. Marshes and swamps are both shallow wetlands, but marshes are grassy and swamps have trees. Both are usually inundated with water and can be fresh or saline.

1.7 Types of Marine Organisms

- Describe types of marine organisms.



How does the ocean seem all the same, yet have so much biodiversity?

Although it may seem like the ocean is all the same, there are many different habitats based on temperature, salinity, pressure, light, currents, and other factors. Organisms have adapted to these conditions in many interesting and effective ways. Covering 70% of Earth's surface, the oceans are home to a large portion of all life on Earth.

Types of Ocean Organisms

The smallest and largest animals on Earth live in the oceans. Why do you think the oceans can support large animals?

Marine animals breathe air or extract oxygen from the water. Some float on the surface and others dive into the ocean's depths. There are animals that eat other animals, and plants generate food from sunlight. A few bizarre creatures break down chemicals to make food! The following section divides ocean life into seven basic groups.

Plankton

Plankton are organisms that cannot swim but that float along with the current. The word "plankton" comes from the Greek for wanderer. Most plankton are microscopic, but some are visible to the naked eye (**Figure** 1.18).

Phytoplankton are tiny plants that make food by photosynthesis. Because they need sunlight, phytoplankton live in the photic zone. Phytoplankton are responsible for about half of the total **primary productivity** (food energy) on Earth. Like other plants, phytoplankton release oxygen as a waste product.

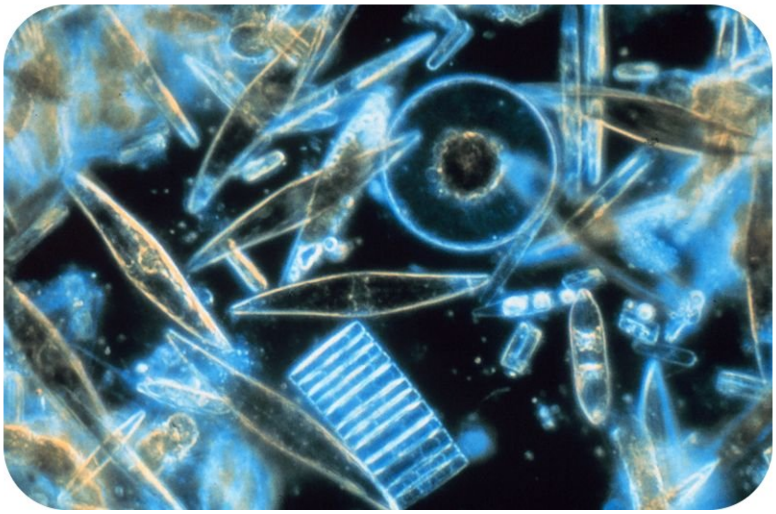


FIGURE 1.18
Microscopic diatoms are a type of phytoplankton.

A video of a research vessel sampling plankton is seen here: http://www.youtube.com/watch?v=mQG4zAoh6xc .

Zooplankton, or animal plankton, eat phytoplankton as their source of food (**Figure** 1.19). Some zooplankton live as plankton all their lives and others are juvenile forms of animals that will attach to the bottom as adults. Some small invertebrates live as zooplankton.

FIGURE 1.19
Copepods are abundant and so are an important food source for larger animals.

Plants and Algae

The few true plants found in the oceans include salt marsh grasses and mangrove trees. Although they are not true plants, large algae, which are called seaweed, also use photosynthesis to make food. Plants and seaweeds are found in the neritic zone, where the light they need penetrates so that they can photosynthesize (**Figure** 1.20).

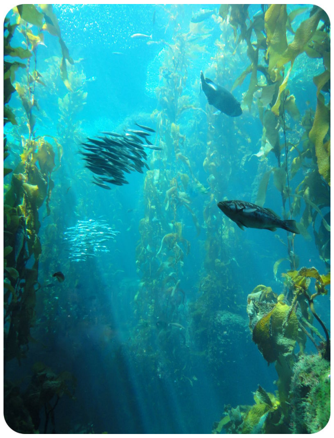


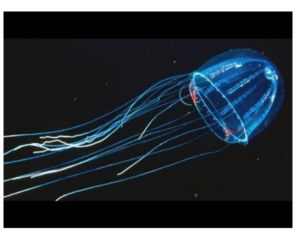
FIGURE 1.20
Kelp grows in forests in the neritic zone. Otters and other organisms depend on the kelp-forest ecosystem.

Marine Invertebrates

The variety and number of **invertebrates**, animals without a backbone, is truly remarkable (**Figure** 1.21). Marine invertebrates include sea slugs, sea anemones, starfish, octopuses, clams, sponges, sea worms, crabs, and lobsters. Most of these animals are found close to the shore, but they can be found throughout the ocean.

Jellies are otherworldly creatures that glow in the dark, without brains or bones, some more than 100 feet long. Along with many other ocean areas, they live just off California's coast.

Learn more about jellies by watching http://science.kqed.org/quest/video/amazing-jellies/ .



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Fish

Fish are **vertebrates**; they have a backbone. What are some of the features fish have that allows them to live in the oceans? All fish have most or all of these traits:

- Fins with which to move and steer.
- Scales for protection.
- Gills for extracting oxygen from the water.
- A swim bladder that lets them rise and sink to different depths.
- Ectothermy (cold-bloodedness), so that their bodies are the same temperature as the surrounding water.

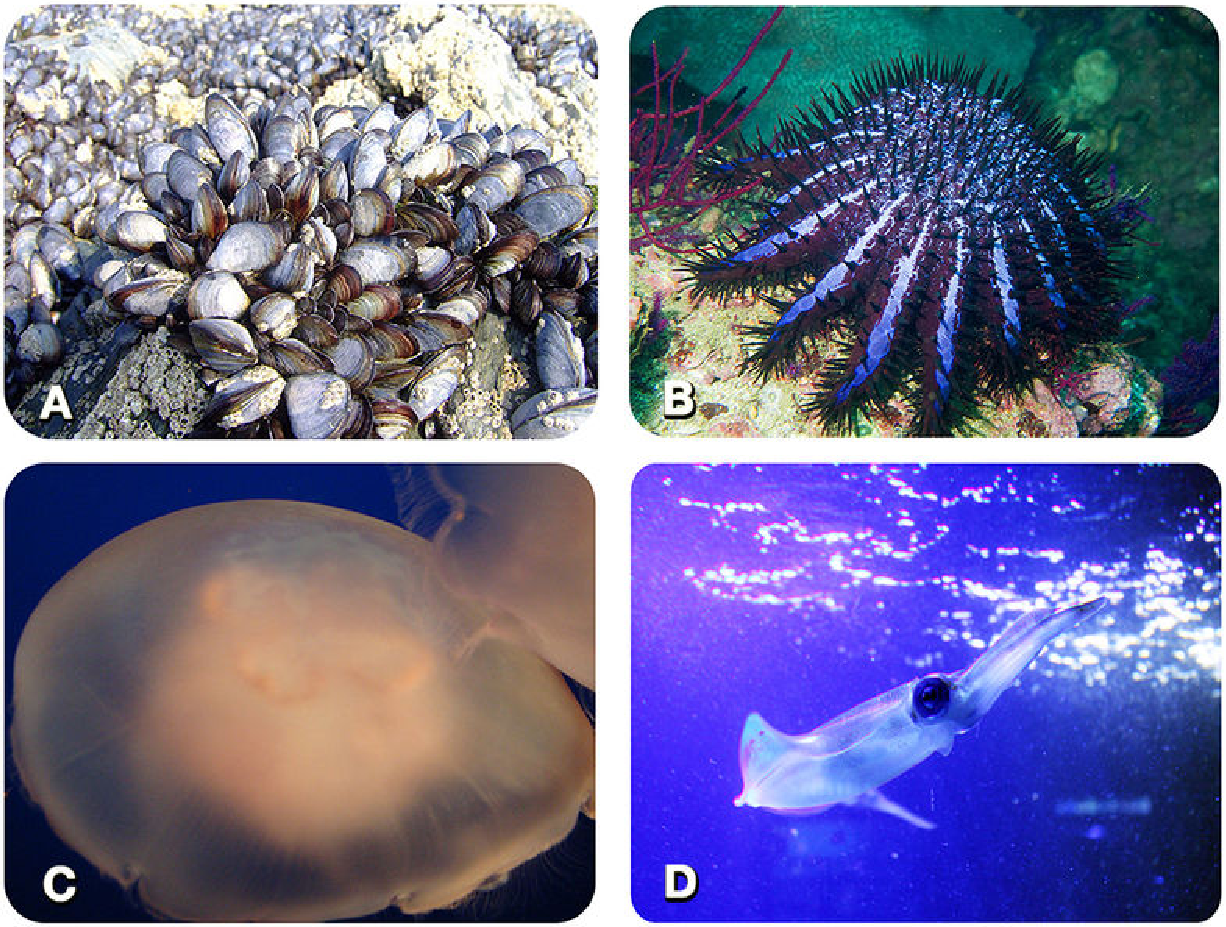


FIGURE 1.21

(a) Mussels; (b) Crown of thorns sea star; (c) Moon jelly; (d) A squid.

- Bioluminescence, or light created from a chemical reaction that can attract prey or mates in the dark ocean.

Included among the fish are sardines, salmon, and eels, as well as the sharks and rays (which lack swim bladders) (**Figure** 1.22).

Reptiles

Only a few types of reptiles live in the oceans and they live in warm water. Why are reptiles so restricted in their ability to live in the sea? Sea turtles, sea snakes, saltwater crocodiles, and marine iguana that are found only at the Galapagos Islands sum up the marine reptile groups (**Figure** 1.23). Sea snakes bear live young in the ocean, but turtles, crocodiles, and marine iguanas all lay their eggs on land.

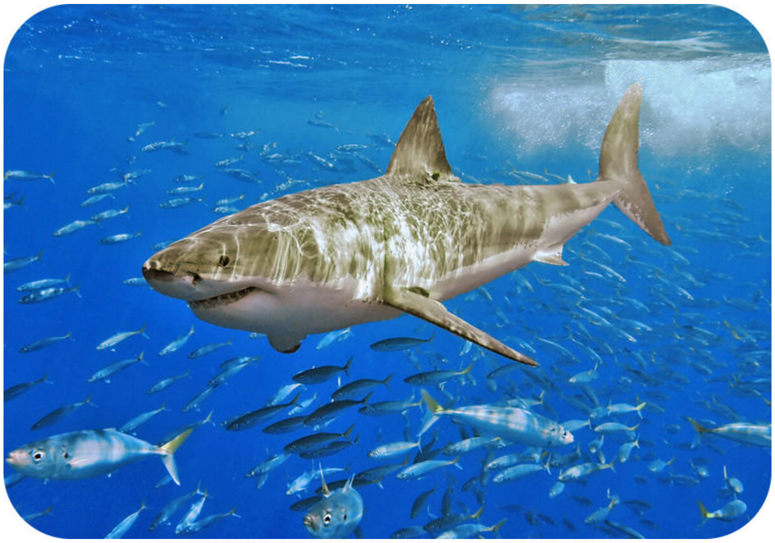


FIGURE 1.22
The Great White Shark is a fish that preys on other fish and marine mammals.

FIGURE 1.23
Sea turtles are found all over the oceans, but their numbers are diminishing.

Seabirds

Many types of birds are adapted to living in the sea or on the shore. With their long legs for wading and long bills for digging in sand for food, shorebirds are well adapted for the intertidal zone. Many seabirds live on land but go to sea to fish, such as gulls, pelicans, and frigate birds. Some birds, like albatross, spend months at sea and only come on shore to raise chicks (**Figure** 1.24).

Marine Mammals

What are the common traits of mammals? Mammals are endothermic (warm-blooded) vertebrates that give birth to live young, feed them with milk, and have hair, ears, and a jaw bone with teeth.

What traits might mammals have to be adapted to life in the ocean?

FIGURE 1.24
(a) Shorebirds; (b) Seabirds; (c) Albatross.

- For swimming: streamlined bodies, slippery skin or hair, fins.
- For warmth: fur, fat, high metabolic rate, small surface area to volume, specialized blood system.
- For salinity: kidneys that excrete salt, impervious skin.

The five types of marine mammals are pictured here: (**Figure** 1.25).

FIGURE 1.25
(a) Cetaceans: whales, dolphins, and porpoises. (b) Sirenians: manatee and the dugong. (c) Mustelids: Sea otters (terrestrial members are skunks, badgers and weasels). (d) Pinnipeds: Seals, sea lions, and walruses. (e) Polar bear.

Summary

- Plankton are tiny organisms that are swept along on currents. Phytoplankton are tiny photosynthesizers and zooplankton are tiny animals.
- Fish have gills for breathing, swim bladders for rising and sinking, and other adaptations for life in the oceans.
- Shorebirds live at the interface of land and sea; some birds live on land but fish at sea, and some birds spend most of their time at sea and only come to shore to nest.

Explore More

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=se_sj0nL3Xk

1. What are kelp? Where are kelp forests found?
2. Why are kelp forests important to their ecosystem?
3. How do kelp withstand the forces of waves and currents?
4. How are the kelp blades kept in the zone for photosynthesis?
5. What does the canopy of the kelp forest provide to organisms and how?
6. what does the ocean provide?

Explore More Answers

1. Kelp are brown algae that live in cool shallow water close to shore. Kelp forests are found along the west coast of North America.
2. They provide food and shelter to fish, invertebrate and mammal species.
3. They hang on with root-like holdfasts. The stipe is flexible and sways with the currents.
4. They contain a gas like a float that keeps them close to the surface.
5. Organisms use this as shelter for young, from predators and storms.
6. Food, oxygen and pharmaceuticals

Review

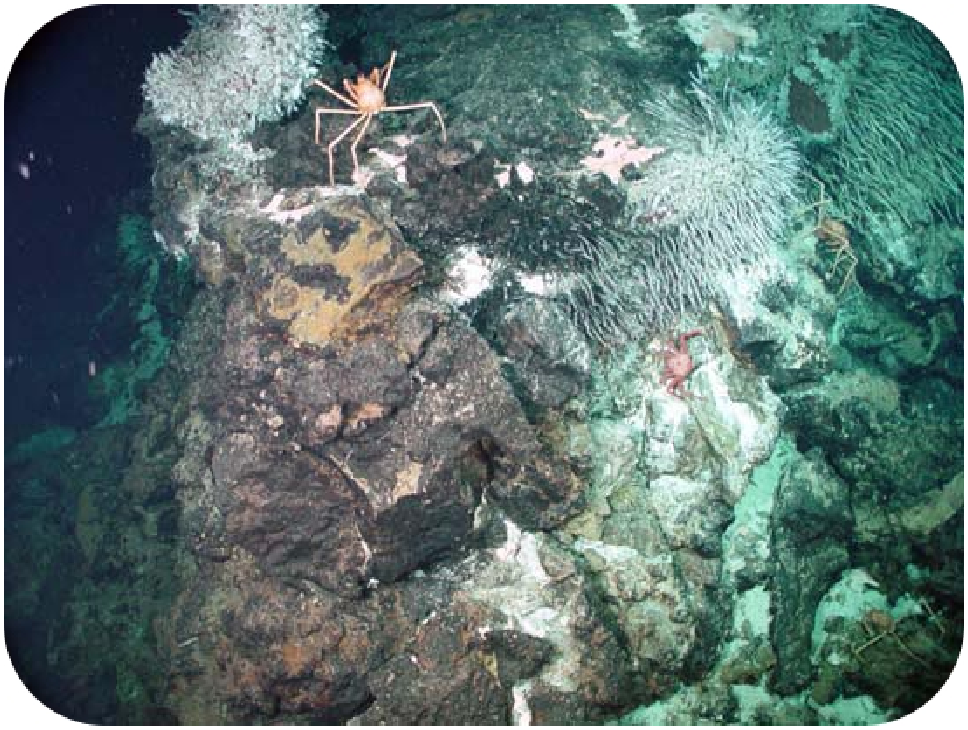
1. How are phytoplankton different from plant-like algae?
2. Describe how fish are adapted to life in the oceans.
3. Describe how marine mammals are adapted to life in the oceans. How are these adaptations different from those of fish?

Review Answers

1. Seaweeds are attached to the bottom and they have large leaves for photosynthesis. They are not true plants. Phytoplankton are tiny plants that photosynthesize but they are not attached to a bottom, they float with the current. They are tiny and also engage in photosynthesis.
2. Fish have any adaptations for life in the oceans including: fins for movement, scales for protection, gills for breathing, a swim bladder to rise and sink, ectothermy to not waste heat in the cold ocean and sometimes bioluminescence that helps them see prey and mates.
3. Marine mammals have streamlined bodies for swimming and fins. They are endotherms so for warmth they have skin, fat, fur and hair, plus a high metabolic rate and kidneys that secrete salt. They have bodies like fish and they may have adaptations to the ocean like for dealing with salt but they are very different from fish.

1.8 Ocean Ecosystems

- Describe the various types of ocean ecosystems.



Which ecosystem doesn't depend on photosynthesis?

When scientists first dove in Alvin and witnessed hydrothermal vents, they were not surprised by the eruptions of hot water. But they never anticipated finding life there. Without sunlight, they knew that photosynthesis could not be the basis of this community. Eventually they discovered a different way of producing food, chemosynthesis. Many more hydrothermal vents were discovered and many more types of vent organisms.

The Intertidal

Conditions in the intertidal zone change rapidly as water covers and uncovers the region and waves pound on the rocks. A great abundance of life is found in the intertidal zone (**Figure** 1.26). High energy waves hit the organisms that live in this zone, so they must be adapted to pounding waves and exposure to air during low tides. Hard shells protect from waves and also protect against drying out when the animal is above water. Strong attachments keep the animals anchored to the rock.

In a tide pool, as in the photo, what organisms are found where and what specific adaptations do they have to that zone? The mussels on the top left have hard shells for protection and to prevent drying because they are often not covered by water. The sea anemones in the lower right are more often submerged and have strong attachments but can close during low tides.

Many young organisms get their start in estuaries and so they must be adapted to rapid shifts in salinity.

FIGURE 1.26
Organisms in a tide pool include sea stars and sea urchins.

Reefs

Corals and other animals deposit calcium carbonate to create rock **reefs** near the shore. Coral reefs are the "rainforests of the oceans," with a tremendous amount of species diversity (**Figure** 1.27).

FIGURE 1.27
Coral reefs are among the most densely inhabited and diverse areas on the globe.

Reefs can form interesting shapes in the oceans. Remember that hot spots create volcanoes on the seafloor. If these volcanoes rise above sea level to become islands, and if they occur in tropical waters, coral reefs will form on them. Since the volcanoes are cones, the reef forms in a circle around the volcano. As the volcano comes off the hot spot, the crust cools. The volcano subsides and then begins to erode away (**Figure** 1.28).

Eventually, all that is left is a reef island called an atoll. A lagoon is found inside the reef.

FIGURE 1.28
In this image of Maupiti Island in the South Pacific, the remnants of the volcano are surrounded by the circular reef.

Oceanic Zone

The open ocean is a vast area. Food either washes down from the land or is created by photosynthesizing plankton. Zooplankton and larger animals feed on the phytoplankton and on each other. Larger animals such as whales and giant groupers may live their entire lives in the open water.

How do fish survive in the deepest ocean? The few species that live in the greatest depths are very specialized (**Figure** 1.29). Since it's rare to find a meal, the fish use very little energy; they move very little, breathe slowly, have minimal bone structure and a slow metabolism. These fish are very small. To maximize the chance of getting a meal, some species may have jaws that unhinge to accept a larger fish or backward-folding teeth to keep prey from escaping.

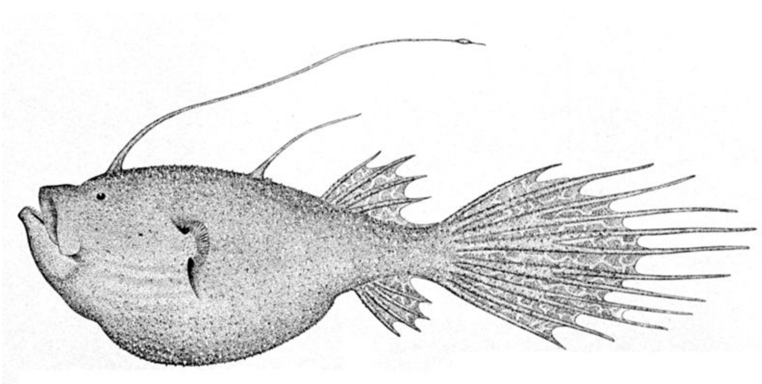


FIGURE 1.29
An 1896 drawing of a deep sea angler fish with a bioluminescent "lure" to attract prey.

Many ocean-related videos are found in National Geographic Videos, Environment Video, Habitat, Ocean section: http://video.nationalgeographic.com/video/player/environment/ . Just a few are listed below.

- How we can know what lives in the ocean is in "Deep-Sea Robo Help."
- Some of the results of the Census of Marine Life have been released and are discussed in "Record-Breaking Sea-Creature Surveys Released."
- Bioluminescence is common in the oceans and seen in "Why Deep Sea Creatures Glow."

Hydrothermal Vents

Hydrothermal vents are among the most unusual ecosystems on Earth since they are dependent on chemosynthetic organisms at the base of the food web. At mid-ocean ridges at **hydrothermal vents**, bacteria that use **chemosynthesis** for food energy are the base of a unique ecosystem (**Figure** 1.30). This ecosystem is entirely separate from the photosynthesis at the surface. Shrimp, clams, fish, and giant tube worms have been found in these extreme places.

FIGURE 1.30
Giant tube worms found at hydrothermal vents get food from the chemosynthetic bacteria that live within them. The bacteria provide food; the worms provide shelter.

A video explaining hydrothermal vents with good footage is seen here: http://www.youtube.com/watch?v=rFHtVRKoaUM .

Summary

- In the ocean, phytoplankton photosynthesize as the main food source. They are eaten by zooplankton and other larger animals.
- Organisms that live in the deepest ocean have amazing adaptations to the exceptionally harsh conditions, such as unhinging jaws, backward-folding teeth, or a bioluminescent lure.
- A hydrothermal vent ecosystem has chemosynthesis as its food source. The ecosystem is independent of photosynthesis at the surface.

Making Connections

MEDIA
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Explore More

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=se_sj0nL3Xk

1. What are a few of the ecological services provided by marine ecosystems?
2. What is the economic value of the oceans?
3. What are the three major life zones in the oceans?
4. What is the coastal zone?
5. What is the value or the coastal zone to the marine ecosystems? Why is this true?
6. What are two estuaries and why are they rich in life?
7. Why is life harsh in the coastal zone?
8. What ecological services do estuaries and coastal marshes provide?
9. What is the intertidal zone? What do organisms in this zone need to deal with?
10. What ecological services are provided by coral reefs?
11. What are the three zones of the open ocean? How are they divided?
12. What are the characteristics of the upper zone?
13. What are the characteristics of the middle zone?
14. What are the characteristics of the bottom zone?
15. Why does the ocean have high productivity?
16. Where is productivity relatively high? Why?
17. Which human activities are causing losses in ocean productivity?

Explore More Answers

1. climate moderation, nutrient cycling, waste treatment, habitat and nursery area, genetic resources, biodiversity
2. Source of food and pharmaceuticals, mechanism for transportation and recreation, soil of fossil fuels
3. coastal, open sea, seafloor
4. The coastal zone is from the high tide mark down the continental shelf. It has warm, nutrient=rich, shallow water.
5. The coastal zone makes up less than 10% of the oceans but contains 90% of all marine species. It is so rich in life because it receives sunlight and nutrients from the land.
6. Estuaries are where rivers meet the sea so there is a lot of variation in habitat for different types of organisms to life in, including a lot of nutrients. They have associated wetlands.
7. Life must be adapted to tides, river flow, temperature and salinity changes, and runoff of sediments and pollutants.
8. Filter pollutants, nutrients and sediments; reduce storm damage by absorbing wave energy and excess water; provide habitats for organisms and young.
9. The intertidal is the zone between the low and high tide. Changes in temperature, salinity and wave action.
10. Coral reefs are very productive, they protect the coast from erosion and they moderate CO2 levels through formation of carbonate skeletons.
11. The euphotic zone, the bathyal zone, and the abyssal zone. They are divided by light.
12. The euphotic zone is well lit, has high dissolved oxygen but low nutrients. There is photosynthesis, which is limited by nutrients.
13. In the bathyal zone light is dim, there is no photosynthesis; many of the organisms live here but migrate to the top to feed at night.
14. The abyssal zone is very cold, little oxygen, survive on nutrients from above. #Hydrothermal vents here support their own ecosystems based on chemosynthesis.
15. It is so large that the productivity adds up.
16. In upwelling zones there is the rise of nutrients, which supports life.

17. Recreation such as diving; increasing ocean temperatures; dredging and trolling by fishers; ocean acidification from carbon dioxide, which forms carbonic acid.

Review

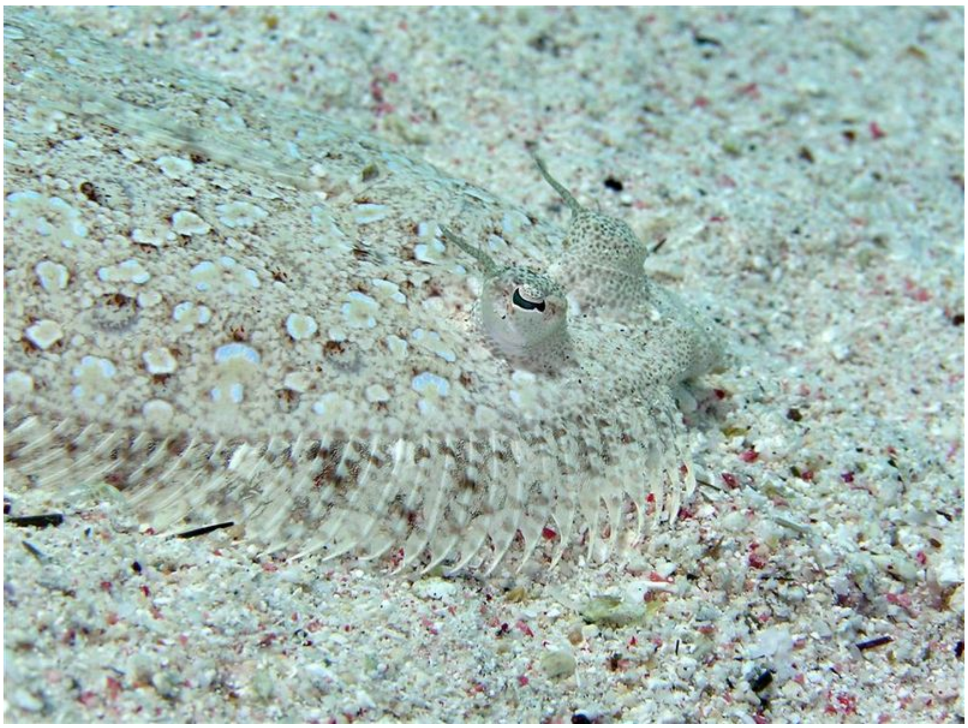
1. Why is there so much biodiversity in the intertidal zone?
2. Why is survival in the deep ocean difficult? What adaptations to organisms have to do this?
3. What is the source of energy at a hydrothermal vent system? How much do these communities depend on the surface?

Review Answers

1. The intertidal has a lot of biodiversity because there are so many changes in conditions between high and low tide. The different organisms deal with these difficulties in very different ways.
2. In the deep ocean there is no light and nutrients come from above, except at hydrothermal vents. The organisms use very little energy by having little movement, slow breathe, slow metabolism and minimal bone structure. They may have unique adaptations to getting fish like jaws that unhinge.
3. Chemosynthesis is the process that provides energy. The organisms get little food from the surface and mostly depend on the chemosynthesizers and the things that eat them for food.

1.9 Adaptation and Evolution of Populations

- Define adaptation.
- Explain the theory of evolution by natural selection.



Why would an organism match its background? Wouldn't it be better to stand out?

An organism that blends with its background is more likely to avoid predators. If it survives, it is more likely to have offspring. Those offspring are more likely to blend into their backgrounds.

Adaptation

The characteristics of an organism that help it to survive in a given environment are called **adaptations**. Adaptations are traits that an organism inherits from its parents. Within a population of organisms are genes coding for a certain number of traits. For example, a human population may have genes for eyes that are blue, green, hazel, or brown, but as far as we know, not purple or lime green.

Adaptations develop when certain **variations** or differences in a population help some members survive better than others (**Figure** 1.31). The variation may already exist within the population, but often the variation comes from a **mutation**, or a random change in an organism's genes. Some mutations are harmful and the organism dies; in that case, the variation will not remain in the population. Many mutations are neutral and remain in the population. If the environment changes, the mutation may be beneficial and it may help the organism adapt to the environment. The organisms that survive pass this favorable trait on to their offspring.

Biological Evolution

Many changes in the genetic makeup of a species may accumulate over time, especially if the environment is changing. Eventually the descendants will be very different from their ancestors and may become a whole new species. Changes in the genetic makeup of a species over time are known as biological **evolution**.

Natural Selection

The mechanism for evolution is **natural selection**. Traits become more or less common in a population depending on whether they are beneficial or harmful. An example of evolution by natural selection can be found in the deer mouse, species *Peromyscus maniculatus*. In Nebraska this mouse is typically brown, but after glaciers carried lighter sand over the darker soil in the Sand Hills, predators could more easily spot the dark mice. Natural selection favored the light mice, and over time, the population became light colored.

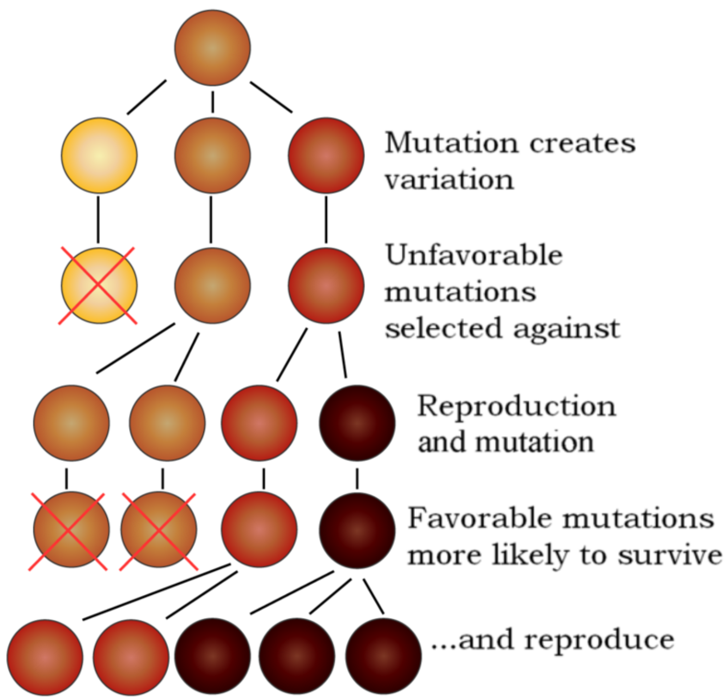


FIGURE 1.31
An explanation of how adaptations develop.

This story is covered in more detail here: http://news.harvard.edu/gazette/story/2009/08/mice-living-in-sand-hills-quickly-evolved-lighter-coloration/ .

Summary

- A population has genetic variations, possibly due to mutations. Favorable variations may allow an organism to be better adapted to its environment and survive to reproduce.
- Beneficial traits are favored in a population so that they may become better represented.
- Changes in the genetic makeup of a species may result in a new species; this is biological evolution.

Making Connections

MEDIA

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Explore More

Use these resources to answer the questions that follow.

https://www.youtube.com/watch?v=-BzPjwL6JAs

1. What is an adaptation? What does an adaptation do?
2. What adaptation does the rock pocket mouse have for living over desert sand and gravel? What adaptation does it have for living over lava?
3. How could bacteria become resistant to antibiotics.
4. As climate warms what may happen to polar bears?
5. How does natural selection change the rock pocket mouse population from brown to black?
6. How do new species form?
7. What are the four factors of natural selection so that a species is better adapted to its environment?
8. What is adaptation? What is the mechanism?

Explore More Answers

1. A trait that allows us to survive.
2. It is brown for desert sand but the black ones will be better adapted for live on lava.
3. Some have a mutation so that they are resistant to antibiotic. If antibiotic is applied, they are the ones that survive and reproduce until all are resistant.
4. As the ice becomes less common they may not need to be as heavy because being so heavy will make them too hot or as white.
5. Owls will be able to see the light mice on dark rock so the dark ones will be more likely to reproduce and the mice will become dark.
6. Small changes over time with natural selection to favor two different sets of traits.
7. reproduction, variation, competition, proliferation
8. Adaptation is how species become better adapted to their environment. The mechanism is natural selection.

Review

1. The Grand Canyon was carved, separating what had once been a single population of squirrel into two separate populations. What do you think happened to those populations over time?
2. How does natural selection work?
3. How does biological evolution work?
4. What will cause evolution to proceed rapidly?

Review Answers

1. They had different variations so over time they evolved into different species.
2. A population has different traits in its genes. One trait may be more advantageous and so members of the species with this trait survive and reproduce. Eventually many or all embers of that species will have that trait.

3. Changes in the genetic makeup of a species over time is biological evolution. It works because natural selection chooses traits that are better adapted to an organism's environment.
4. A change in the species' environment.

1.10 Population Size

- Describe the factors that regulate population size.

How many penguins are the right number for this beach?

As many as can survive and have healthy offspring! A population will tend to grow as big as it can for the resources it needs. Once it is too large, some of its members will die off. This keeps the population size at the right number.

Populations

Biotic and abiotic factors determine the population size of a species in an ecosystem. What are some important biotic factors? Biotic factors include the amount of food that is available to that species and the number of organisms that also use that food source. What are some important abiotic factors? Space, water, and climate all help determine a species population.

When does a population grow? A population grows when the number of births is greater than the number of deaths. When does a population shrink? When deaths exceed births.

What causes a population to grow? For a population to grow there must be ample resources and no major problems. What causes a population to shrink? A population can shrink either because of biotic or abiotic limits. An increase in predators, the emergence of a new disease, or the loss of habitat are just three possible problems that will decrease a population. A population may also shrink if it grows too large for the resources required to support it.

Carrying Capacity

When the number of births equals the number of deaths, the population is at its **carrying capacity** for that habitat. In a population at its carrying capacity, there are as many organisms of that species as the habitat can support. The carrying capacity depends on biotic and abiotic factors. If these factors improve, the carrying capacity increases. If the factors become less plentiful, the carrying capacity drops. If resources are being used faster than they are being replenished, then the species has exceeded its carrying capacity. If this occurs, the population will then decrease in size.

Limiting Factors

Every stable population has one or more factors that limit its growth. A **limiting factor** determines the carrying capacity for a species. A limiting factor can be any biotic or abiotic factor: nutrient, space, and water availability are examples (**Figure** 1.32). The size of a population is tied to its limiting factor.

FIGURE 1.32
In a desert such as this, what is the limiting factor on plant populations? What would make the population increase? What would make the population decrease?

What happens if a limiting factor increases a lot? Is it still a limiting factor? If a limiting factor increases a lot, another factor will most likely become the new limiting factor.

This may be a bit confusing, so let's look at an example of limiting factors. Say you want to make as many chocolate chip cookies as you can with the ingredients you have on hand. It turns out that you have plenty of flour and other ingredients, but only two eggs. You can make only one batch of cookies, because eggs are the limiting factor. But then your neighbor comes over with a dozen eggs. Now you have enough eggs for seven batches of cookies, but only two pounds of butter. You can make four batches of cookies, with butter as the limiting factor. If you get more butter, some other ingredient will be limiting.

Species ordinarily produce more offspring than their habitat can support (**Figure** 1.33). If conditions improve, more young survive and the population grows. If conditions worsen, or if too many young are born, there is competition between individuals. As in any competition, there are some winners and some losers. Those individuals that survive to fill the available spots in the niche are those that are the most fit for their habitat.

Summary

- Biotic factors that a population needs include food availability. Abiotic factors may include space, water, and climate.
- The carrying capacity of an environment is reached when the number of births equal the number of deaths.
- A limiting factor determines the carrying capacity for a species.

FIGURE 1.33
A frog in frog spawn. An animal produces many more offspring than will survive.

Explore More

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=atNZeaRDCmcQ Note that when he says "people," he's really talking about any population of organisms.

1. Under what circumstances can population growth be exponential?
2. What is carrying capacity?
3. What does reaching the carrying capacity do to population growth?
4. What does carrying capacity depend on?
5. What happens if a population exceeds its carrying capacity?
6. Is the carrying capacity constant? What changes it?
7. What are the two ways to eliminate a pest from your home?
8. Give the definition of density dependent factors that are limiting to population growth.
9. Give four examples and explain them for density dependent factors.
10. How do natural disasters affect the population size in a region?

Explore More Answers

1. Only when there are unlimited resources.
2. Carrying capacity is the maximum number of organisms that can be supported.
3. It causes population growth to slow down.
4. The biological productivity, hunting, predators, starvation, habitat space.
5. More organisms will be lost.
6. No it is not constant, it can be changed by many factors, like a bad winter.
7. Lower the capacity by lowering the productivity (their food source); increase their death rate (add a predator)
8. Density dependent factors are things that limit population growth but depend on how many individuals are living there.
9. Competition: there is only so much good grass so there is competition for that good grass; predation: the number of prey determines the number of predators; parasitism (disease, toxins): disease spreads faster when population density is higher, toxins collect faster; intrinsic factors: reproduction shuts down when population gets too high.
10. It can completely destroy the population.

Review

1. Why don't populations continue to grow and grow?
2. What happens if a population exceeds its carrying capacity?
3. What happens if a factor that has limited a population's size becomes more available?

Review Answers

1. A population will grow until something limits its growth. This limiting factor keeps the population from growing past its carrying capacity.
2. If there is no change in factors the population can't grow any more so excess organisms will die off.
3. The population will grow until it begins to run out of another limiting fctor.

1.11 Extinction and Radiation of Life

- Define extinction and explain why it occurs.
- Define adaptive radiation, and explain its relationship to extinction.

Should this pterodactyl be concerned? Should you?

When the dinosaurs were wiped out by an asteroid impact, the mammals were waiting to take over their niches. Could this happen again? Are there other ways species could go extinct and leave open niches for new organisms to fill?

Extinction

Most of the species that have lived have also gone extinct. There are two ways to go extinct: besides the obvious way of dying out completely, a species goes extinct if it evolves into a different species. Extinction is a normal part of Earth's history.

But sometimes large numbers of species go extinct in a short amount of time. This is a **mass extinction**. The causes of different mass extinctions are different: collisions with comets or asteroids, massive volcanic eruptions, or rapidly changing climate are all possible causes of some of these disasters (**Figure** 1.34).

Adaptive Radiation

After a mass extinction, many habitats are no longer inhabited by organisms because they have gone extinct. With new habitats available, some species will adapt to the new environments. Evolutionary processes act rapidly during

FIGURE 1.34
An extinct *Tyrannosaurus rex*. This fossil resembles a living organism.

these times and many new species evolve to fill those available habitats. The process in which many new species evolve in a short period of time to fill available niches is called **adaptive radiation**. At the end of this period of rapid evolution the life forms do not look much like the ones that were around before the mass extinction. For example, after the extinction of the dinosaurs, mammals underwent adaptive radiation and became the dominant life form.

Summary

- Species go extinct when all of the individuals die out or evolve into a different species.
- Many species go extinct at roughly the same time during a mass extinction.
- New habitats become available and species evolve to fill them so that biodiversity increases during adaptive radiation.

Making Connections

MEDIA
Click image to the left for use the URL below.
URL: http://gamma.ck12.org/flx/render/embeddedobject/115461

Explore More

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=yJLRl2G41nQ

1. What does a branch on a phylogenetic tree indicate?
2. What two things could have happened when a species disappears?
3. What is necessary regarding ability to mate for one species to become two different species?
4. What two things might a changing environment force to happen? What do each of these to things do to biodiversity?

5. How did natural selection take place in three-spined stickelbacks at Loberg Lake in Alaska? How is this an example of speciation?
6. Under what conditions does adaptive radiation take place? How are honeycreepers in Hawaii an example?
7. How many species that ever existed are now extinct?
8. How many mass extinctions have been identified according to the teacher? What is a mass extinction?
9. What is the K-T (Cretaceous-Tertiary) boundary?
10. What is found at the K-T boundary? What could that mean?

Explore More Answers

1. Speciation: going from one species to two.
2. It has evolved into two different species or it has gone extinct.
3. The two different populations must be reproductively isolated.
4. Speciation, which causes an increase in biodiversity, or extinction, which causes a decrease in biodiversity.
5. After poisoning the lake, fully armored sticklebacks made their way into the lake. Over time low armored sticklebacks took over. This is because the low armored sticklebacks grow faster and experienced less predation. If the two types can't interbreed they will someday be two species.
6. Adaptive radiation takes place where there is a new environment. They adapted to different flowers on different islands so their beaks evolved to be different.
7. 99.9%
8. 5 in which the rate of extinction was dramatic.
9. Before the boundary there are dinosaurs and after there aren't.
10. Iridium is found all over the world at the boundary and that could indicate an impact from an asteroid.

Review

1. Why is extinction considered a normal part of Earth's history?
2. What are some of the possible causes of mass extinctions?
3. Why do many new species evolve after a mass extinction?

Review Answers

1. Most of the species that have lived have gone extinct.
2. Mass extinctions can be caused by asteroid impacts, massive volcanic eruptions or rapidly changing climate.
3. Many habitats are empty of organisms so other organisms adapt to fill them. This leads to the origin of many new species, an event called adaptive radiation.

1.12 Characteristics and Origins of Life

- Describe the characteristics and origins of life on Earth, and explain how scientists study early life.

What is *life* ?

How can you tell a blob of organic material from a living creature? What characteristics does something need to be considered alive? Is this material rust or is it bacteria?

The Origin Of Life

No one knows how or when life first began on the turbulent early Earth. There is little hard evidence from so long ago. Scientists think that it is extremely likely that life began and was wiped out more than once; for example, by the impact that created the Moon.

This issue of what's living and what's not becomes important when talking about the origin of life. If we're going to know when a blob of organic material crossed over into being alive, we need to have a definition of life.

Characteristics of Life

To be considered alive a molecule must:

- be organic. The organic molecules needed are amino acids, the building blocks of life.
- have a metabolism.
- be capable of replication (be able to reproduce).

Learning About the Origin of Life

To look for information regarding the origin of life, scientists:

- perform experiments to recreate the environmental conditions found at that time.
- study the living creatures that make their homes in the types of extreme environments that were typical in Earth's early days.
- seek traces of life left by ancient microorganisms, also called **microbes**, such as microscopic features or isotopic ratios indicative of life. Any traces of life from this time period are so ancient it is difficult to be certain whether they originated by biological or non-biological means.

Amino Acids

Amino acids are the building blocks of life because they create proteins. To form proteins, the amino acids are linked together by covalent bonds to form polymers called polypeptide chains (**Figure** 1.35).

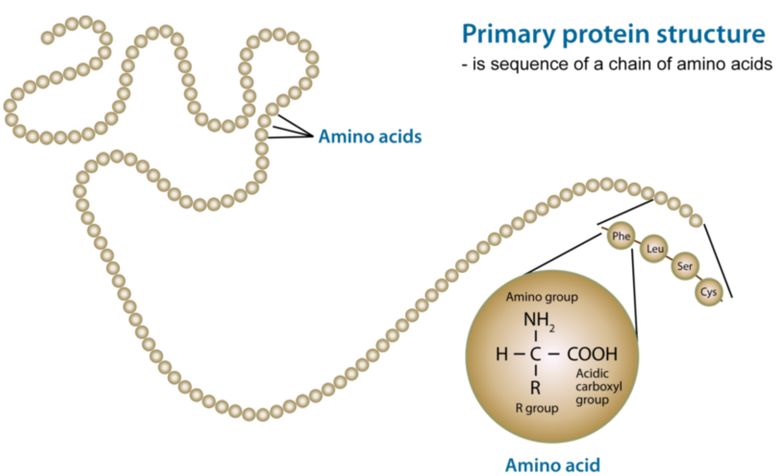


FIGURE 1.35
Amino acids form polypeptide chains.

These chains are arranged in a specific order to form each different type of protein. Proteins are the most abundant class of biological molecules.

An important question facing scientists is where the first amino acids came from: did they originate on Earth or did they fly in from outer space? No matter where they originated, the creation of amino acids requires the right starting materials and some energy.

Miller-Urey Experiment

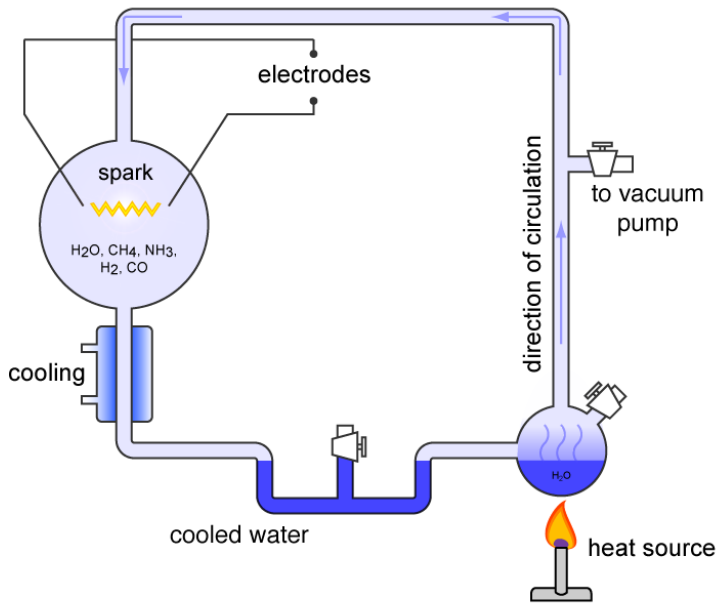


FIGURE 1.36
The setup of the Miller-Urey experiment.

To see if amino acids could originate in the environment thought to be present in the first years of Earth's existence, Stanley Miller and Harold Urey performed a famous experiment in 1953. To simulate the early atmosphere they placed hydrogen, methane, and ammonia in a flask of heated water that created water vapor, which they called the primordial soup. Sparks simulated lightning, which the scientists thought could have been the energy that drove the chemical reactions that created the amino acids. It worked! The gases combined to form water-soluble organic compounds including amino acids.

A dramatic reenactment of this experiment is performed on this video from the 1980 TV show Cosmos: http://www.youtube.com/watch?v=yet1xkAv_HY . At the end you can learn about the possible role of RNA.

Amino acids might also have originated at hydrothermal vents or deep in the crust where Earth's internal heat is the energy source. Meteorites containing amino acids currently enter the Earth system and so meteorites could have delivered amino acids to the planet from elsewhere in the solar system (where they would have formed by processes similar to those outlined here).

Summary

- Amino acids are linked by covalent bonds to form peptide chains that are ordered to create specific types of proteins.
- For something to be alive it must be organic, have a metabolism, and be capable of replication.
- Miller and Urey simulated the early atmosphere with hydrogen, methane, ammonia, and water vapor, to which they added sparks and created amino acids.

Explore More

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=jbQnfoGSOGI

1. What is the first characteristic of living things presented in the video and what does it mean?

2. How can an organism be just one cell?
3. What is the second characteristic of living things presented in the video and what does it mean?
    a. What is the third characteristic of living things presented in the video and what does it mean?
    b. What is the fourth characteristic of living things presented in the video and what does it mean?
4. How does your body do homeostasis?
    a. What is the fifth characteristic of living things presented in the video and what does it mean?
5. How is the walking stick adapted to its environment?

Explore More Answers

1. The first characteristic: Life shows organization; it is made of cells that carry on the functions of life.
2. The parts of a cell do all the functions that are needed for the cell to live.
3. The second characteristic: Living things can reproduce; they can continue the species.
4. The third characteristic: Living things must be able to grow and develop; they are born, they grow, they change and they die.
5. All living things can adjust to their environment. They have a response to a stimulus.
6. Because you are alive your body uses energy to regulate your internal environment.
7. Living things can adapt and evolve; this takes time.
8. The walking stick looks like sticks in its environment, which makes i harder for predators to see.

Review

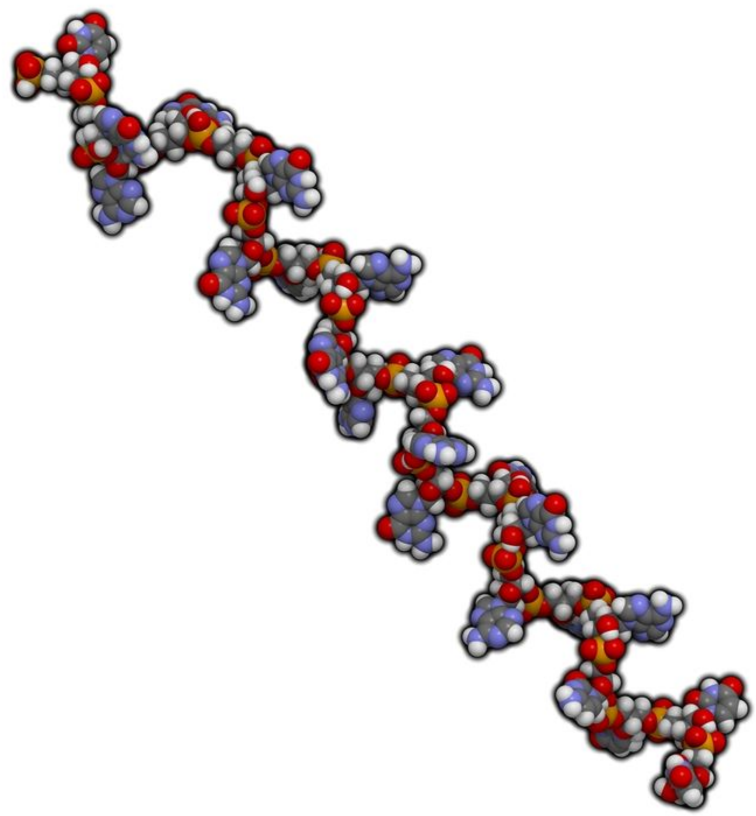
1. Why must something that is alive be capable of replication?
2. Why do scientists that are interested in the origin of life study extreme environments?
3. How do scientists learn about the origins of life?

Review Answers

1. If it couldn't reproduce and pass on its traits the species would die out.
2. Early Earth was extreme so when life formed it must have begun in an extreme environment.
3. They perform experiments that recreate the environmental conditions of the early Earth and see what happens; they study organisms that currently live in extreme environments; they look for fossil of the earliest life, which is microbes.

1.13 Metabolism and Replication

- Define metabolism.
- Describe the relationship between nucleic acids and replication.
- Explain the RNA world hypothesis.



What is an RNA world?

Life must self-replicate, a task that is mostly accomplished with DNA today. Some scientists think that the first replicator was not DNA but RNA. They call this the RNA world hypothesis.

Metabolism

Organic molecules must also carry out the chemical work of cells; that is, their **metabolism**. Chemical reactions in a living organism allow that organism to live in its environment, grow, and reproduce. Metabolism gets energy from other sources and creates structures needed in cells. The chemical reactions occur in a sequence of steps known as metabolic pathways. The metabolic pathways are very similar between unicellular bacteria that have been around for billions of years and the most complex life forms on Earth today. This means that they evolved very early in Earth's history.

Replication

Living cells need organic molecules, known as **nucleic acids**, to store genetic information and pass it to the next generation. Deoxyribonucleic acid (DNA) is the nucleic acid that carries information for nearly all living cells today and did for most of Earth's history. Ribonucleic acid (RNA) delivers genetic instructions to the location in a cell where protein is synthesized.

The famous double helix structure of DNA is seen in this animation: http://upload.wikimedia.org/wikipedia/commons/8/81/ADN_animation.gif .

RNA World

Many scientists think that RNA was the first replicator. Since RNA catalyzes protein synthesis, most scientists think that RNA came before proteins. RNA can also encode genetic instructions and carry it to daughter cells, such as DNA.

The idea that RNA is the most primitive organic molecule is called the **RNA world hypothesis**, referring to the possibility that the RNA is more ancient than DNA. RNA can pass along genetic instructions as DNA can, and some RNA can carry out chemical reactions like proteins can.

A video explaining the RNA world hypothesis is seen here: http://www.youtube.com/watch?v=sAkgb3yNgqg .

Pieces of many scenarios can be put together to come up with a plausible suggestion for how life began.

Summary

- An organism's metabolism is the chemical reactions that allow it to live, grow, and reproduce.
- Nucleic acids pass genetic information to the next generation: DNA for living cells, and RNA for protein synthesis.
- The RNA world hypothesis suggests that RNA was the first nucleic acid to evolve and DNA came later.

Explore More

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=8kK2zwjRV0M End at 6:23

1. What does DNA do? What does that mean?
2. How many chromosomes does every cell in a human have? How many DNA molecules does each cell have? Where are the DNA molecules in human cells?
3. What are the two nucleic acids?
4. What are the four bases called and what are their letter symbols?
5. What is the structure of the DNA molecule? What connects the two strands of the structure?
6. What are the base pairs? How many are in every cell?
7. What are the differences between RNA and DNA?

Explore More Answers

1. DNA stores our genetic instructions; this is the information that programs our cells activities.
2. 46; 1; in the nucleus
3. DNA and RNA
4. adenine (A), thymine (T), cytosine (C) and guanine (G)

5. The structure is a double helix; the support is the bases
6. A T; C G; about 6 billion
7. RNA is a single strand, RNA has ribose as its sugar rather than deoxyribose and it doesn't contains urasil rather than thymine.

Review

1. What is the purpose of an organism's metabolism?
2. Why is the fact that metabolic pathways are similar between organisms significant?
3. Explain the RNA world hypothesis.

Review Answers

1. The metabolism is the chemical reactions that allow the organism to live, grow and reproduce. it creates structures.
2. It means that we have evolved from common ancestors; the metabolic pathways evolved very early in Earth history.
3. In the RNA world hypothesis, RNA was the first replicator rather than DNA.

1.14 Evolution of Simple Cells

- Identify and describe key developments in the evolution of early life on Earth.

Who was the ancestor to us all (and I really mean us ALL)?

If we trace all the evolutionary lineages (humans, sponges, slime molds, etc.) back, at some point there would be one organism that is the ancestor to all of the others. This organism is referred to as LUCA, which stands for the "Last Universal Common Ancestor." LUCA lived 3.5 to 3.8 billion years ago.

Simple Cells Evolve

Simple organic molecules such as proteins and nucleic acids eventually became complex organic substances. Scientists think that the organic molecules adhered to clay minerals, which provided the structure needed for these substances to organize. The clays, along with their metal cations, catalyzed the chemical reactions that caused the molecules to form polymers. The first RNA fragments could also have come together on ancient clays.

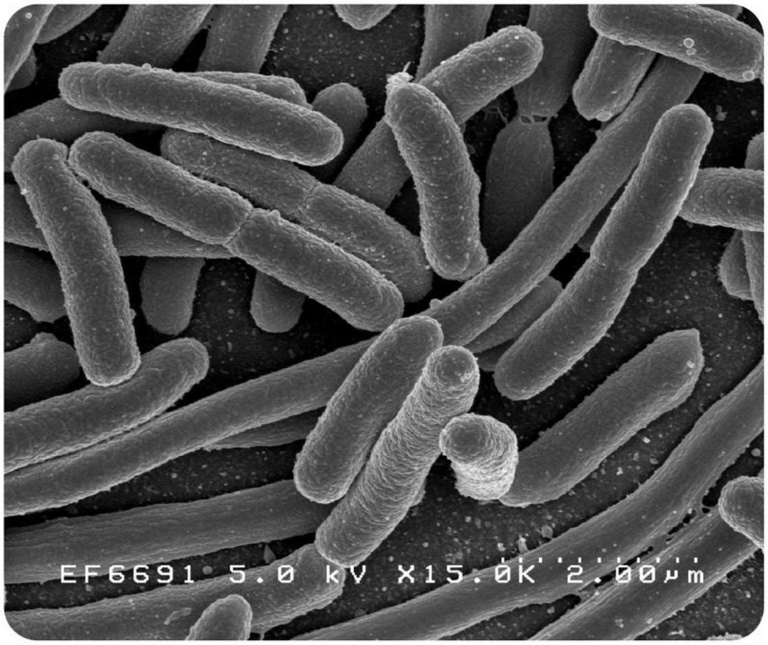


FIGURE 1.37

E. coli (*Escherichia coli*) is a primitive prokaryote that may resemble the earliest cells.

For an organic molecule to become a cell, it must be able to separate itself from its environment. To enclose the molecule, a lipid membrane grew around the organic material. Eventually the molecules could synthesize their own organic material and replicate themselves. These became the first cells.

Prokaryotes

The earliest cells were **prokaryotes** (**Figure** 1.37). Although prokaryotes have a cell membrane, they lack a cell nucleus and other organelles. Without a nucleus, RNA was loose within the cell. Over time the cells became more complex.

LUCA was a prokaryote but differed from the first living cells because its genetic code was based on DNA. The oldest fossils are tiny microbe-like objects that are 3.5 billion years old. Evidence for bacteria, the first single-celled life forms, goes back 3.5 billion years (**Figure** 1.38).

To learn more about LUCA's characteristics, see Wikipedia: http://en.wikipedia.org/wiki/Last_universal_ancestor .

This animation begins with the Big Bang, which will be discussed in the chapter Beyond the Solar System, and goes through the history of life on Earth: http://www.johnkyrk.com/evolution.html .

Photosynthesis

The earliest life forms did not have the ability to photosynthesize. Without photosynthesis what did the earliest cells eat? Most likely they absorbed the nutrients that floated around in the organic soup that surrounded them. After hundreds of millions of years, these nutrients would have become less abundant.

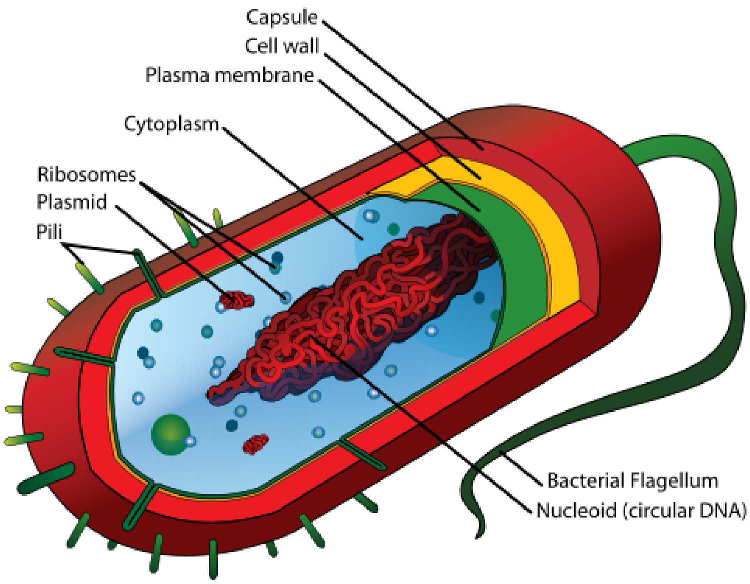


FIGURE 1.38
A diagram of a bacterium.

Sometime around 3 billion years ago (about 1.5 billion years after Earth formed!), photosynthesis began. **Photosynthesis** allowed organisms to use sunlight and inorganic molecules, such as carbon dioxide and water, to create chemical energy that they could use for food. To photosynthesize, a cell needs chloroplasts (**Figure** 1.39).

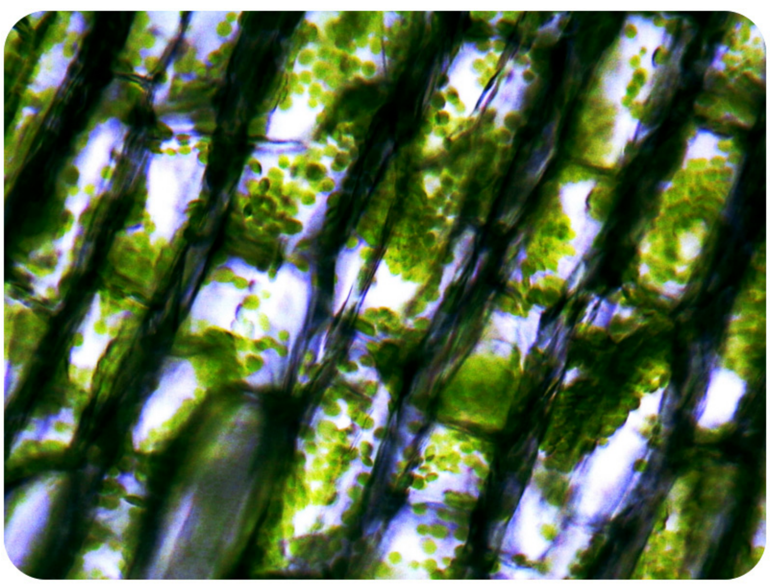


FIGURE 1.39
Chloroplasts are visible in these cells found within a moss.

Importance of Photosynthesis

In what two ways did photosynthesis make the planet much more favorable for life?

1. Photosynthesis allowed organisms to create food energy so that they did not need to rely on nutrients floating around in the environment. Photosynthesizing organisms could also become food for other organisms.

2. A byproduct of photosynthesis is oxygen. When photosynthesis evolved, all of a sudden oxygen was present in large amounts in the atmosphere. For organisms used to an anaerobic environment, the gas was toxic, and many organisms died out.

Cyanobacteria

What were these organisms that completely changed the progression of life on Earth by changing the atmosphere from anaerobic to aerobic? The oldest known fossils that are from organisms known to photosynthesize are **cyanobacteria**. Cyanobacteria were present by 2.8 billion years ago, and some may have been around as far back as 3.5 billion years.

Cyanobacteria were the dominant life forms in the Archean. Why would such a primitive life-form have been dominant in the Precambrian? Many cyanobacteria lived in reef-like structures known as **stromatolites** (**Figure** 1.40). Stromatolites continued on into the Cambrian but their numbers declined.

FIGURE 1.40
These rocks in Glacier National Park, Montana may contain some of the oldest fossil microbes on Earth.

Modern cyanobacteria are also called blue-green algae. These organisms may consist of a single or many cells and they are found in many different environments (**Figure** 1.41). Even now cyanobacteria account for 20% to 30% of photosynthesis on Earth.

Summary

- A prokaryote has a cell membrane but otherwise organelles are loose within the cell.
- Photosynthesis allows organisms to produce food energy with oxygen as a by-product.
- Cyanobacteria, which are still around today, were the earliest known photosynthesizing organisms.

Explore More

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=yWs4Wb0bzP0

1. Why is NASA interested in how life on Earth began?
2. Where did the self-assembling molecules that were necessary for life on Earth to begin come from?

FIGURE 1.41
A large bloom of cyanobacteria is harmful to this lake.

3. What do these molecules self-assemble into? What portion of a cell do they resemble?
4. What was the early Earth like geologically? Where might organic material have come from?
5. What do people who support intelligent design people say about early molecules?
6. What does the scientist being interviewed say about that idea? How can the scientists test that ATP synthase is not too complex?

Explore More Answers

1. If there is life on Mars it will be primitive like early life on Earth.
2. meteorites and volcanic processes
3. They form a vesicle, which is like a cell membrane.
4. Early Earth was volcanic. Stony meteorites delivered organic material.
5. The molecules are too complex to have been produced by evolutionary processes.
6. It is a judgement call. There are simpler molecules that evolved to ATP synthase.

Review

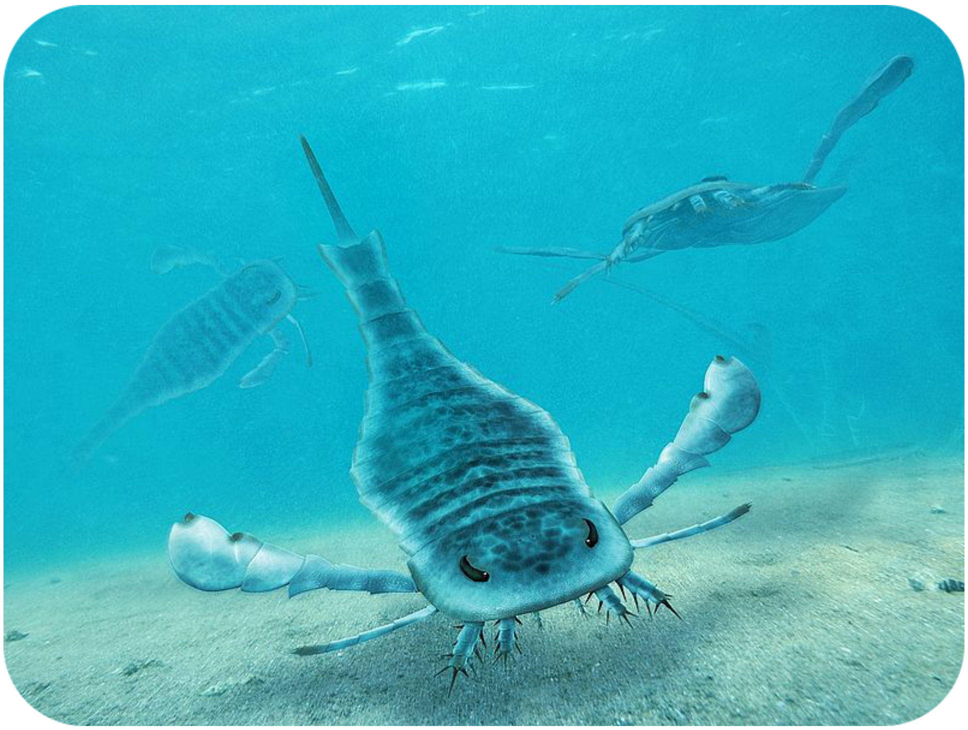
1. What were the characteristics of LUCA, the last common ancestor of life on Earth? Where did it get its nutrients?
2. Why was the development of photosynthesis so important to the evolution of life?
3. What is the role of modern, primitive photosynthesizing organisms?

Review Answers

1. LUCA was a prokaryote that used DNA for its replicating molecule. It absorbed nutrients from the organic soup it floated in.
2. The organic soup couldn't last forever and life on Earth needed to make food. Photosynthesis uses widely available materials to crate food from solar energy.
3. Cyanobacteria are extremely important primary producers and hold up food webs.

1.15 Evolution of Eukaryotes to Multicellular Life

- Identify and describe key developments in the evolution of eukaryotes and multicellular organisms.



Is this an ancestor of modern life? How can we tell?

No one knows quite how to categorize these organisms. Some scientists think that they are the ancestors of organisms that came later. Others think that the Ediacara fauna died out and that the organisms that took over during the Cambrian were a different group. It may not be possible to know the solution to this problem.

Evolution of Eukaryotes

About 2 billion years ago, **eukaryotes** evolved. Eukaryotic cells have a nucleus that encloses their DNA and RNA. All complex cells and nearly all multicellular animals are eukaryotic.

The evolution of eukaryotes from prokaryotes is an interesting subject in the study of early life. Scientists think that small prokaryotic cells began to live together in a **symbiotic** relationship; that is, different types of small cells were beneficial to each other and none harmed the others. The small cell types each took on a specialized function and became the organelles within a larger cell. Organelles supplied energy, broke down wastes, or did other jobs that were needed for cells to become more complex.

What is thought to be the oldest eukaryote fossil found so far is 2.1 billion years old. Eukaryotic cells were much better able to live and replicate themselves, so they continued to evolve and became the dominant life form over prokaryotic cells.

Multicellular Life

Prokaryotes and eukaryotes can both be multicellular. The first multicellular organisms were probably prokaryotic cyanobacteria. Multicellularity may have evolved more than once in Earth's history, likely at least once for plants and once for animals.

Early multicellular organisms were soft bodied and did not fossilize well, so little remains of their existence.

Ediacara Fauna

Although the explosion in the number and type of life forms did not come until the beginning of the Cambrian, life at the end of the Precambrian became more complex. Paleontologists find worldwide evidence of a group of extremely diverse multicellular organisms toward the end of the Precambrian (580-542 million years ago). The organism in the introduction is a member of the Ediacara fauna. These organisms have a variety of forms of symmetry, range from soft to rigid, and they take the form of discs, bags, or even "quilted mattresses" (**Figure** 1.42). The organisms seem to have appeared as Earth defrosted from a worldwide glaciation.

FIGURE 1.42
An example of an Ediacara organism.

Why So Long?

Why did it take 4 billion years for organisms as complex as the Ediacara biota to evolve? Scientists do not really know, although there are many possible explanations:

- Evolutionary processes are slow and it took a long time for complexity to evolve.
- There was no evolutionary advantage to being larger and more complex.
- Atmospheric oxygen was limited, so complex organisms could not evolve.
- The planet was too cold for complex life.
- Complex life evolved but was wiped out by the massive global glaciations.

Why Did They Die Out?

Scientists do not know for sure whether the Edicara organisms died out, but most think that they did. If they did die out, the scientists don't know why. Some possibilities include:

- The evolution of predators with skeletons in the Cambrian.
- Competition from more advanced Cambrian organisms.
- Changes in environmental conditions caused by supercontinent breakups, including rising sea level, limited nutrients, or changing atmospheric and oceanic chemistry.

The existence of the Ediacaran fauna does show that a diversity of life forms existed before the Cambrian.

Summary

- Eukaryotic cells may have evolved from a symbiotic relationship between specialized prokaryotic cells.
- There are many reasons why complex life may have taken so long to evolve, including the rate of evolutionary processes, the lack of an evolutionary advantage, unfavorable environmental conditions, or mass extinctions.
- Ediacara organisms probably went extinct due to advances in predators, competition, or changes in environmental conditions.

Explore More

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=-FQmAnmLZtE

1. What are the two major groups of cells and what are their characteristics?
2. What does endosymbiosis mean?
3. Before the evolution of eukaryotic cells: What were aerobic bacteria doing? (2) What were cyanobacteria doing?
4. What happened next in the evolution of eukaryotes? What happened to the aerobic bacteria and the cyanobacteria?
5. How does symbiosis work in coral?
6. What evidence is there that mitochondria came from bacteria?
7. Where are mitochondria in the cell?
8. Where do you get your mitochondria from?

Explore More Answers

1. Prokaryotic cells: cell membrane, cell wall, no nucleus; eukaryotic cells: nucleus, organelles
2. Organisms living together within one another.
3. Aerobic bacteria were breaking down food in the presence of oxygen; (2) Cyanobacteria were engaging in photosynthesis.
4. These bacteria were engulfed by a host bacterium. The aerobic bacteria became the mitochondria and the cyanobacteria became the chloroplasts.
5. Coral take in an algae that lives within the coral. The algae photosynthesis, the food is taken in by the coral and the coral give the algae a place to live.
6. The double membranes are similar; their reproduction is similar; their DNA is similar.
7. Mitochondria are in the cell but are not part of the cell; they have their own separate DNA.
8. Mitochondria are found in the egg cell. When the cell splits mitochondria are in each side.

Review

1. How did eukaryotes evolve from prokaryotes?
2. What are some possible reasons that it took so long for multicellular, complex organisms to evolve?
3. If the Edicara fauna died out, who are the ancestors of life on Earth?

Review Answers

1. Small prokaryotic cells began to live together in a symbiotic relationship. Each small cell became an organelle within a larger cell.
2. Evolutionary processes are slow; there was no evolutionary advantage to being larger and more complex; atmospheric oxygen was limited so complex organisms couldn't evolve; the planet was too cold for complex life; complex life evolved but was wiped out.
3. The ancestors would have to be a different fauna that did not go extinct.

1.16 History of Paleozoic Life

- The describe the diversification and extinction of life during the Paleozoic.

If you woke up and found yourself in the Paleozoic, would you recognize the planet?

Probably not. You'd see things like this bizarre soft-bodied animal. The creature had five eyes, and a long nose like a vacuum cleaner hose. This creature was found as a fossil in the Burgess shale.

Paleozoic Life

The Paleozoic saw the evolution a tremendous diversity of life throughout the seas and onto land.

Cambrian Explosion

The Cambrian began with the most rapid and far-reaching evolution of life forms ever in Earth's history. Evolving to inhabit so many different habitats resulted in a tremendous diversification of life forms. Shallow seas covered the lands, so every major marine organism group, including nearly all invertebrate animal phyla, evolved during this time. With the evolution of hard body parts, fossils are much more abundant and better preserved from this period than from the Precambrian.

The Burgess shale formation in the Rocky Mountains of British Columbia, Canada, contains an amazing diversity of middle Cambrian life forms, from about 505 million years ago. Paleontologists do not agree on whether the Burgess shale fossils can all be classified into modern groups of organisms or whether many represent lines that have gone completely extinct.

Paleozoic Evolution

Throughout the Paleozoic, seas transgressed and regressed. When continental areas were covered with shallow seas, the number and diversity of marine organisms increased. During regressions the number shrank. Arthropods, fish, amphibians and reptiles all originated in the Paleozoic.

FIGURE 1.43
Trilobites were shallow marine animals that flourished during the lower Paleozoic.

Simple plants began to colonize the land during the Ordovician, but land plants really flourished when seeds evolved during the Carboniferous (**Figure** 1.44). The abundant swamps became the coal and petroleum deposits that are the source of much of our fossil fuels today. During the later part of the Paleozoic, land animals and insects greatly increased in numbers and diversity.

FIGURE 1.44
A modern rainforest has many seed-bearing plants that are similar to those that were common during the Carboniferous.

Mass Extinctions

Large extinction events separate the periods of the Paleozoic. After extinctions, new life forms evolved (**Figure**). For example, after the extinction at the end of the Ordovician, fish and the first tetrapod animals appeared. Tetrapods are four legged vertebrates, but the earliest ones did not leave shallow, brackish water.

Permian Extinction

The largest mass extinction in Earth's history occurred at the end of the Permian period, about 250 million years ago. In this catastrophe, it is estimated that more than 95% of marine species on Earth went extinct. Marine species with calcium carbonate shells and skeletons suffered worst. About 70% of terrestrial vertebrate species (land animals) suffered the same fate. This was the only known mass extinction of insects.

This mass extinction appears to have taken place in three pulses, with three separate causes. Gradual environmental change, an asteroid impact, intense volcanism, or changes in the composition of the atmosphere may all have played a role.

Summary

- During the Cambrian explosion many more life forms evolved than at any other time in Earth's history.
- Today's fossil fuels originated in the tremendous number of plants that spread over the land during the Carboniferous.
- The major periods of the Paleozoic are separated by extinction events, the largest of which brought the end of the Paleozoic.

Explore More

Use this resource to answer the questions that follow.

http://www.youtube.com/watch?v=hDbz2dpebhQ

MEDIA

Click image to the left for use the URL below.

URL: http://gamma.ck12.org/flx/render/embeddedobject/1510

1. What were the first creatures to dominate the land?
2. What happened 250 million years ago?
3. What is a flood basalt eruption? What was the Siberian eruption like?
4. What happened to the Earth's temperature during this extinction? Why did this happen?
5. What occurs when the Earth's temperature raises 4-5 degrees?
6. Why didn't Peter Ward think that the Siberian Traps eruption was the sole reason for the Permian mass extinctions?
7. When and where did the extinction event begin?
8. When and where did the marine extinction phase begin?
9. What are the characteristics of the third phase of the extinction?
10. What is methane hydrate?
11. What caused the increase of carbon-12?

12. Why was it important for the Permian Mass Extinction to take place in the history of life on Earth?

Explore More Answers

1. Therapsids: half mammal, half reptile
2. Almost every living thing suddenly died.
3. A flood basalt is a large volcanic eruption when the crust splits apart and can last for millions of years on and off; this is the largest known volcanic eruption.
4. The temperature rose 5-degrees due to carbon dioxide gas fro the eruptions that entered the atmosphere.
5. Many species will die.
6. His calculations showed that that temperature increase couldn't cause 95% of the species to go extinct. It needed about twice as much increase in temperature.
7. For about 40,000 years, the extinction begins on land with plants and animals.
8. An abrupt extinction of virtually everything in the seas begins, very sharp.
9. The extinction moved back to land. any more species go extinct to about 80,000 years after the extinction began.
10. Methane hydrate is a gas frozen into reservoirs under the sea bed.
11. Normally it is produced by rotting plants and animals. This was too big to be explained by that alone. The increase in heat released methane hydrates; methane is a greenhouse gas so the atmosphere heated up 5-degrees more.
12. The mass extinction freed up niches so that reptiles could adapt to fill them and many types of reptiles evolved.

Review

1. Give two reasons that the Cambrian is significant for the evolution of life.
2. How did extinctions during the Paleozoic lead to changes in life forms?
3. What brought about the Permian extinction?

Review Answers

1. The Cambrian was when life forms began to diversify. Shallow seas covered the land so there were many niches available. Hard parts allowed organisms to protect themselves and mean that the fossil record is more complete.
2. After a mass extinction niches are open for organisms to evolve into so there is adaptive radiation.
3. The Permian extinction took place in three pulses with three separate causes. Some of the possibilities include gradual environmental change, an asteroid impact, intense volcanism, or changes in atmospheric composition.

If you wound up in the Mesozoic would you recognize Earth?

So if you woke up in the Paleozoic, you probably wouldn't recognize Earth. How about if you woke up in the Mesozoic? In some ways, the planet would look a lot more like it does today. Animals would fill the niches you're used to seeing animals fill. But if you looked closely, you'd see that the animals are mostly all reptiles. And some of them may be interested in having you for dinner!

Mesozoic Life

With most niches available after the mass extinction, a great diversity of organisms evolved. Mostly these niches were filled with reptiles.

Climate alternated between cool, warm, and tropical, but overall the planet was much warmer than today. These conditions were good for reptiles. Surprisingly, there was more oxygen in the Mesozoic atmosphere than there is today.

Marine Life

Tiny phytoplankton arose to become the base of the marine food web. At the beginning of the Mesozoic, Pangaea began to break apart, so more beaches and continental shelf areas were available for colonization by new species of marine organisms. Marine reptiles colonized the seas and diversified. Some became huge, filling the niches that are filled by large marine mammals today.

Terrestrial Life

On land, seed plants and trees diversified and spread widely. Ferns were common at the time of the dinosaurs (**Figure** 1.45). The earliest known fossil of a flowering plant is from the Cretaceous, 125 million years old.

Dinosaurs

Of course the most famous Mesozoic reptiles were the dinosaurs (**Figure** 1.46). Dinosaurs reigned for 160 million years and had tremendous numbers and diversity. Species of dinosaurs filled all the niches that are currently filled by mammals. Dinosaurs were plant eaters, meat eaters, bipedal, quadrupedal, endothermic (warm-blooded), exothermic (cold-blooded), enormous, small, and some could swim or fly.

Scientists now think that some dinosaurs were endotherms (warm-blooded) due to the evidence that has been collected over the decades. There are still some scientists who do not agree, but the amount of evidence makes it likely. Some dinosaurs lived in polar regions where animals that needed sunlight for warmth could not survive in winter. Dinosaurs bones had canals, similar to those of birds, indicating that they grew fast and were very active. Fast growth usually indicates an active metabolism typical of endotherms. Dinosaurs had erect posture and large brains, both correlated with endothermy.

FIGURE 1.45
The earliest known fossil of a flowering plant is this 125 million year old Cretaceous fossil.

An interesting look at the points for dinosaur endothermy is seen here: http://www.ucmp.berkeley.edu/diapsids/endothermy.html .

Rise of the Mammals

Mammals appeared near the end of the Triassic, but the Mesozoic is known as the age of the reptiles. In a great advance over amphibians, which must live near water, reptiles developed adaptations for living away from water. Their thick skin keeps them from drying out, and the evolution of the amniote egg allowed them to lay their eggs on dry land. The **amniote egg** has a shell and contains all the nutrients and water required for the developing embryo (**Figure** 1.47).

Cretaceous Mass Extinction

Between the Mesozoic and the Cenozoic, 65 million years ago, about 50% of all animal species, including the dinosaurs, became extinct. Although there are other hypotheses, most scientists think that this mass extinction took place when a giant meteorite struck Earth with 2 million times the energy of the most powerful nuclear weapon (**Figure** 1.48).

The impact kicked up a massive dust cloud, and when the particles rained back onto the surface they heated the atmosphere until it became as hot as a kitchen oven. Animals roasted. Dust that remained in the atmosphere blocked sunlight for a year or more, causing a deep freeze and temporarily ending photosynthesis. Sulfur from the impact mixed with water in the atmosphere to form acid rain, which dissolved the shells of the tiny marine plankton that form the base of the food chain. With little food being produced by land plants and plankton, animals starved. Carbon dioxide was also released from the impact and eventually caused global warming. Life forms could not survive the dramatic temperature swings.

You may be surprised to know that dinosaurs in one form survived the mass extinctions and live all over the world today. Birds evolved from theropod dinosaurs, and these creatures not only survived the asteroid impact and its aftermath, but they have also diversified into some of the most fantastic creatures we know (**Figure** 1.49).

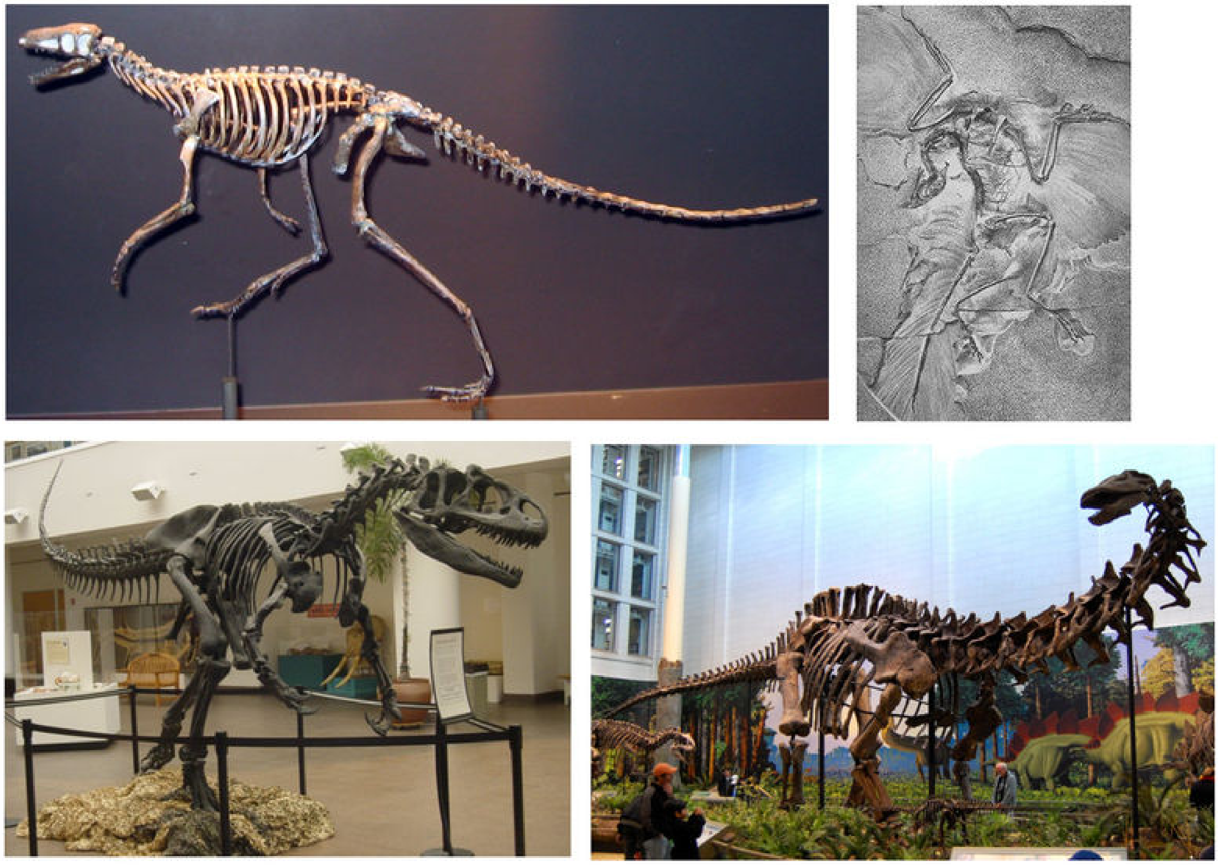


FIGURE 1.46
Some examples of Mesozoic dinosaurs include the Ornithopods. Pictured clockwise, starting from the upper left: Marasuchus, Archaeopteryx, Apatosaurus, and Allosaurus.

FIGURE 1.47
Amniotic eggs containing snake hatchlings.

FIGURE 1.48
An artist's painting of the impact that caused the Cretaceous extinctions.

FIGURE 1.49
Archeopteryx, the earliest known bird, lived during the late Jurassic.

Summary

- Phytoplankton evolved to become the base of the marine food web.
- In the Mesozoic dinosaurs filled the niches that mammals fill today.
- Life of the Mesozoic appears to have ended with a giant asteroid impact.

Practice

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=D3MI7BkFdUI

1. Why is the Atlantic Ocean only half as wide at the end of the Mesozoic as it is today?
2. Why were there no grasses?
3. What were conditions like during the Jurassic?
4. What filled the niches of the birds? What filled the niches of dolphins and whales?
5. What were conditions like 220 million years ago?
6. How long did dinosaurs rule Earth?

Practice Answers

1. The time is closer to when Pangaea broke up and the continents were not in the current positions yet.
2. They hadn't evolved yet.
3. The climate was warm and tropical; there were no ice caps at the poles; there were no flowering plants or broad-leaf trees; dinosaurs are the most common animals.
4. Reptiles filled the niches mammals fill today. Pterosaurs flew in the skies and massive marine reptiles swam in the seas.
5. The continents were not separate, there was only Pangaea. The landscape was dominated by deserts.
6. 160 million years

Review

1. How did life in the Mesozoic resemble life today? How did it differ from life today?
2. What was the importance of the amniotic egg for Mesozoic life?
3. Why do scientists say that dinosaurs didn't entirely go extinct? What is their evidence?

Review Answers

1. The niches were filled by organisms that are similar to those that fill those niches today, but in the Mesozoic the dominant life forms were reptiles and now they are mammals.
2. The amniotic egg has a shell and contains all the nutrients and fluids needed for the developing embryo. It can be laid away from water so it allowed reptiles to colonize dry land.
3. The theropod dinosaurs survived the asteroid impact and evolved into birds.

1.18 History of Cenozoic Life

- Describe the diversification of life during the Cenozoic and its relationship to modern biodiversity.

Why are Pleistocene animals so large?

A smaller surface area-to-volume ratio is better for keeping warm, so many ice age mammals were huge. Although the dominant animals were mammals, you might not recognize the Pleistocene Earth any more than the Mesozoic Earth.

Cenozoic Life

The extinction of so many species at the end of the Mesozoic again left many niches available to be filled. Although we call the Cenozoic the age of mammals, birds are more common and more diverse. Early in the era, terrestrial crocodiles lumbered around along with large, primitive mammals and prehistoric birds.

Diversification of the Mammals

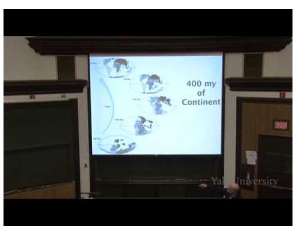
Their adaptations have allowed mammals to spread to even more environments than reptiles. The success of mammals is due to several of their unique traits. Mammals are endothermic and have fur, hair, or blubber for warmth. Mammals can swim, fly, and live in nearly all terrestrial environments. Mammals initially filled the forests that covered many early Cenozoic lands. Over time, the forests gave way to grasslands, which created more niches for mammals to fill.

Pleistocene Megafauna

As climate cooled during the ice ages, large mammals were able to stand the cold weather, so many interesting megafauna developed. These included giant sloths, saber-toothed cats, wooly mammoths, giant condors, and many other animals that are now extinct (**Figure** 1.50).

FIGURE 1.50
The saber-toothed cat lived during the Pleistocene.

A lecture from Yale University on the effect of life on Earth and Earth on life during 4.5 billion years. Glaciations appear at minute mark 23:30-26:20 and then the video goes into mass extinctions: http://www.youtube.com/watch?v=K6Dl_Vs-ZkY (47:10).



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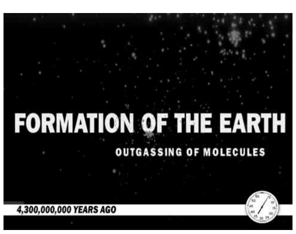
URL: http://gamma.ck12.org/flx/render/embeddedobject/1505

"The Evolution of Life in 60 Seconds" scales all 4.6 billion years of Earth history into one minute. Don't blink at the end: http://www.youtube.com/watch?v=YXSEyttblMI (1:03).



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Many of the organisms that made up the Pleistocene megafauna went extinct as conditions warmed. Some may have been driven to extinction by human activities.

Imagine a vast grassy plain covered with herds of elephants, bison and camels stretching as far as the eye can see. Lions, tigers, wolves and later, humans, hunt the herds on their summer migration.This was the San Francisco Bay Area at the close of the last Ice Age.

Learn more at http://www.kqed.org/quest/television/ice-age-bay-area2 .

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Summary

- With the extinction of the dinosaurs, mammals diversified and took over the available niches.
- Many of the organisms of the Pleistocene were enormous, probably in have a low surface area to body ratio.
- Many of the Pleistocene megafauna have gone extinct but some remain.

Practice

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=x_Nx6C5cSHU

1. What are the characteristics of the Clovis spear points?
2. What does Paul Martin suggest caused the extinction of the Pleistocene megafauna? What else could have been the cause?
3. What happened to the environment at the end of the Pleistocene?
4. Why do we still have megafauna in Africa, but the megafauna in North America is largely extinct?
5. What happened in Australia?
6. What is the evidence that the extinctions in North America were caused by a combination of humans and climate change?

Practice Answers

1. They are spread over a large area and they are almost the same age; almost entirely confined to mammoth sites.
2. Human hunters; climate change
3. Plants changed range; communities died out.
4. Humans evolved in Africa so the animals evolved with them and could survive. They arrived all at once in North America.
5. Radiocarbon dating doesn't work well so the time frame of human arrival and megafaunal extinction isn't known.
6. Many other megafauna went extinct than just mammoths, but the Clovis points are only found at mammoth sites.

Review

1. What are the Pleistocene megafauna and why were they so large?
2. What characteristics do mammals have that allow them to fill so many niches?
3. How does climate affect evolution? How about climate change?

Review Answers

1. Megafauna lived during the ice ages because a smaller surface area to volume ratio is better for keeping warm.

2. Mammals filled niches because they are endotherms, which was an advantage when Earth experienced climate changes; they can walk, swim or fly. They have adapted to all sorts of environments.
3. Climate determines the characteristics that will be suitable for organisms to have. For example, when it is cold, having less surface area is an advantage. Climate change drives evolution because what is beneficial in one climate regime is not in another so adaptation will include natural selection for more advantageous traits.

1.19 Human Evolution

- Identify and describe key developments in human evolution.

What is a "cave man"?

What if you were to wake up in the Cenozoic, even in the very recent Cenozoic, but with a group of Neanderthals? They were close relatives, but you might find them to be a bit different from your usual friends.

Human Evolution

Humans evolved during the later Cenozoic. New fossil discoveries alter the details of what we know about the evolution of modern humans, but the major evolutionary path is well understood.

Primate Ancestors

Humans evolved from primates, and apes and humans have a primate common ancestor. About 7 million years ago, chimpanzees (our closest living relatives) and humans shared their last common ancestor.

Hominids

Animals of the genus *Ardipithecus*, living roughly 4 to 6 million years ago, had brains roughly the size of a female chimp. Although they lived in trees, they were bipedal. Standing on two feet allows an organism to see and also to use its hands and arms for hunting. By the time of *Australopithecus afarensis*, between 3.9 and 2.9 million years ago, these human ancestors were completely bipedal and their brains were growing rapidly (**Figure** 1.51).

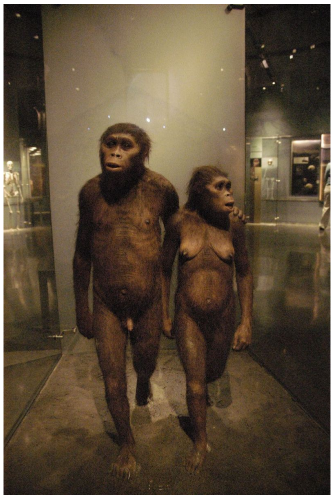

FIGURE 1.51
Australopithecus afarensis is a human ancestor that lived about 3 million years ago.

The genus *Homo* appeared about 2.5 million years ago. Humans developed the first stone tools. *Homo erectus* evolved in Africa about 1.8 million years ago. Fossils of these animals show a much more human-like body structure, which allowed them to travel long distances to hunt. Cultures begin and evolve.

Homo sapiens, our species, originated about 200,000 years ago in Africa. Evidence of a spiritual life appears about 32,000 years ago with stone figurines that probably have religious significance (**Figure** 1.52).

The ice ages allowed humans to migrate. During the ice ages, water was frozen in glaciers and so land bridges such as the Bering Strait allowed humans to walk from the old world to the new world.

DNA evidence suggests that the humans who migrated out of Africa interbred with Neanderthal since these people contain some Neanderthal DNA.

Summary

- *Australopithecus afarensis* was completely bipedal and had a growing brain.
- *Homo erectus* evolved 1.8 million years ago and left behind signs of an early culture.
- Our species is *Homo sapiens*, which evolved 200,000 years ago in Africa and continues to today.

Practice

Use this resource to answer the questions that follow.

FIGURE 1.52
Stone figurines likely indicate a spiritual life.

1. Why might early mammals have survived the Cretaceous-Tertiary extinction when so many extremely successful reptiles did not?
2. Why did mammals experience adaptive radiation in the early Cenozoic?
3. What was the line from mammals to humans, starting with primitive primates?
4. How are the great apes different from monkeys? What are some of their descendents?
5. When did we last have a common ancestor with chimps?
6. What is Lucy?
7. What are the differences between Australopithecus and Homo habilis?
8. What are the differences between Homo habilis and Homo erectus?
9. What is the complicated relationship between neanderthals and modern humans?
10. What are modern humans in genus and species and when did they appear?
11. When did neanderthals disappear and what happened to them?

Practice Answers

1. They were small and burrowed underground and kept their food near them; maybe they hibernated.
2. There were many niches that were vacant.
3. primitive primates to monkeys to great apes, including humans
4. They spend more time out of trees they lose their tails. Gorillas, modern chimps, early humans
5. 7 million years ago
6. A 3.3 million year old Australopithecus fossil.
7. In Homo habilus the cranial capacity is greater and they have stone tools; they lived 2.3 to 1.4 million years ago.
8. Larger cranial capacity, similar to modern humans; they lived 1.8 to 1.3 million years ago.
9. Neanderthals and humans have a common ancestor or we might be subspecies. It appears that some modern humans mated with neanderthals.
10. Homo sapiens appeared around 200,000 years ago.
11. They disappeared about 30,000 years ago. They may have been killed off by modern humans or they may have mated with us or both.

Review

1. What are the characteristics that make humans human?
2. Why did the evolution of bipedalism advance human evolution?
3. How did people get from the old world to the new world?

Review Answers

1. Being bipedal allowed organisms to make and use tools and also they could see over grass.
2. Bipedal, large brain, opposable thumb, no complete fur coat, culture
3. Glaciers kept water so sea level went down. This exposed land bridges such as the Bering Strait.

1.20 Modern Biodiversity

- Describe modern biodiversity and its relationship to evolutionary adaptations.

How well do you know life on Earth?

It's possible that you could wake up on Earth right now and still not recognize the planet. That's because of the incredible diversity of species. Habitats that you've never encountered would be inhabited by organisms that you've never seen or known about.

Modern Biodiversity

There are more than 1 million species of plants and animals known to be currently alive on Earth (**Figure** 1.53) and many millions more that have not been discovered yet. The tremendous variety of creatures is due to the tremendous numbers of habitats that organisms have evolved to fill.

Adaptations

Many adaptations protect organisms from the external environment (**Figure** 1.54).

Other adaptations help an organism move or gather food. Reindeer have sponge-like hoofs that help them walk on snowy ground without slipping and falling. Hummingbirds have long, thin beaks that help them drink nectar from flowers. Organisms have special features that help them avoid being eaten. When a herd of zebras run away from lions, the zebras' dark stripes confuse the predators so that they have difficulty focusing on just one zebra during the chase. Some plants have poisonous or foul-tasting substances in them that keep animals from eating them. Their brightly colored flowers serve as a warning.

FIGURE 1.53
There is an amazing diversity of organisms on Earth. How do the organisms in this picture each make their living?

FIGURE 1.54
Cacti have thick, water- retaining bodies that help them conserve water.

FIGURE 1.55
Poison dart frogs have toxins in their skin. Their bright colors warn potential predators not to take a bite!

Thousands of northern elephant seals —some weighing up to 4,500 pounds —make an annual migration to breed each winter at Año Nuevo State Reserve in California. Marine biologists are using high-tech tools to explore the secrets of these amazing creatures.

Find out more at http://science.kqed.org/quest/video/into-the-deep-with-elephant-seals/ .

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Summary

- There are 1 million known species, but many more have not been discovered.
- The enormous number of species is due to the tremendous variety of habitats.
- Organisms have adaptations that help them to find food or avoid being eaten.

Practice

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=7tgNamjTRkk

1. What is biodiversity?
2. How does evolutionary history lead to biodiversity?
3. What are the five categories of values that say that biodiversity is important?
4. What is the negative value of biodiversity?
5. What is the Anthropocene?
6. What are the challenges presented by biodiversity decline?
7. Is it possible to be optimistic about biodiversity decline?

Practice Answers

1. Biodiversity is all the different species exist in a given area and all of the genetic variability within them; also the diversity of ecosystems.
2. Evolutionary history gives rise to genetic diversity, which leads to all the species. The functions of the ecosystems and the processes that result from the living world.
3. Economic: timber, fish; ecological life support: ecosystem services, benefits we obtain from the natural world; cultural: the world around us informs the way we feel about the world; recreational: people like to rejuvenate in the wild; scientific value: systematic pursuit of knowledge about nature.
4. Part of the natural world is unpleasant.
5. It builds upon the geological eras to include the era that is dominated by human activity.
6. understand, analyze and deal with ongoing decline; understand the full complexity of biodiversity; how best to contribute to discussions about resource use.
7. We are becoming aware, we are learning about it, we have community involvement.

Review

1. What are the adaptations of the cactus to its desert environment?
2. What are the adaptations of poison dart frogs to their environment?
3. How does adaptation lead to biodiversity?

Review Answers

1. Cacti have thick skins to retain water and spines to keep other organisms from eating them.
2. Colorful frogs contain poisons and warn predators not to eat them.
3. There are so many different niches that having organisms fill all of them requires a lot of diversity.

Summary

Although different ecosystems differ greatly from one another, the structure of an ecosystem is the same. There must be a source of food energy, usually from photosynthesis, and then herbivores, predators, scavengers, and decomposers, among others. Energy flows through the ecosystems in tropic levels and connections between organisms are made in a web, known as the food web. There are many types of ecosystems in fresh water, the oceans, and on land. Organisms must be well adapted to their habitats or they may go extinct. Extinction of a species opens up a niche, which a different species will likely evolve to fill. This has occurred throughout Earth's history as mass extinctions have opened habitats and adaptive radiation has acted on a different set of organisms to fill those habitats. The earliest life was simple cells, possible with RNA as the nucleic acid. Photosynthesis evolved and provided a food source for the food web, plus oxygen to the atmosphere. Multicellular life didn't evolve for 4 billion years. During most of the Paleozoic, life was restricted to the seas. Reptiles ruled in the Mesozoic and even in the Cenozoic life was fairly different from what we see today. The biological processes that govern the evolution of species has resulted in tremendous biodiversity we see today. This includes the evolution of humans, which is better understood as more fossils are discovered.

1.21 References

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