The big picture

? Guiding question(s)

- How are the adaptations and habitats of species related?
- What causes the similarities between ecosystems within a terrestrial biome?

Keep the guiding questions in mind as you learn the science in this subtopic. You will be ready to answer them at the end of this subtopic. The guiding questions require you to pull together your knowledge and skills from different sections, to see the bigger picture and to build your conceptual understanding.

Earth is home to a diverse range of environmental conditions, from hot deserts to cold tundras, from humid rainforests to dry savannas. How do species not only survive but thrive in these extremes of temperature and humidity?

The giant Pacific octopus (*Enteroctopus dofleini*) (**Figure 1**) has evolved several adaptations to help it survive in its environment.

Overview (/study/ap 422- cid- 755105/o

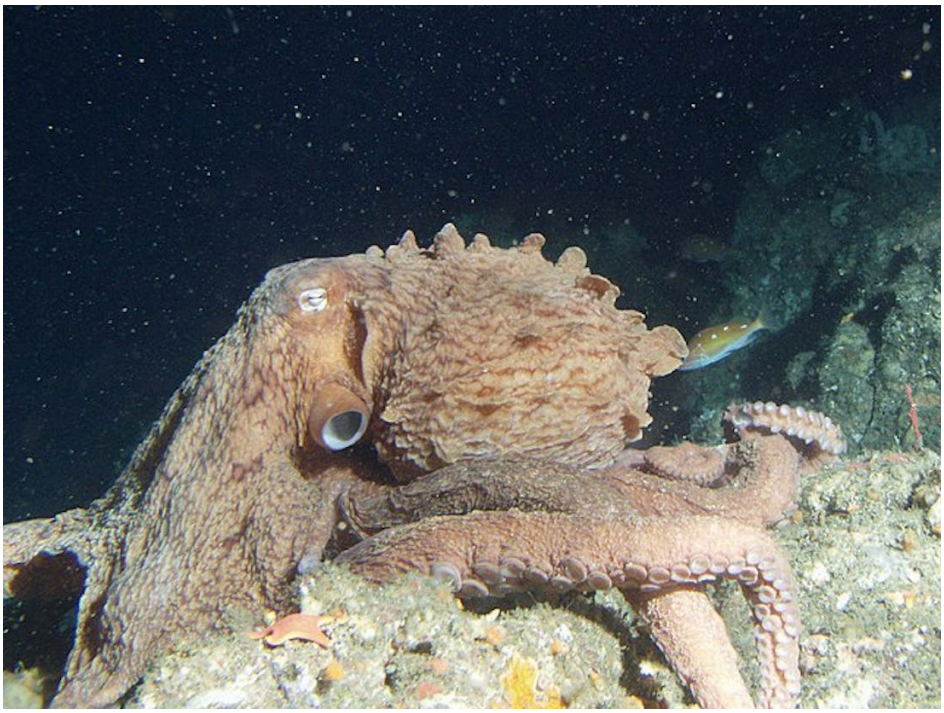
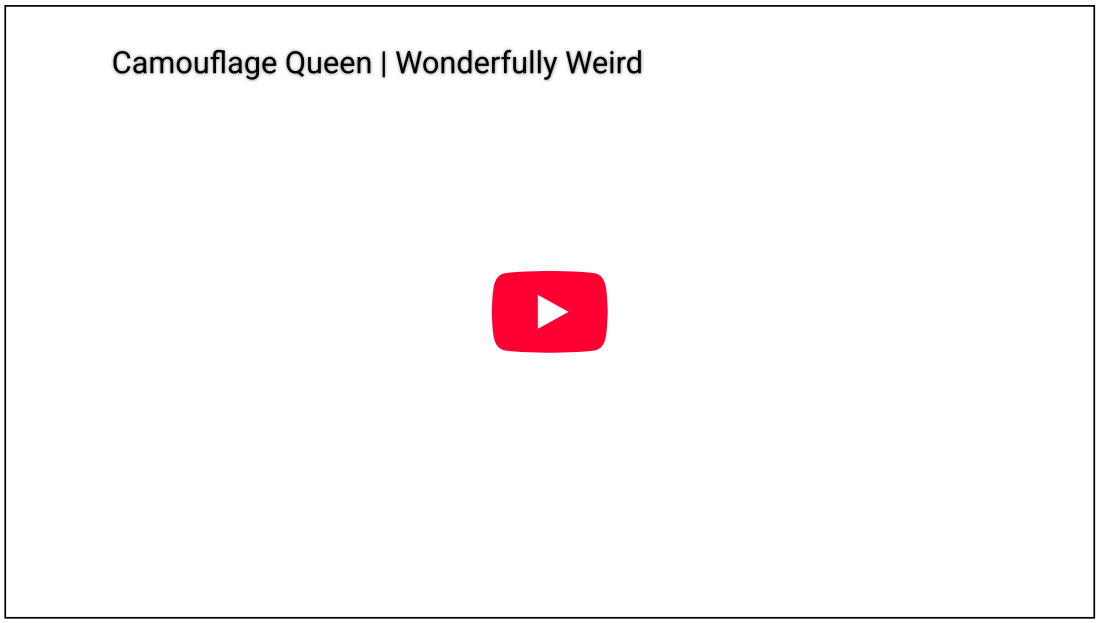


Figure 1. Giant Pacific octopus (*Enteroctopus dofleini*).

Source "Enteroctopus dolfeini (https://commons.wikimedia.org/wiki/File:Enteroctopus_dolfeini.jpg)" by NOAA/R. N. Lea is in the public domain

Watch **Video 1** about the giant Pacific octopus and note the features that help it succeed within its environment.



Video 1. Camouflage queen – giant Pacific octopus (*Enteroctopus dofleini*).

Student view

The octopus:

Overview (/study/ap 422- cid- 755105/o

- can change colour and texture to blend in with its surroundings, and can even make itself nearly invisible
- has eight arms, each of which is lined with dozens of suction cups that it can use to grip and manipulate objects with remarkable efficiency
- can release a cloud of ink to confuse and distract predators, allowing it to escape or hide
- is highly intelligent and is able to solve complex problems and use tools to obtain food and other resources.

These adaptations make the giant Pacific octopus a highly successful and adaptable predator. Similarly, many other plants and animals have evolved a wide range of adaptations to help them survive and reproduce in their environments. You will learn more about these in this subtopic.

Prior learning

Before you study this subtopic make sure that you understand the following:

- Biological species concept — only those organisms which can interbreed with each other to produce fertile offspring belong to the same species (see section A3.1.1—4 (/study/app/bio/sid-422-cid-755105/book/what-is-a-species-id-43227/)).
- There are diverse forms of organisms that share the same environment. This concept is called biodiversity (see section C4.1.1 (/study/app/bio/sid-422-cid-755105/book/population-sizes-and-random-sampling-id-44711/)).
- Biodiversity varies for every ecosystem and it includes plants, animals and microorganisms like bacteria and fungi living in that ecosystem (see subtopic C4.1 (/study/app/bio/sid-422-cid-755105/book/big-picture-id-43544/)).

Practical skills

Once you have completed this subtopic, you can gain application of skills for estimating population size by going to Practical 7: Measuring percentage cover to assess the distribution and abundance of plants in a habitat (/study/app/bio/sid-422-cid-755105/book/measuring-percentage-cover-id-46706/).

Overview (/study/ap 422-cid-755105/o

Adaptations of organisms to a habitat and species distribution

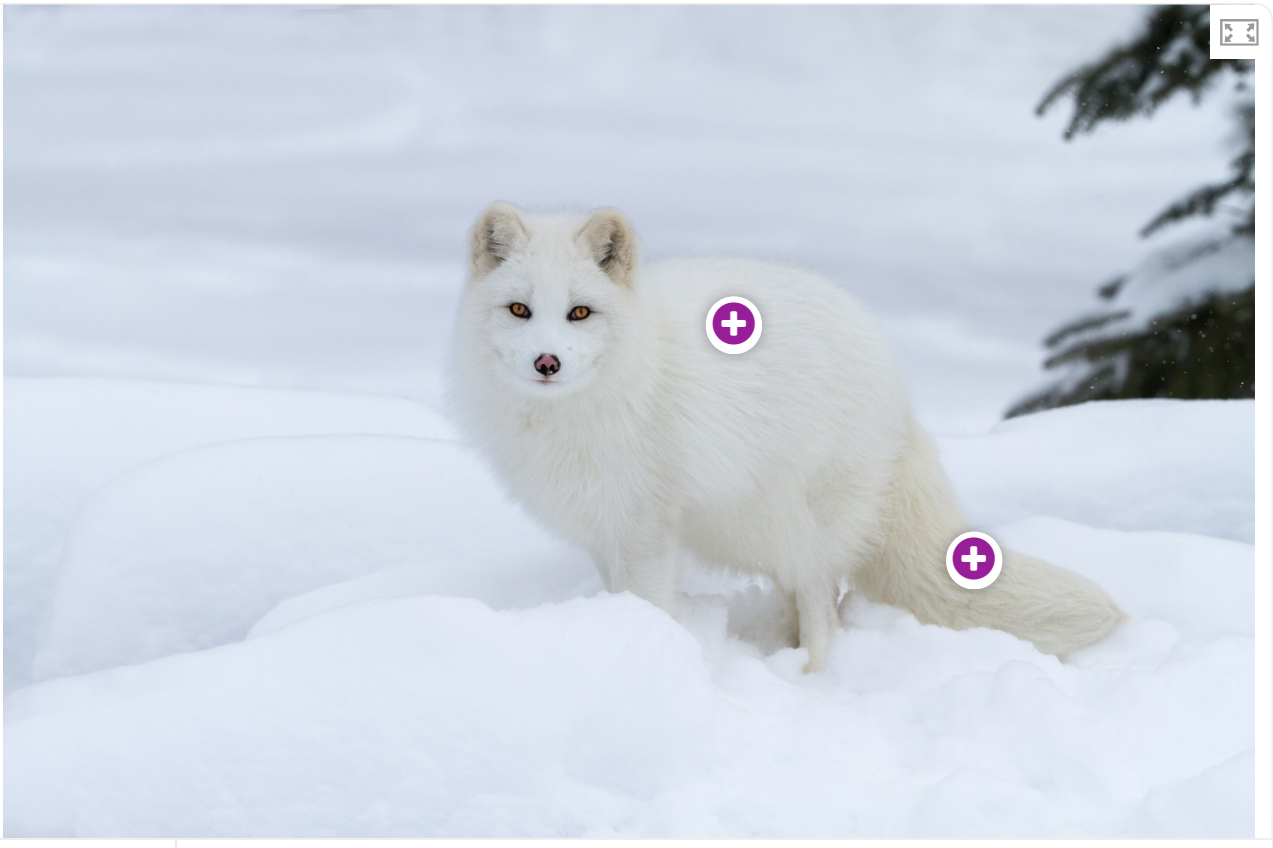
B4.1.1: Habitats B4.1.2: Adaptations to the abiotic environment of a habitat

Learning outcomes

By the end of this section you should be able to:

- Define habitat as a place in which a community, species, population or organism lives.
- Define adaptation and discuss various ways that organisms have adapted to the abiotic factors of their habitat, particularly sand dunes and mangrove swamp.

Look at the image of the Arctic fox (*Vulpes lagopus*) in **Interactive 1** and think of three adaptations it has undergone to survive in the cold environment. Click on the hotspots for some ideas.



Interactive 1. Adaptations of an Arctic Fox in the Snow.

Student view

More information for interactive 1

An interactive photograph displays an Arctic fox resting in the snow. The fox has thick, fluffy, white fur. A round face with a small muzzle, round ears, and dark ears and nose. Its tail is thick and furry.

The photograph has two plus signs, representing interactive hotspots. Selecting a hotspot reveals a description of the corresponding part.

Hotspot on body fur reads, Fur colour: white fur colour to blend in with surroundings.
Hotspot on tail reads, Fur hair: thick fur for insulation.

This photograph helps users understand the unique adaptations of the Arctic fox that enable it to survive in its cold environment.

By considering specific examples of adaptations in different environments, we can begin to understand the diversity of ways that organisms can adapt to survive in challenging conditions.

Habitat

A habitat is a place where an organism or a group of organisms lives and interacts with its surroundings. It can be defined as a geographical or physical location that provides the necessary resources for an organism's survival and reproduction. Habitats can vary in size, from small microhabitats, such as the space beneath a rock, to large habitats, such as a tropical rainforest. Habitats consist of both biotic (living) and abiotic (non-living) factors (see sections A3.1.1–4 (/study/app/bio/sid-422-cid-755105/book/what-is-a-species-id-43227/), C4.1.1 (/study/app/bio/sid-422-cid-755105/book/population-sizes-and-random-sampling-id-44711/) and C4.1.9 (/study/app/bio/sid-422-cid-755105/book/intraspecific-interactions-id-44712/)).

To describe the habitat of a species, we need to look at:

- geographical location – this could be on a map or in a specific area
- physical location – this includes the environment which incorporates factors such as the type of soil, availability of water and food, and other plants and animals around
- ecosystem – this is the bigger picture of all the biotic and abiotic factors and their relationships in a particular area.

Overview (/study/ap 422-cid-755105/o

By understanding all these things, we can have a complete idea of a species' habitat and what it needs to survive.

Habitats on Earth can be classified into two broad categories based on their geographical location (**Figure 1**):

- terrestrial habitats, i.e. land-based environments and
- aquatic habitats, i.e. all water-based environments.

Each of these categories of habitat has distinct physical and chemical characteristics that support different types of organisms and contribute to the overall diversity of life on Earth. In this subtopic you will focus on studying terrestrial habitats.

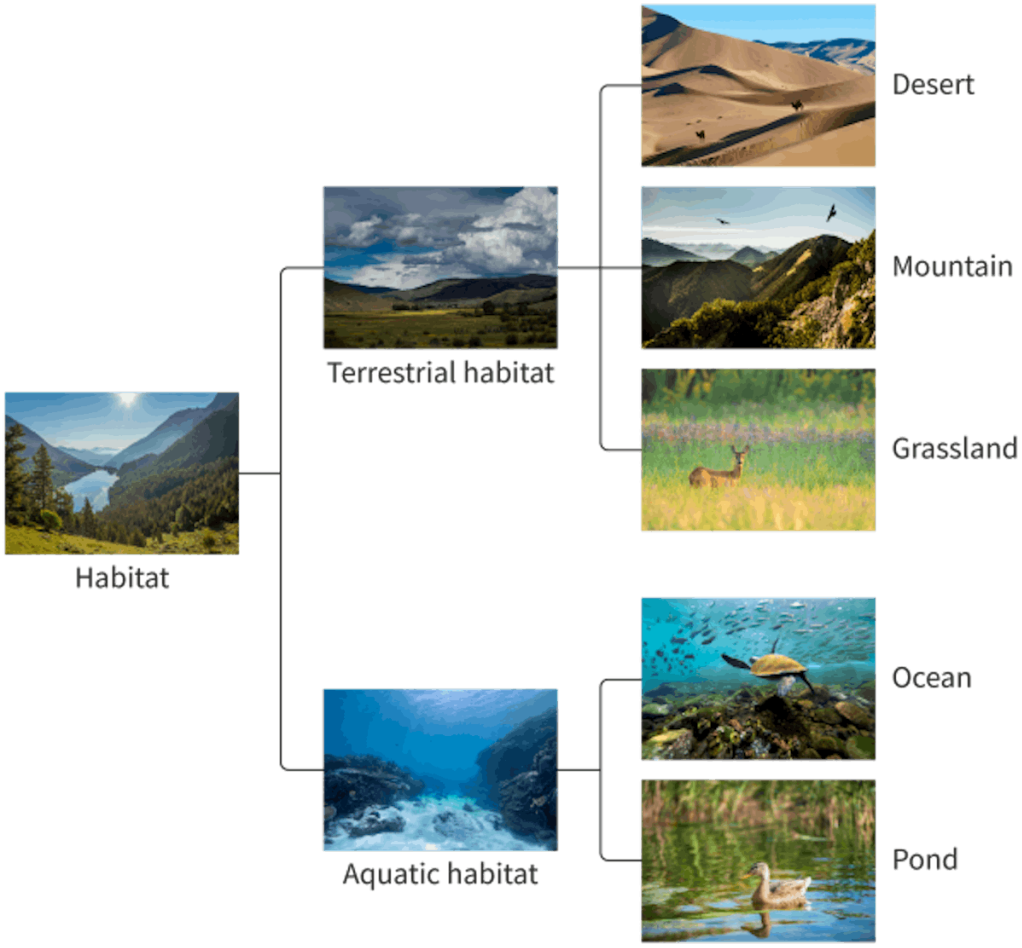


Figure 1. Different types of habitat.

Credit kb79, Getty Images (https://www.gettyimages.com/detail/photo/el-mirador-de-lestany-nature-and-landscape-during-royalty-free-image/1157346929), Credit: Utah-based Photographer Ryan Houston, Getty Images (https://www.gettyimages.com/detail/photo/mountains-and-fields-near-gunnison-royalty-free-image/1015154690), Credit: Mitchell Pettigrew, Getty Images (https://www.gettyimages.com/detail/photo/seascape-royalty-free-image/1410017059), Credit: Tuul & Bruno Morandi, Getty Images (https://www.gettyimages.com/detail/photo/china-inner-mongolia-

Student view

Overview (/study/ap 422-cid-755105/o

badain-jaran-desert-royalty-free-image/596335203), Credit: Cyril Gosselin, Getty Images (https://www.gettyimages.com/detail/photo/outlook-from-martinskopf-summit-over-the-bavarian-royalty-free-image/861759110), Credit: Gerhard Kummer, Getty Images (https://www.gettyimages.com/detail/photo/curious-royalty-free-image/981472440), Credit: Jay Dickman, Getty Images (https://www.gettyimages.com/detail/photo/galapagos-turtle-royalty-free-image/521438982), Credit: Liudmila Chendekova, Getty Images (https://www.gettyimages.com/detail/photo/birds-and-animals-in-wildlife-concept-amazing-royalty-free-image/1266008490)

More information for figure 1

This image is a diagram illustrating different types of habitats. It starts with a central category labeled 'Habitat,' branching into two main types: 'Terrestrial habitat' and 'Aquatic habitat.'

Under 'Terrestrial habitat,' there are three sub-categories: 1. Desert - An image shows sand dunes in a dry environment. 2. Mountain - An image of mountainous terrain with some vegetation. 3. Grassland - An image depicting open fields with grass and a deer.

Under 'Aquatic habitat,' there are two sub-categories: 1. Ocean - An underwater image shows marine life, including a turtle and fish. 2. Pond - An image of a small water body with a duck.

Each category of habitat is illustrated with relevant images, emphasizing the diversity in each environment.

[Generated by AI]

Adaptations of organisms to the abiotic environment of their habitat

Adaptation can be defined as (but not restricted to) a genetic change that increases an organism's chances of survival and reproduction in a particular environment. These genetic changes can occur randomly through mutation or can be driven by selective pressures in the environment. Natural selection is the mechanism that drives the spread of beneficial genetic mutations throughout a population. This is because individuals with advantageous traits are more likely to survive and pass on their genes to the next generation. Over time, these advantageous traits become more common in the population as they are passed down from one generation to the next (see section D4.1.1 (/study/app/bio/sid-422-cid-755105/book/natural-selection-id-43805/)).

Student view

Overview (/study/ap 422- cid- 755105/o

This process of adaptation is significant for the survival of a population of species and plays a critical role in the evolution of life on Earth (see sections A4.1.1 (/study/app/bio/sid-422-cid-755105/book/evolution-as-change-in-heritable-characteristics-id-43790/) and D4.1.1 (/study/app/bio/sid-422-cid-755105/book/natural-selection-id-43805/)).

Organisms develop adaptations to cope with the physical or abiotic conditions of their habitat, such as temperature, moisture, light, and other environmental factors. Organisms that are better adapted to their environment are more likely to survive and pass on their advantageous traits to future generations. Let us now look at the adaptations of certain species to two very different habitats: sand dunes and mangroves.

Sand dunes habitat

Sand dunes are created by the accumulation of sand that has been carried inland from the beach by onshore winds and trapped by debris or plants. This accumulated sand provides a suitable habitat for hardy beach grasses which have strong, horizontal roots that help stabilise the collected sand, allowing more sand to settle on top.

Sand dunes are difficult places for plants to survive, due to the harsh and unstable conditions. However, there are a select few plant species that have adapted to these environments and are able to thrive in such conditions. One such plant is marram grass (*Ammophila arenaria*), which has evolved specific adaptations to survive in sand dunes (**Figure 2**).

Student view

Overview (/study/ap 422-cid-755105/o

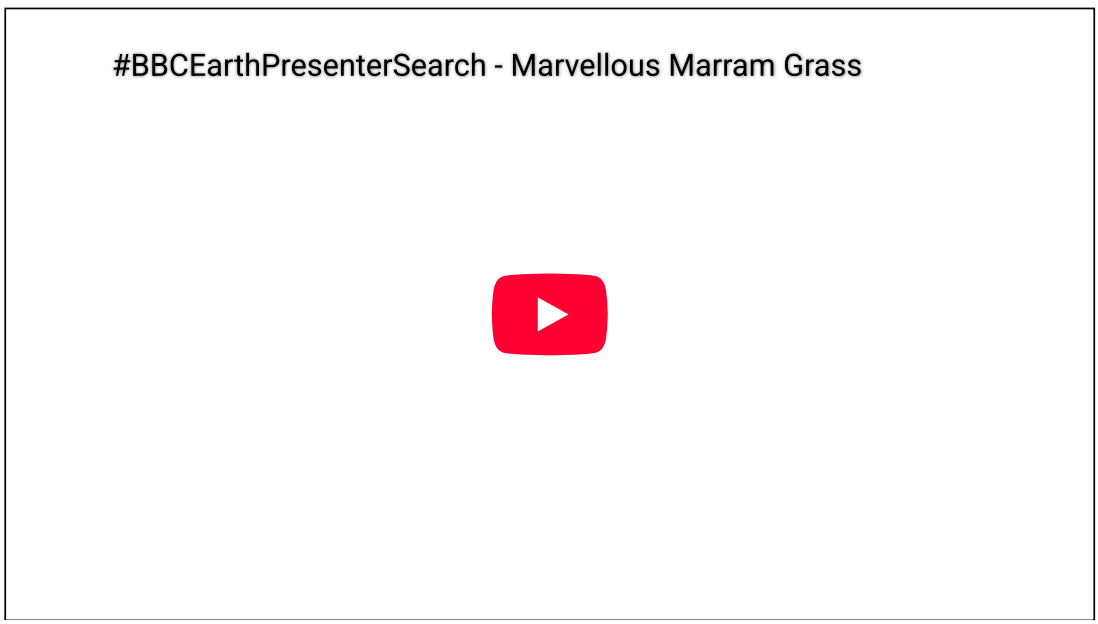
Figure 2. Marram grass growing in a sand dune.

Interactive 2 shows some adaptations of marram grass to survive in the harsh sand dune conditions. These adaptations allow marram grass to not only survive, but also play a crucial role in the stabilisation and formation of sand dunes.

- **Tolerance to drought**
- **Tolerance to salt**
- **Root adaptations**
- **Leaf adaptations**
- **Sand-binding**
- **Rhizomes**

Interactive 2. Adaptations of marram grass (*Ammophila arenaria*).

Watch **Video 1** to review the adaptations of marram grass.



Student view

Overview (/study/ap 422- cid- 755105/o

Video 1. Marram grass adaptations.

Creativity, activity, service

Strand: Service
Learning outcomes:

- Show commitment to, and perseverance in CAS, experiences
- Demonstrate the skills and recognise the benefits of working collaboratively
- Demonstrate engagement with issues of global significance
- Recognise and consider the ethics of choices and actions

One potential CAS idea for you is to get involved in beach clean-up efforts and raise awareness of biodiversity in your local community. Specifically, if you are based near a similar habitat such as a coastal region, you can participate in beach clean-up activities to help preserve the natural environment.

Additionally, you could take on the responsibility of educating your community about the habitat and adaptation of plants growing in the area. For example, you could organise community workshops, create informational brochures or posters, or conduct presentations to share your knowledge about the plants and animals that thrive in the coastal ecosystem.

By undertaking such an activity, you will not only contribute to the preservation of the natural environment but also develop a deeper understanding of the importance of sustainability and conservation efforts. This can also help to instil a sense of responsibility and stewardship in you towards the environment.

To implement this CAS idea, you could collaborate with local environmental groups, such as beach clean-up organisations, or work with your school administration to organise a beach or other environmental clean-up event. You can also coordinate with local experts or conservationists to learn more about the local ecosystem and identify the different species of plants and animals that inhabit the area.

Mangrove forests habitat

Mangroves develop where there is a mixture of saltwater and freshwater, and the water level fluctuates with the tides. Mangroves are difficult places for plants to survive due to high levels of salinity in their environment. However, there are a select few plant species that

Student view

Overview (/study/ap 422-cid-755105/o

have adapted to these environments and are able to thrive in such conditions. One such plant is *Rhizophora apiculata* (**Figure 3**) which has evolved specific adaptations to survive in mangroves.

Credit: smuay, Getty Images (https://www.gettyimages.com/detail/photo/rhizophora-apiculata-blume-forest-royalty-free-image/1320032537)

Credit: Hi-Point, Getty Images (https://www.gettyimages.com/detail/photo/spindly-roots-growing-upward-through-water-royalty-free-image/1398475123)

Figure 3. *Rhizophora apiculata* (left) and pneumatophores (right).

Interactive 3 gives some of the key adaptations of *Rhizophora apiculata*. *Rhizophora apiculata* is a halophyte, which means the plant can survive in extreme high salinity. The specialised roots, called pneumatophores, help to provide the roots with oxygen in waterlogged soil.

Student view

Overview (/study/ap 422-cid-755105/o

- **Salt tolerance**
- **Root adaptations**
- **Flood tolerance**
- **Propagation**

Interactive 3. Adaptations of *Rhizophora apiculata*.

Theory of Knowledge

To what extent does interdisciplinary knowledge enhance our understanding of the natural world?

The interdisciplinary approach to the study of adaptations and habitats is essential because it allows us to gain a more comprehensive understanding of the complex interactions between living organisms and their environment. Biology provides knowledge of the physiological and genetic mechanisms that allow organisms to adapt to their habitats. Ecology studies the interactions between living organisms and their environment, including the relationships between different species and the impact of environmental changes. Geography provides insight into the physical and climatic characteristics of different habitats and how they shape the distribution of species. By integrating these different fields of knowledge, we can gain a more holistic understanding of adaptations and habitats.

Try this group activity to research some abiotic factors in a habitat and the adaptations organisms in that habitat may have developed.

Activity

- **IB learner profile attribute:**
  - Inquirer
  - Thinker
  - Reflective
- **Approaches to learning:**
  - Research skills — Evaluating information sources for accuracy, bias, credibility and relevance

Student view

Overview (/study/ap 422- cid- 755105/o

- Thinking skills — Providing a reasoned argument to support conclusions

- **Time required to complete activity:** 20 minutes
- **Activity type**: Group activity

Divide into groups of two or three and assign each group a different habitat (e.g. Forest, Desert, Grassland, Mountain). In your groups, carry out the following tasks.

1. Research and list the abiotic factors that are important in your habitat. Select an organism that is a top predator in your allocated habitat.
2. Brainstorm and list adaptations that organisms in your habitat have evolved to survive in these abiotic conditions. Consider adaptations related to physical structure, behaviour, physiology, and life history traits of organisms in that habitat.
3. Present your list of adaptations to the class.

As each group presents, other students may ask questions and offer additional examples of adaptations they may know about.

5 section questions

B4. Form and function: Ecosystems / B4.1 Adaptation to environment

Limitations of adaptations and range of tolerance

B4.1.3: Abiotic variables affecting species distribution B4.1.4: Range of tolerance of a limiting factor

Learning outcomes

By the end of this section you should be able to:

- Explain how abiotic variables affect a species distribution and contribute to its range of tolerance.
- Use transect data to correlate the distribution of an organism using sensors and data loggers.

Student view

Overview (/study/ap 422- cid- 755105/o

Figure 1. Joshua trees (*Yucca brevifolia*) in the Mojave Desert, United States.

Credit: PHOTOSTOCK-ISRAEL/SCIENCE PHOTO LIBRARY, Getty Images (https://www.gettyimages.com/detail/photo/joshua-tree-national-park-royalty-free-image/758302569)

The Joshua tree (**Figure 1**) is a slow-growing, long-lived tree that is found only in the Mojave Desert, which is a hot, arid region. This tree has various adaptations that help it survive in the hot environment of the Mojave Desert, such as its small waxy leaves and extensive root system. However, changes in abiotic factors – such as temperature and rainfall patterns due to climate change – could threaten its survival. By studying the abiotic variables that affect the distribution of the Joshua tree, researchers can better understand how to protect this important species and its ecosystem. This will ensure that the Joshua tree and other desert species can continue to thrive in their natural habitats.

Abiotic variables affecting species distribution

Species distribution range refers to the geographic location and range of occurrence of a particular species. This can be influenced by a variety of factors, including the range of tolerance of the species for different abiotic factors.

Abiotic factors (**Figure 2**) such as temperature, humidity, light, water availability and soil composition can affect the distribution, abundance and diversity of living organisms within an ecosystem. Certain species are adapted to specific abiotic conditions, such as extreme

Student view

Overview (/study/ap 422-cid-755105/o

temperatures, low water availability or acidic soil, whereas others may not be able to survive in these conditions and will be limited to regions that have more favourable abiotic conditions.

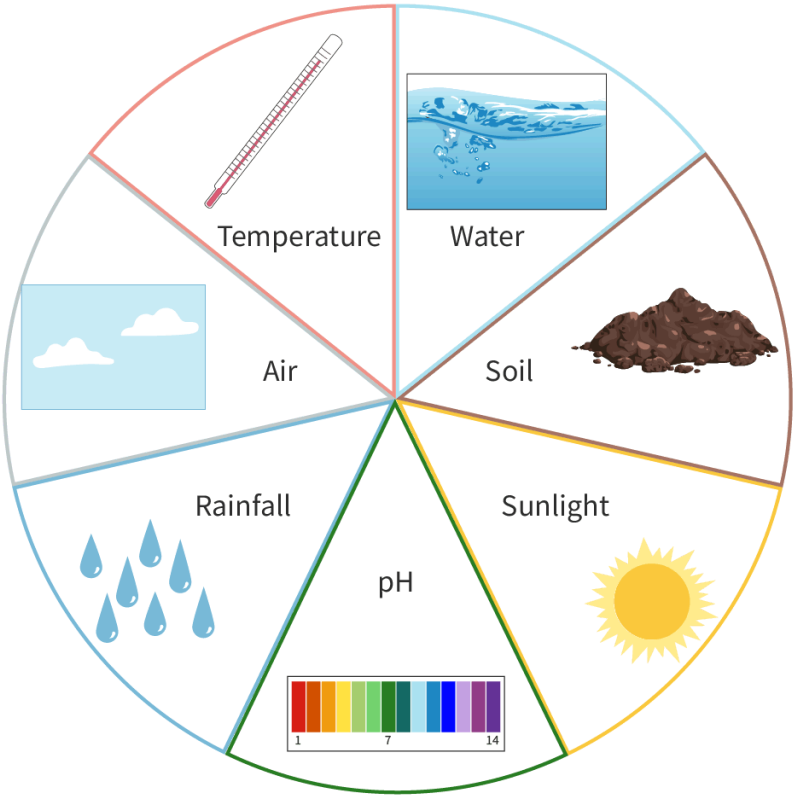


Figure 2. Abiotic factors affecting an ecosystem.

More information for figure 2

This diagram is a circular chart divided into seven sections, each representing different abiotic factors affecting an ecosystem. The sections are labeled as Temperature, Water, Soil, Air, Rainfall, Sunlight, and pH.

- **Temperature:** This section includes an image of a thermometer.
- **Water:** Illustrated with a picture showing a body of water.
- **Soil:** Displayed with a graphic of a soil mound.
- **Air:** Represented with a simple illustration of clouds.
- **Rainfall:** Shown with raindrop icons.
- **Sunlight:** Features a sun icon.
- **pH:** Includes a pH scale bar, ranging from 1 to 14, indicating acidity or alkalinity.

Each segment is color-coded and graphically represents the corresponding abiotic factor, highlighting their role in influencing ecosystems.

[Generated by AI]

Student view

Overview (/study/ap 422-cid-755105/o

Abiotic variables can also influence the interactions between different species in an ecosystem. For example, in a desert ecosystem, water availability may be a limiting factor for both plant and animal species. This can lead to competition between species for access to water, and hierarchical relationships establishing between species based on their ability to access and conserve (keep) water.

Abiotic factors play a crucial role in shaping the distribution of living species, and understanding their impact is essential for understanding the ecology and evolution of organisms. We need to remember that no species is capable of surviving under all the varying conditions found on the Earth, thus leading to restrictions in their distribution.

Next, you will learn about how some abiotic factors affect the growth and distribution of certain plants and animals.

Abiotic factors that affect the growth of plants

Plants are highly sensitive to abiotic factors such as temperature, water availability, light intensity, soil nutrients and atmospheric gases. Some plants may be well-adapted to specific abiotic conditions and thrive in certain habitats, while others may struggle to survive under the same conditions.

Table 1 shows some abiotic factors and examples of how some plant species have adapted to these abiotic factors.

Table 1. Adaptations of plants to abiotic factors.

Abiotic factor	Condition	Examples of adaptations
Light	Insufficient light	Ferns and shade-tolerant trees grow larger, thinner leaves and increase chlorophyll content to maximise light absorption.
Light	Too much light	Succulents and cacti have thick, waxy skin that helps them retain water and reflect sunlight.
Temperature	Extreme high temperatures	Tomato plants have developed heat shock proteins to protect against high temperatures.

Student view

Overview (/study/ap 422-cid-755105/o

Abiotic factor	Condition	Examples of adaptations
Water	Inadequate water supply	During drought, rice plants can reduce water loss by closing their stomata.
Soil	Poor soil quality	Legumes have developed symbiotic relationships with nitrogen-fixing bacteria to obtain nitrogen from the air.

Some additional examples of plant adaptations are shown in **Interactive 1**.

Interactive 1. Adaptations of Plants to Abiotic Factors.

More information for interactive 1

An interactive slideshow with four slides presents photographs of different plants, along with descriptions. Users can switch between slides using the arrows present at the bottom of each slide.

Slide 1:

Photo: A close-up view of the flowers on a Desert sage (Salvia dorrii) plant. The flowers are bright purple with magenta bracts, growing in dense spikes. The bracts have tiny hair-like structures.

Description: Hairy leaves to reduce water loss in hot and dry environments.

Slide 2:

Student view

Overview (/study/ap 422-cid-755105/o

Photo: A large baobab tree (Adansonia rubrostipa) has a thick, wide trunk. The branches spread out from the top of the trunk.

Description: Ability to store large amounts of water in its trunk to survive in dry environments.

Slide 3:

Photo: A person touching the leaves of a sensitive plant (Mimosa pudica). The leaves are small, feathery, and fern-like structures. The leaflets near the touch point are closed, showing the plant's touch response.

Description: Rapid leaf closure response to touch or disturbance to deter herbivores

Slide 4:

Photo: A close-up of the red, thick, cone-shaped stem of a snow plant (Sarcodes sanguinea) growing from the ground. The stem is covered in scale-like leaves and is surrounded by several stalks and twigs.

Description: Bright red stem that photosynthesises without leaves to absorb sunlight reflecting from the snow in cold, snowy environments.

This slideshow helps users recognize how plants adapt to specific environments such as deserts, forests, and snow-covered areas.

Abiotic factors that affect the growth of animals

Just like plants, animals too are highly sensitive to abiotic factors such as temperature, water availability, light intensity, soil nutrients and atmospheric gases. Some animals may be well-adapted to specific abiotic conditions and thrive in certain habitats, while others may struggle to survive under the same conditions.

Table 2 shows some abiotic factors and examples of how some animal species have adapted to these abiotic factors.

Table 2. Adaptations of animals to abiotic factors.

Student view

Overview (/study/ap 422-cid-755105/o

Abiotic factor	Condition	Examples of adaptations
Temperature	Extreme temperatures	Polar bears and penguins have thick layers of fur or blubber to insulate them from extreme cold.
Water	Fluctuations in water levels	Camels and kangaroo rats store water in their bodies to survive in arid environments.
Light intensity	Changes in light	Bats and owls are active at night to avoid predators and take advantage of prey that are active at night.
Food	Changes in food supply	Herbivores have adapted to have specialised teeth or digestive systems to extract nutrients from tough plant material.
Climate	Climate patterns	Bats and ground squirrels hibernate during the winter months to conserve energy and survive in colder temperatures.

Some additional examples of animal adaptations are shown in **Interactive 2.**

Interactive 2. Adaptations of Animals to Abiotic Factors.

More information for interactive 2

Student view

An interactive slideshow with four slides presents photographs of animals along with descriptions. Users can switch between slides using the navigation arrows present at the bottom of each slide.

Overview (/study/ap 422-cid-755105/o

Slide 1:

Photo: An owl has bright, round eyes with black pupils.

Description below reads, Great horned owl (Bubo virginianus). Large eyes with more rods than cones to maximise vision in low light conditions.

Slide 2:

Photo: A camel with two large humps.

Description below reads, Camel (Camelus bactrianus). Large humps to store fat for energy and water, and the ability to conserve water by not sweating excessively.

Slide 3:

Photo: A rat with long hind legs and a long tail.

Description below reads, Kangaroo rat (Dipodomys merriami). Long, narrow nasal passages to conserve water and prevent overheating in hot, desert climates.

Slide 4:

Photo: An earthworm with a cylindrical, segmented body with a tapered end.

Description below reads, Earthworm (Lumbricus terrestris). The ability to break down organic matter and enrich soil with nutrients, improving soil quality and promoting plant growth.

This interactive slideshow explains how different animals adapt to factors such as temperature, water availability, enhancing soil quality, and supporting plant growth.

Creativity, activity, service

Strand: Service
Learning outcome: Demonstrate how to initiate and plan a CAS

Composting in a school environment can be a fun and educational activity which can be a good experience for your CAS portfolios. Composting is a process that involves interactions between biotic and abiotic factors. The interactions between living and non-living components in composting create a complex and dynamic ecosystem which produces heat, gas and humus in the process. Compost is a natural and safer alternative to artificial fertilisers. Providing compost to your school garden is a good service.

Here are some steps to consider:

Student view

- Collect organic waste material such as fruit and vegetable scraps, eggshells, coffee grounds, and leaves.
- Place the waste material in a compost bin or pile in a sunny location.
- Add dry leaves or straw to the compost pile to provide air pockets for proper aeration.
- Water the pile regularly to keep the material moist.
- Turn the pile regularly with a pitchfork to ensure proper mixing and aeration.
- Observe the compost pile and discuss the changes that are occurring as the waste material decomposes.
- Once the compost is fully decomposed, it can be used as a natural fertiliser in the school garden or in pots and planters around the school.

Range of tolerance as a limiting factor

Range of tolerance refers to the range of environmental conditions, within which an organism can survive and function optimally. Organisms have a specific range of tolerance to each environmental factor, beyond which they may experience stress or even death which varies among different species. For example, if a plant is exposed to extreme temperatures outside of its range of tolerance, it may experience wilting, leaf drop or even death.

Table 3 shows the preferred range of tolerance for some animals.

Table 3. Animal species and their range of tolerance.

Animal	Preferred range of tolerance
Lion	Seasonal rainfall, high temperatures
Polar bear	Extremely low temperatures, high salinity
Chimpanzee	High humidity, high rainfall and relatively stable temperatures
Kangaroo	Low rainfall, high temperatures and frequent droughts
Emperor penguin	Extremely low temperatures, high winds
Grizzly bear	Moderate to high rainfall, cold winters and warm summers

Overview (/study/ap 422-cid-755105/o

Each animal species in **Table 3** has specific requirements of certain abiotic factors and they often need to be in a particular geographical location to survive. If the environmental conditions in a particular area fall within a species' range of tolerance, it is more likely to occur there. However, if the environmental conditions are outside of its range of tolerance, the species may not be able to survive or reproduce successfully.

One important thing to remember is that the range of tolerance can be affected by environmental changes, such as climate change, pollution or habitat destruction. If the environmental conditions change beyond a species' range of tolerance, it may be forced to migrate to more suitable areas or face extinction.

How does range of tolerance act as a limiting factor?

In tropical rainforests, the dense canopy of trees limits the amount of sunlight that reaches the forest floor, leading to low light availability for plants growing on the ground. At the same time, the high rainfall in these areas often leads to waterlogged soils, which can limit the ability of plants to take up nutrients and oxygen. As a result, plant growth in tropical rainforests may be limited by both light and water availability (**Figure 3**).

Figure 3. Dense cover of trees forming a canopy in a rainforest.

Credit: susan.k., Getty Images (https://www.gettyimages.com/detail/photo/beautiful-scenery-of-tropical-rainforest-royalty-free-image/934336804)

The example in **Figure 3** explains to us that the range of tolerance of a species is often determined by limiting factors. In the above example, the limiting factors were sunlight and rainfall rate. The availability of these limiting factors sets the upper limit for the size of a

Student view

Overview (/study/ap 422-cid-755105/o

species in an ecosystem. When one or more limiting factors are in short supply, it can have a significant impact on the distribution, abundance and diversity of species within an ecosystem (see later in this section).

Use of transect lines for sampling

The use of sampling techniques is necessary to study the correlation between abiotic variables and species distribution. The transect line method is the most commonly used technique.

Transect line method is a sampling technique used in ecology to gather data on the distribution and abundance of plants and animals in a particular area. It involves establishing a straight line across a particular habitat and then taking measurements or samples at regular intervals along the line (**Figure 4**).

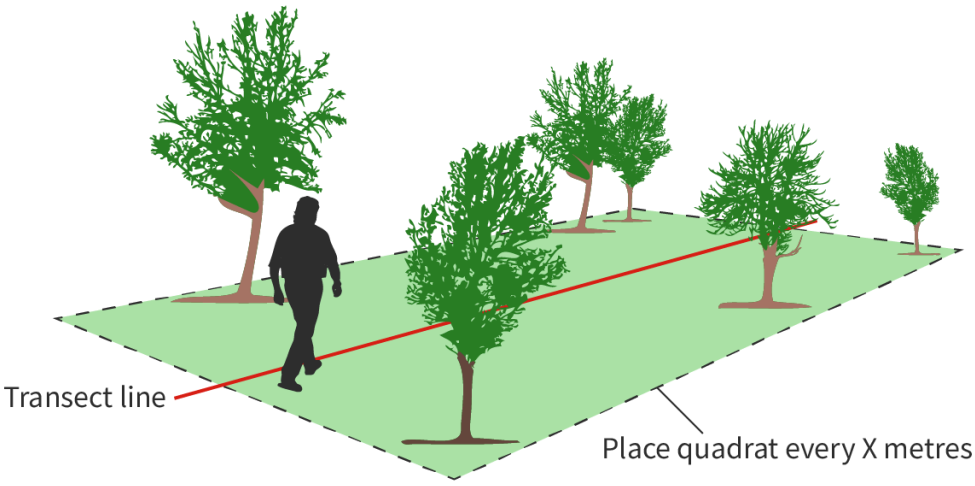


Figure 4. Collecting ecological data using a transect line.

More information for figure 4

The image is a diagram illustrating the transect line method used in ecology. It shows a straight red line drawn across a grassy field with scattered trees. A silhouette of a person is walking alongside the transect line. The diagram labels indicate the "Transect line" and a note to "Place quadrat every X metres." The layout suggests the process of placing quadrats at regular intervals along the transect line to study ecological data, such as the distribution of plant species within the designated habitat area.

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Student view

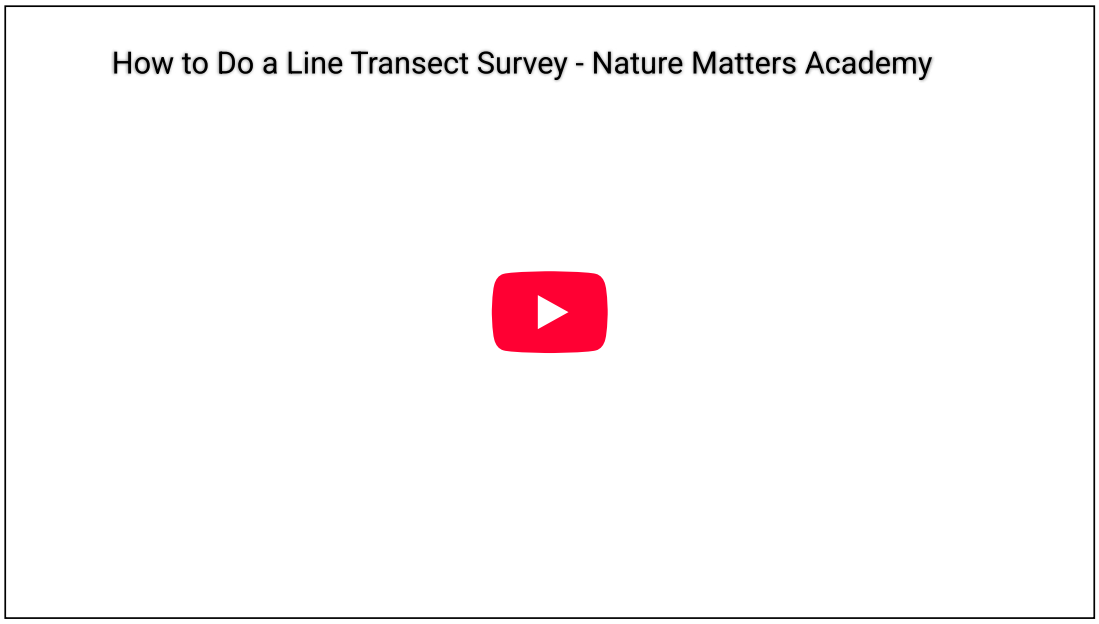
Overview (/study/ap 422-cid-755105/o

The transect line method can be used in a variety of habitats, including forests, grasslands and aquatic environments. First, a tape measure or rope is set out in a straight line across the habitat. Along the line, measurements or samples are taken at regular intervals, such as every metre or every 5 metres. The measurements can include things like plant species richness, plant height, leaf area index, soil moisture or animal abundance.

The following three are different methods of using a transect for sampling.

1. **Belt transect:** Used to study the distribution and abundance of organisms in a particular habitat by placing a long, narrow belt over the area of interest and counting the number of individuals within the belt.
2. **Observational transect:** Used in environmental monitoring to observe and record data along a designated linear path or transect in a specific habitat or ecosystem.
3. **Line intercept sampling:** Used to measure the abundance and distribution of plant species in a particular habitat by recording the points where a line or tape intersects with plant stems or foliage.

Watch **Video 1** to understand how to perform a transect line sampling study.



Video 1. How to use a transect line.

Try this practical activity to measure the effects of light intensity on abundance and distribution of plant species along a transect line.

Student view

Practical skills

Overview (/study/ap 422- cid- 755105/o

- **IB learner profile attribute:**
  - Inquirer
  - Thinker
  - Reflective
- **Approaches to learning:**
  - Research skills — Evaluating information sources for accuracy, bias, credibility and relevance,
  - Thinking skills — Providing a reasoned argument to support conclusions
- **Tool 1**: Experimental techniques — Applying techniques
- **Inquiry 1**: Exploring and designing — Controlling variables
- **Time required to complete activity:** 60—75 minutes
- **Activity type:** Group activity (2—3 students)

Objective

To measure the change in light intensity along a transect line and understand how this affects plant growth and distribution.

Materials

- Measuring tape
- Light meter (LUX app — available for free on android and apple stores)
- Notebook or data sheet

Procedure

1. Choose a transect line that represents the area of interest. This can be done by selecting a line that traverses a gradient in light intensity, such as from a sunny area to a shaded area in a garden.
2. Mark the starting and ending points of the transect line using a measuring tape or ruler.
3. Divide the transect line into equal sections, such as 1 m or 2 m intervals, using the measuring tape or ruler.
4. At each interval, measure the light intensity using a light meter. Hold the light meter at a consistent height above the ground to ensure consistent measurements.
5. Record the light intensity measurements in a notebook along with the location of the measurement along the transect line.
6. Take note of the plant species present at each interval along the transect line. Record their names, location and any notable characteristics.

Student view

Overview (/study/ap 422- cid- 755105/o

7. After recording the light intensity and plant species data, analyse the data to understand how light intensity affects plant growth and distribution. This can be done by creating graphs or charts to visualise the data and by comparing the plant species present at different light intensity levels.

Overall, this procedure will allow you to measure the change in light intensity along a transect line and understand how this affects plant growth and distribution. By analysing the data collected, you can gain insights into how plants respond to changes in light intensity and how they are distributed across different light environments.

Sensors and data loggers

As science and technology develops, the methods used to make observations also develop. Observations using sensors and data loggers have become increasingly popular in environmental monitoring. Sensors are devices that measure physical or chemical properties such as temperature, pressure, humidity, light intensity and sound level. Data loggers, on the other hand, are electronic devices that record data from sensors over time.

Some advantages of data loggers and sensors are:

- They can provide continuous and precise measurements of physical or chemical properties.
- They can operate in hazardous or remote environments where human observation is impractical or dangerous.
- They can provide real-time data that can be analysed and acted upon quickly.
- They can take multiple readings quickly.

Aspects:

- Patterns and Trends
- Evidence

The Christmas Bird Count is a citizen science project that has been collecting data on bird species distribution since 1900. In 2009, researchers at the National Audubon Society used observational data from the bird count to investigate the potential impacts of climate change on bird species in North America. The

Student view

Overview (/study/ap 422- cid- 755105/o

researchers analysed the data to determine the range shifts of over 300 bird species between 1968 and 2008 and used this information to predict future range shifts under different climate change scenarios.

The results of the study showed that, on average, bird species in North America had shifted their ranges northward by 35 miles over the 40-year study period, as temperatures have warmed. The researchers also predicted that if greenhouse gas emissions continue to increase, more than half of the bird species in North America could lose over 50% of their current range by 2080, and some species could lose their entire range.

This case study illustrates the critical role of evidence in the study of species distribution. Observational data and laboratory experiments are essential tools for investigating the complex patterns and processes that determine the geographical range of different species. Furthermore, the integration of evidence from different sources is crucial for developing robust hypotheses and theories.

Try the activity below to measure how abiotic factors affect distribution of a plant species in your local area.

Activity

- **IB learner profile attribute**:
  - Inquirer
  - Thinker
  - Reflective
- **Approaches to learning**:
  - Research skills — Evaluating information sources for accuracy, bias, credibility and relevance
  - Thinking skills — Providing a reasoned argument to support conclusions
- **Time required to complete activity**: 2 hours
- **Activity type:** Group activity (groups of three)

Objective

To conduct a plant survey to understand how abiotic factors, such as soil pH and temperature, affect plant species distribution in your local area.

Method

Student view

Overview (/study/ap 422- cid- 755105/o

1. Choose an outdoor location that has a variety of plants growing, such as your school garden or local park or a building garden.
2. Bring a soil pH paper strip and a local temperature measuring device.
3. Select a specific area to survey, and take note of the location and any distinguishing features of the plants in that area.
4. Collect some soil samples in a test tube using a spatula or spoon and add a little water. Insert a pH strip to the test tube to note the pH of the soil based on the colour of the strip. Record the results.
5. Use the local temperature measuring device to measure the temperature in the selected area. Record the results.
6. Take note of the types of plants growing in the selected area and record their names.
7. Research the ideal pH level and temperature ranges for each of the plant species found in the selected area.
8. Compare the results of your soil pH and local temperature measurements to the ideal ranges for each plant species.
9. Analyse the data to understand which plant species are thriving in the selected area and which may need additional care or attention to grow.
10. Consider the environmental factors that may be influencing the plant species in the selected area, such as sunlight, moisture levels, and soil type.

5 section questions

B4. Form and function: Ecosystems / B4.1 Adaptation to environment

Coral reef formation

B4.1.5: Conditions required for coral reef formation

Learning outcomes

By the end of this section you should be able to state the conditions required for coral reef formation.

Student view

Overview (/study/ap 422-cid-755105/o

The waters of the Raja Ampat Islands have 450 species of reef-building coral, making it an area with the largest coral reef biodiversity based on its size (**Figure 1**). When scientists discovered this fact, they put a plan into motion to protect this underwater habitat, as so many reefs around the world are at risk. Located in the heart of the Coral Triangle, an area with 75 per cent of all identifiable coral species, the area also has an impressive 1427 species of fish. But how do coral reefs form and why are they under threat?

Figure 1. Hawksbill turtle (*Eretmochelys imbricata*) swimming over coral reef in Misool, Raja Ampat, West Papua, Indonesia.

Credit: susan.k., Getty Images (https://www.gettyimages.com/detail/photo/beautiful-scenery-of-tropical-rainforest-royalty-free-image/934336804)

One of the most important and dynamic ecosystems on Earth is the marine ecosystem. It is a complex and dynamic system that is home to a vast array of organisms, from tiny plankton to massive whales.

The marine ecosystem is strongly influenced by various abiotic factors, such as water depth, temperature, salinity, pH and currents. These factors have a significant impact on the survival and growth of marine organisms, including coral reefs (**Figure 2**).

Student view

Overview (/study/ap 422- cid- 755105/o

Credit: Jason Edwards, Getty Images (https://www.gettyimages.com/detail/photo/branching-orange-and-purple-tree-coral-perched-on-a-royalty-free-image/452417883)

Credit: Lea McQuillan / 500px, Getty Images (https://www.gettyimages.com/detail/photo/reef-landscape-at-ribbon-reef-no-9-great-barrier-royalty-free-image/1365178419)

Figure 2. Coral reefs.

Corals are marine invertebrates that typically grow in colonies. Here are some interesting facts about them:

- Corals are not plants, they are animals.
- Corals are slow-growing, and some coral species can take hundreds of years to reach maturity.
- Corals can come in a variety of colours, including pink, yellow, blue, green and purple.
- Some coral species have the ability to regenerate and rebuild their skeletons, making them resilient to environmental stress.

Student view

Overview (/study/ap 422-cid-755105/o

Conditions required for coral reef formation

Coral reefs are underwater structures made up of the calcified skeletons of coral polyps, tiny invertebrate animals. Coral reefs are incredibly diverse ecosystems, home to a vast array of marine organisms such as fish, crustaceans, molluscs and sponges. Coral reefs are also essential for the livelihoods and well-being of millions of people around the world. They provide valuable ecosystem services, such as food production, coastal protection and tourism.

Coral reefs are delicate ecosystems and require specific conditions to thrive. Coral reefs are particularly sensitive to changes in abiotic conditions. It is important to study the ideal conditions required for coral formation to protect them and prevent changes to their habitat.

The following conditions are required for coral reef formation:

- **Water depth:** Coral reefs can grow in shallow waters, typically between 2 and 45 metres, where sunlight can penetrate and support the growth of algae.
- **pH:** Coral reefs thrive in water with a pH between 8.0 and 8.4, which is slightly alkaline.
- **Salinity:** Coral reefs need a stable salt concentration typically from 30 to 37 ppt (parts per thousand). Most reef-building corals also require very saline (salty) water ranging from 32 to 42 ppt.
- **Water clarity:** The water must also be clear so that a maximum amount of light penetrates it. This is because most reef-building corals contain photosynthetic algae, called zooxanthellae, which live in their tissues. The corals and algae have a unique relationship. The coral provides the algae with a protected environment and compounds they need for photosynthesis. In return, the algae produce oxygen and help the coral to remove wastes. Most importantly, zooxanthellae supply the coral with food. The algae need light to produce food via photosynthesis.
- **Temperature:** Reef-building corals cannot tolerate water temperatures below 18 °C. Many grow optimally in water temperatures between 23 and 29 °C, but some can tolerate temperatures as high as 40 °C for short periods.

Because coral reefs are such a dynamic ecosystem which serve as a habitat for so many species, the organisms in a coral reef ecosystem have developed a variety of adaptations to survive in their challenging environment. Some of these adaptations include:

Student view

- **Symbiotic relationships:** Many species in a coral reef ecosystem have formed symbiotic relationships with other species; for example, corals have a symbiotic

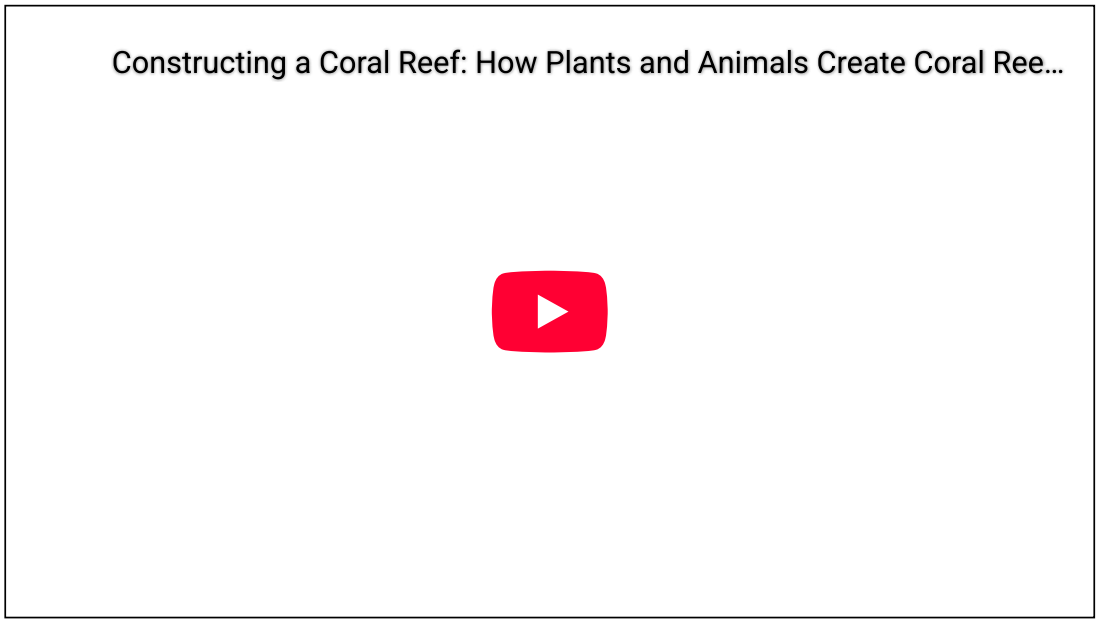
Overview (/study/ap 422-cid-755105/o

relationship with algae that provide them with energy.

- **Camouflage:** Some species in a coral reef ecosystem, such as octopuses, have developed unique colour patterns that allow them to blend into their surroundings and avoid predators.
- **Protective covering:** Certain types of snails and sea urchins in the coral ecosystem have developed hard, protective shells to help them survive.
- **Stingers and spines:** Many species in a coral reef ecosystem have developed stingers or spines to deter predators and protect themselves.
- **Reproductive strategies:** Different species have evolved different reproductive strategies to ensure the survival of their species. Some species reproduce by laying eggs, while others use asexual reproduction.

These adaptations help the species in a coral reef ecosystem to survive in their challenging environment, and they play a crucial role in maintaining the health and diversity of the coral reef ecosystem.

Watch **Video 1** to understand how organisms adapt in the coral ecosystem.



Video 1. Relationships between different species in a coral reef.

Coral reefs are under threat from a range of human activities, including climate change, overfishing, pollution and coastal development. These are causing coral bleaching and death, leading to the degradation of coral reef ecosystems (see section D4.3.7 (:sectionlink:134576)).

Student view

Overview (/study/ap 422-cid-755105/o

Efforts are underway to protect and conserve coral reefs, including establishing marine protected areas, promoting sustainable fishing practices and reducing greenhouse gas emissions to mitigate the impacts of climate change.

International Mindedness

The Great Barrier Reef is the world's largest coral reef system, covering an area of over 344 000 square kilometres off the coast of Queensland, Australia. In recent years, the Great Barrier Reef has experienced several mass bleaching events, due to climate change and pollution, where corals have turned white and eventually died.

Australia has recognised the importance of international cooperation and has established partnerships with other countries, including the United States, to share knowledge and best practices for coral reef conservation.

The Australian government has also worked with international organisations, such as the United Nations Educational, Scientific and Cultural Organization (UNESCO), to ensure the protection of the reef. The Great Barrier Reef is now a UNESCO World Heritage Site, which means that it is recognised as a site of outstanding natural beauty and cultural significance. This designation highlights the importance of international cooperation in protecting the reef and promoting sustainable tourism practices that benefit both people and the environment.

The Great Barrier Reef is a prime example of how international cooperation is essential for protecting habitats.

How can countries balance economic development with the protection of coral reefs?

Try this activity to learn more about the importance of coral reefs.

Activity

- **IB learner profile attribute:** Inquirer
- **Approaches to learning:**
  - Communication skills — Practising active listening skills
  - Social skills — Assigning and accepting specific roles during group activities, Actively seeking and considering the perspective of others
- **Time required to complete activity:** 20 minutes

Student view

Overview (/study/ap 422-cid-755105/o

- **Activity type:** Group activity (groups of four)

Objective

To gain an understanding of the importance of coral reef ecosystems and the threats they face through exploring the resources on the NOAA National Marine Sanctuaries website.

Task

1. Explore the NOAA National Marine Sanctuaries (https://sanctuaries.noaa.gov/education/teachers/coral-reef/lesson-plans.html) website.
2. Take some time to read different tabs on the website and try to find answers to the following questions.

   - What are some of the animals that live in coral reefs?
   - What are some of the benefits that coral reefs provide to humans?
   - What are some of the threats facing coral reefs?
   - What are some ways that we can protect coral reefs?

Each group member can work on answering one question. After discussing all answers within your group, share your findings with the class as a class discussion.

As an extension activity, you could research a specific threat facing coral reefs in more depth and create a presentation or poster to share with the class.

5 section questions

B4. Form and function: Ecosystems / B4.1 Adaptation to environment

Determinants of biome distribution and biomes as groups of ecosystem

B4.1.6: Abiotic factors as the determinants of biome distribution B4.1.7: Biomes as groups of ecosystems with similar communities

Learning outcomes

By the end of this section you should be able to:

Student view

Overview (/study/ap 422-cid-755105/o

- Describe how abiotic factors act as the determinants of terrestrial biome distribution.
- Recognise biomes as groups of ecosystems with similar communities due to similar abiotic conditions and convergent evolution.

Figure 1. The Amazon Rainforest in Peru.

Source: "Rio Madre de Dios, Peru (https://commons.wikimedia.org/wiki/File:Rio_Madre_de_Dios,_Peru.JPG)" by Roosevelt Garcia is in the public domain

The rainforest region in **Figure 1** is classified as a biome. With the person sitting next to you, discuss two abiotic factors that are necessary for the rainforest region to survive.

Answers could include sunlight, rainfall, soil pH, temperature.

Abiotic factors and terrestrial biome distribution

A biome is a large community of plants and animals that occupy a distinct geographical region and are adapted to its climate and other environmental conditions. Biomes are characterised by the dominant vegetation, animals and climate patterns found in a

Student view

Overview (/study/ap 422-cid-755105/o

particular area. Here, we will focus on six major terrestrial biomes (**Figure 2**): tropical rainforest, temperate forest, taiga, grassland, tundra and hot desert biomes.

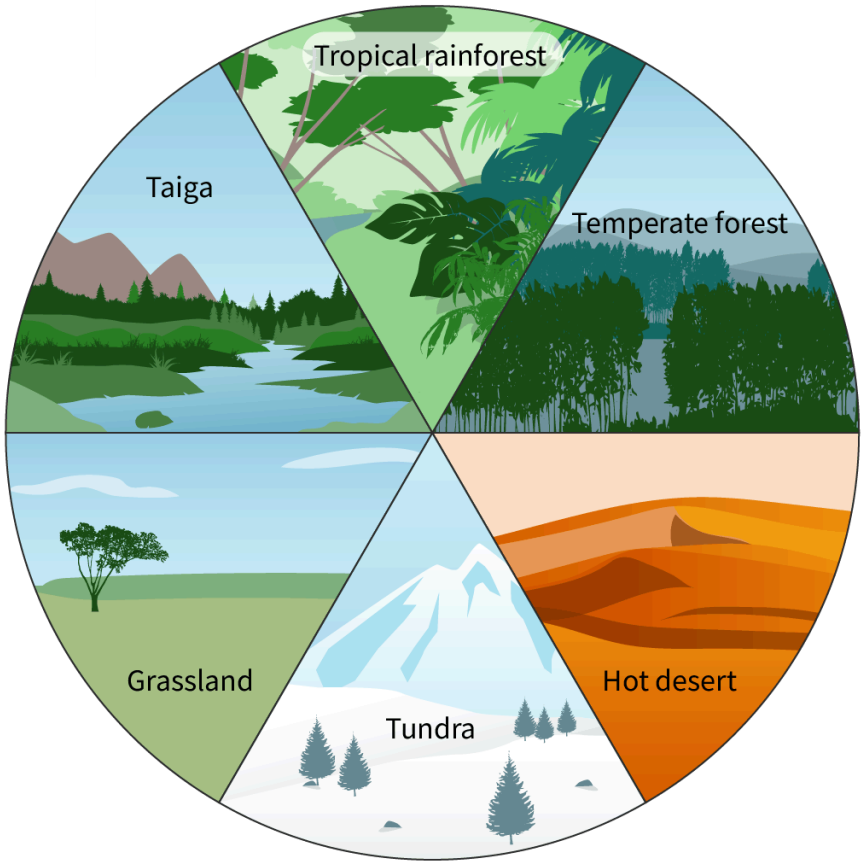


Figure 2. Terrestrial biomes.

More information for figure 2

The image is a circular diagram divided into six equal segments, each representing a different terrestrial biome. Starting from the top and moving clockwise, the biomes are labeled as:

1. **Tropical Rainforest**: The segment features dense green foliage, depicting a lush, tropical environment.
2. **Temperate Forest**: This area shows a dense forest scene typical of temperate climate zones.
3. **Hot Desert**: It illustrates an arid desert landscape with sand dunes.
4. **Tundra**: Here, there is a snowy landscape with a few coniferous trees, indicative of a cold, icy region.
5. **Grassland**: The grassland segment shows an open landscape with sparse trees and expansive grass fields.
6. **Taiga**: This depicts a landscape with large pine trees, often found in northern forested regions.

Each segment visually represents the unique characteristics of its biome, emphasizing their distinct climates and landscapes.

[Generated by AI]

Student view

There are two main abiotic factors which mostly determine the type of biome that will exist in a particular region. These factors are temperature and rainfall pattern. These two interact with each other to create a unique climate in each area, which affects the types of plants and animals that can survive in that environment.

Temperature has a direct impact on the distribution of biomes because it affects the rate of biological processes such as photosynthesis, growth and metabolism. Rainfall, on the other hand, determines the availability of water, which is essential for the survival of plants and animals.

Together, temperature and rainfall patterns help to create distinct biomes. For a given temperature and rainfall pattern, there is likely to be only one dominant biome that develops in an area. For example, a region with hot and humid tropical climates is likely to have a tropical rainforest biome. Every biome is defined by climate and therefore, the same biome can occur in geographically different locations with similar climates.

A temperature versus rainfall graph is often used to illustrate how different biomes are distributed based on their climate conditions (**Figure 3**). In general, this type of graph shows that there is a relationship between temperature and precipitation that determines the type of biome that can exist in a given area. For example, areas with high temperatures and high precipitation may support tropical rainforests, while areas with low temperatures and low precipitation may support tundra biomes.

Overview (/study/ap 422-cid-755105/o

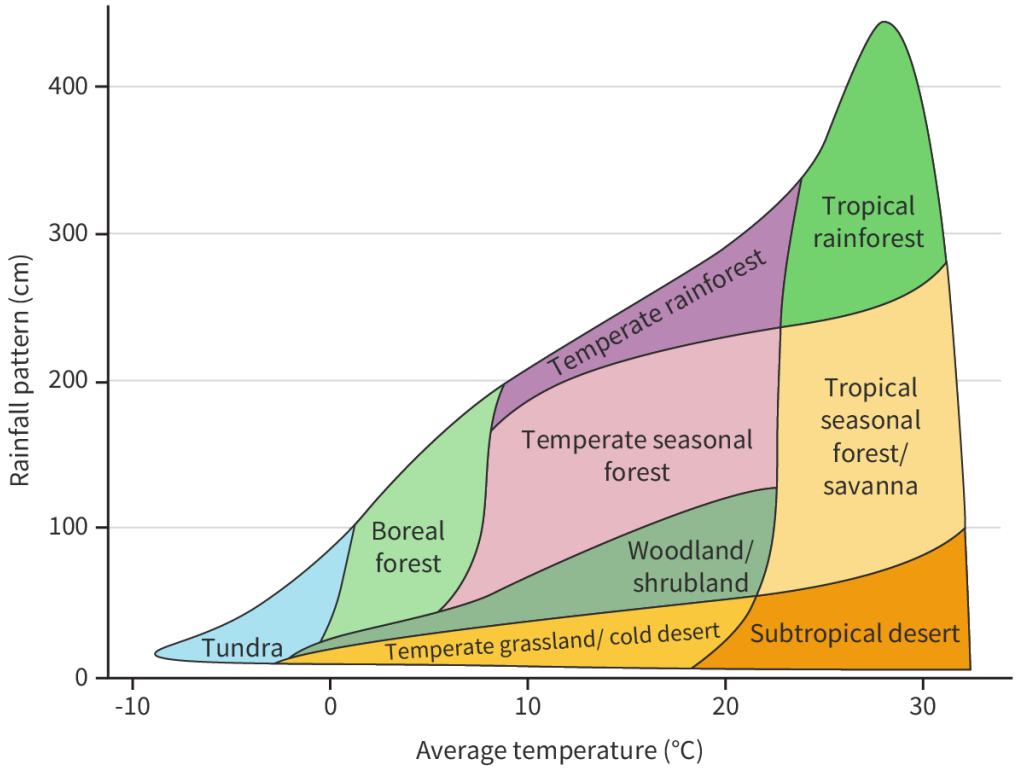


Figure 3. Terrestrial biomes based on the rainfall pattern and temperature.

More information for figure 3

The graph displays terrestrial biomes mapped against average temperature (°C) on the X-axis and rainfall pattern (cm) on the Y-axis. The X-axis ranges from -10°C to 30°C, while the Y-axis spans from 0 cm to 400 cm of rainfall. Various biome regions are illustrated as follows: "Tundra" at the low end of both scales with temperatures below 0°C and rainfall below 100 cm. "Boreal forest" lies slightly higher in temperature and rainfall, bordering "Temperate grassland/cold desert," which occupies moderate temperatures around 0°C to 10°C and low rainfall. "Temperate seasonal forest" is in the mid-range, with moderate temperature and intermediate rainfall. "Temperate rainforest" appears above it, at similar temperatures but with more rainfall, reaching around 200-300 cm. "Woodland/shrubland" is positioned at moderate temperatures and low rainfall. "Tropical seasonal forest/savanna" and "Subtropical desert" appear on the higher temperature side, with the former having moderate rainfall and the latter minimal. "Tropical rainforest" is positioned at high temperatures and high rainfall, around 30°C and upwards of 300 cm. The regions indicate specific climate conditions suitable for each biome.

[Generated by AI]

Student view

The graph typically shows temperature on the horizontal axis and rainfall on the vertical axis, and different biomes are represented as distinct regions on the graph. The precise location of each biome on the graph can vary depending on the specific criteria used to

Overview (/study/ap 422-cid-755105/o

define each biome, but in general, the graph can help to illustrate the patterns of temperature and rainfall that are associated with each biome type.

Biomes as groups of ecosystems with similar communities

Section Student... (0/0) Feedback Print (/study/app/bio/sid-422-cid-755105/book/coral-reef-formation-id-44706/print/) Assign

Figure 4 shows two very similar looking images. One is an ecosystem and the other is a biome. Can you state the difference between the two?

Credit: Flavio Di Monaco, Getty Images (https://www.gettyimages.com/detail/photo/sucuri-river-beautiful-thick-bush-of-southern-royalty-free-image/1478121538)

Credit: Giordano Cipriani, Getty Images (https://www.gettyimages.com/detail/photo/brazil-bonito-school-of-fish-in-sucuri-river-royalty-free-image/629640625)

Figure 4. Biomes as groups of ecosystems with similar communities due to similar abiotic factors.

Biomes are groups of ecosystems that share similar abiotic conditions, such as climate, soil and water, which in turn result in similar communities of plants and animals due to convergent evolution. Convergent evolution refers to the process where different species evolve to have similar traits in response to similar environmental pressures, even though they have different evolutionary histories. For example, a forest is a type of biome that can contain multiple ecosystems, such as a deciduous forest or a rainforest (see subtopic A4.1

Student view

Overview (/study/ap 422- cid- 755105/o

(/study/app/bio/sid-422-cid-755105/book/the-big-picture-id-43246/)). The marine biome is another example. Convergent evolution is seen in the fusiform (bullet-shaped) body plan of the dolphin (mammal) and the shark (cartilaginous fish). These two organisms have evolved in response to the environmental pressures of the marine biome.

In short, a biome is a larger and more broadly defined area, whereas an ecosystem is a smaller and more specific area. Biomes are often strongly influenced by their latitude, as the climatic conditions and vegetation patterns can vary greatly with changes in latitude. Ecosystems, on the other hand, can exist in a variety of climates and can be influenced by many other factors besides latitude, such as altitude, topography and human activities.

Watch **Video 1** to see the organisation of a temperate grassland biome.

Video 1. Temperate grassland biomes.

Having understood the significance of abiotic factors in determining the terrestrial biome distribution and studying the difference between ecosystem and biomes, you should now understand the different climatic conditions and limiting factors that have resulted in the formation of six different terrestrial biomes (**Interactive 1**).

Student view

Overview (/study/ap 422-cid-755105/o

Interactive 1. Terrestrial Biomes with Their Abiotic Environments.

More information for interactive 1

An interactive slideshow with six slides represents different terrestrial biomes. Each slide includes a photograph and a description of the abiotic environments of the biomes. Users can switch between slides using the arrows present at the bottom of each slide.

Slide 1:

Photo: A dense forest with a variety of trees.

Description below the photo reads, Tropical forest biome, Temperature: High (20–30 °C), Precipitation: High (1500–2500 mm), Light intensity: High, Seasonal variation: Low (relatively constant climate throughout the year).

Slide 2:

Photo: Two giraffes in a grassland.

Description below the photo reads, Grassland biome, Temperature: Moderate to high (10–25 °C), Precipitation: Low to moderate (250–1000 mm), Light intensity: High, Seasonal variation: High (with hot summers and cold winters)

Slide 3:

Photo 1: A tiger runs through snow, with coniferous trees in the background.

Student view

Overview (/study/ap 422-cid-755105/o

Description below the photo reads, Taiga biome, Temperature: Low to Moderate (−20–10 °C), Precipitation: Moderate (400–900 mm), Light intensity: Low to moderate, Seasonal variation: High (with long, cold winters and short, cool summers).

Slide 4:

Photo: A grassland with densely packed coniferous trees in the background. Mountain ranges are visible at a far distance.

Description below the photo reads, Temperate biome, Temperature: Moderate (5–20 °C), Precipitation: Moderate to high (500–1500 mm), Light intensity: Moderate, Seasonal variation: Moderate (with less pronounced seasons).

Slide 5:

Photo: A group of deer moves in a line through a snow-covered environment, with snow-covered mountains in the background.

Description below the photo reads, Tundra biome, Temperature: Low (−30–10 °C), Precipitation: Low (100–500 mm), Light intensity: Moderate to high, Seasonal variation: High (with long, cold winters and short, cool summers).

Slide 6:

Photo: A person followed by a camel in a desert.

Description below the photo reads, Desert biome, Temperature: High (20–40 °C), Precipitation: Low (50–250 mm), Light intensity: High, Seasonal variation: Low (with only slight variations in temperature and rainfall throughout the year).

This slideshow helps users identify different terrestrial biomes based on visual and environmental features.

Try the activity below to explore biomes around the world.

Student view

Activity

- **IB learner profile attribute:** Thinker
- **Approaches to learning:**
  - Communication skills — Using terminology, symbols and communication conventions consistently and correctly, Presenting data appropriately,
  - Thinking skills — Designing procedures and models
- **Time required to complete activity:** 15 minutes
- **Activity type:** Pair activity

There are several biomes that may exist in different places around the world at the same time.

In this activity, you will be exploring different biomes using the BiomeViewer (https://www.biointeractive.org/classroom-resources/biomeviewer) tool. Click on 'Start interactive' after opening the link.

In pairs, explore different biomes using the BiomeViewer tool. Pay attention to the characteristics of each biome, including the climate, vegetation and animal life.

Once you are familiar with the software, in your pair explore the biome present at any one of the few places mentioned below. Understand the biome that exists in that region and answer the following questions.

1. Which biome exists in the region?
2. What is the average precipitation rate?
3. What is the average temperature?
4. What are a few examples of mammalian species found in the region?

Regions to consider: Maldives, Iraq, Tokyo, Alaska, Dubai, Mexico, Jaipur, Adelaide

After you have had a chance to explore the biomes, discuss your findings with the class. Share your observations and any patterns you noticed across biomes. You should try and think about how abiotic factors may have influenced the distribution and characteristics of each biome.

After completing the activity, you may wish to explore the website further to study the biome, climate and vegetation in your country/state.

Overview (/study/ap 422-cid-755105/o

B4. Form and function: Ecosystems / B4.1 Adaptation to environment

Adaptations to desert and rainforest biomes

B4.1.8: Adaptations to life in hot deserts and tropical rainforest

Learning outcomes

By the end of this section you should be able to state the adaptations to life in hot deserts and tropical rainforest.

Animals, in particular, are constantly adapting to their environment in order to survive and thrive. The discovery of *Sericomyrmex radioheadi*, a new species of ant adapted to the Atacama Desert, is a perfect example of this (**Figure 1**). This ant species has evolved by living underground and feeding on the fungi that grows there. This new species reproduces by asexual reproduction called parthenogenesis, where the female ants can produce offspring without mating with a male. This adaptation allows the ants to rapidly colonise new areas of the desert and survive in an environment where resources are scarce.

The discovery of *Sericomyrmex radioheadi* also underscores the importance of ongoing research and exploration in understanding the natural world. Do you think as we continue to learn more about the world around us, we will undoubtedly discover more examples of how animals have adapted to survive in even the harshest of environments?

Student view

Overview (/study/ap 422-cid-755105/o

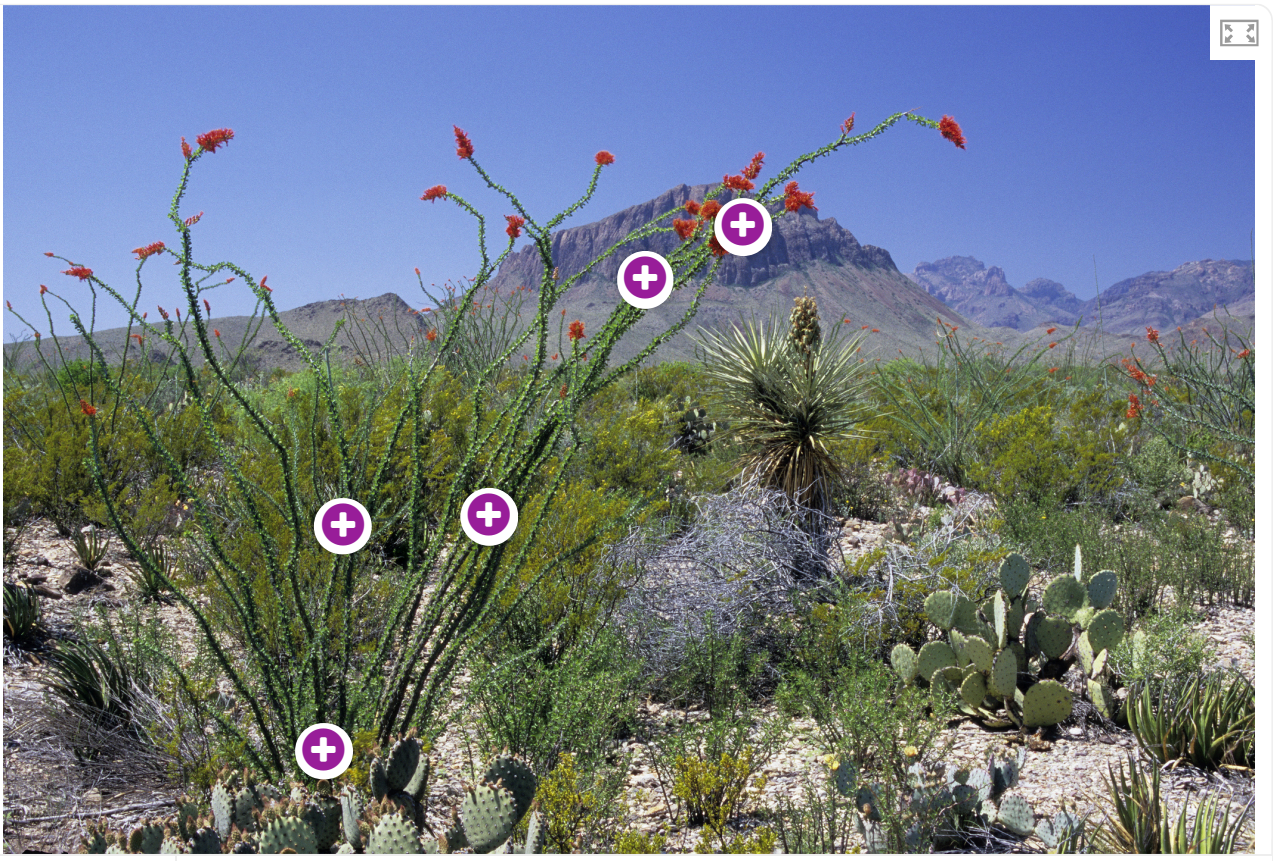
Figure 1. *Sericomyrmex radioheadi* — a newly discovered species of ant.

Source: "Sericomyrmex radioheadi worker (lateral) (https://commons.wikimedia.org/wiki/File:Sericomyrmex_radioheadi_worker_(lateral).jpg)" by Ana Ješovnik and Ted R. Schultz is licensed under CC BY 4.0 (https://creativecommons.org/licenses/by/4.0/deed.en)

Adaptations to life in hot deserts

Deserts are arid regions that receive little rainfall. They are characterised by extreme dryness, high temperatures during the day and low temperatures at night, and a lack of water and vegetation. These conditions make it difficult for most plants and animals to survive, and those that do must be well-adapted to the harsh desert environment. Below are examples of a plant and animal that have adapted to these harsh desert environments to survive.

Interactive 1 and **Interactive 2** show examples of species adapted to hot desert biomes. Click on the hotspots to reveal the adaptations.



Interactive 1. Adaptations of Ocotillo to the Sonoran Desert at Gila Bend, Arizona.

More information for interactive 1

Student view

Overview (/study/ap 422-cid-755105/o

An interactive photograph illustrates an ocotillo plant growing next to a cactus. The ocotillo has a cluster of tall, spiny, wand-like stems growing from its root. Small leaves grow on the stems. At the tip of the stems, there are clusters of bright orange-red flowers.

The background features several cactus and ocotillo plants, with a mountain range in the far distance.

The photograph has five plus signs, representing interactive hotspots. Selecting a hotspot reveals a description of the corresponding part.

Hotspot on root reads, Deep root system which allows it to access water from deep in the soil and an additional horizontal root system which allows it to quickly absorb even small amounts of precipitation.

Hotspot on bark reads, Greenish chlorophyll-containing bark allows it to carry out photosynthesis even when there are no leaves present.

Hotspot on stems reads, Long thorny stems can expand to store water during droughts, allowing it to survive when water is scarce; thorns also serve as a deterrent to herbivores.

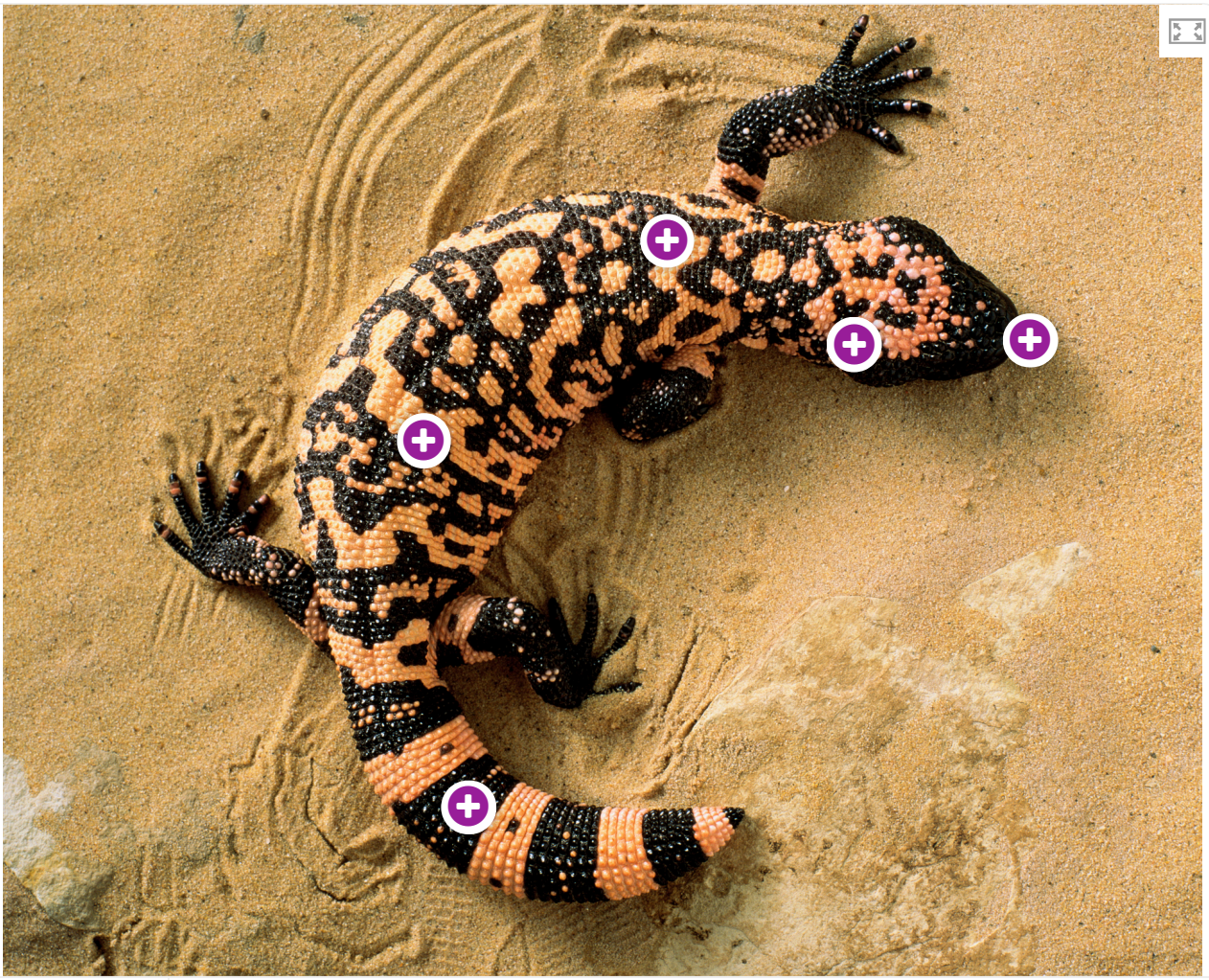
Hotspot on leaves reads, Leaves sprout after rainfall to perform photosynthesis.

Hotspot on flowers reads, Vibrant red flowers attract pollinators for reproduction.

This photograph helps users identify and describe the key physical features of the ocotillo plant, including its roots, bark, stems, leaves, and flowers. It also explains how each part of this plant is adapted to survive in arid environments.

Student view

Overview (/study/ap 422- cid- 755105/o



Rights of use

Interactive 2. Adaptations of Gila Monster to a Hot Desert Biome.

More information for interactive 2

An interactive photograph features a Gila monster resting on the ground. It has a stocky body with a thick tail, and its body surface is covered with bumpy scales. The body is orange with patches of black. It has a broad, blunt head with a prominent jaw and four legs with sharp claws.

The photograph has five plus signs, representing interactive hotspots. Selecting a hotspot reveals a description of the corresponding part.

Hotspot on mouth reads, Venom contains toxins that can cause intense pain and swelling, making it a strong creature to encounter in the wild.

Hotspot on jaw reads, Powerful jaws and venomous saliva, which it uses to overpower its prey and protect itself from predators.

Hotspot on body reads, Slow metabolic rate allowing it to go for long periods without food and water.

Hotspot on skin reads, Skin is covered in bumpy scales, which help it retain moisture.

Hotspot on tail reads, Unique ability to store fat in its tail helping it survive long periods of time without food.

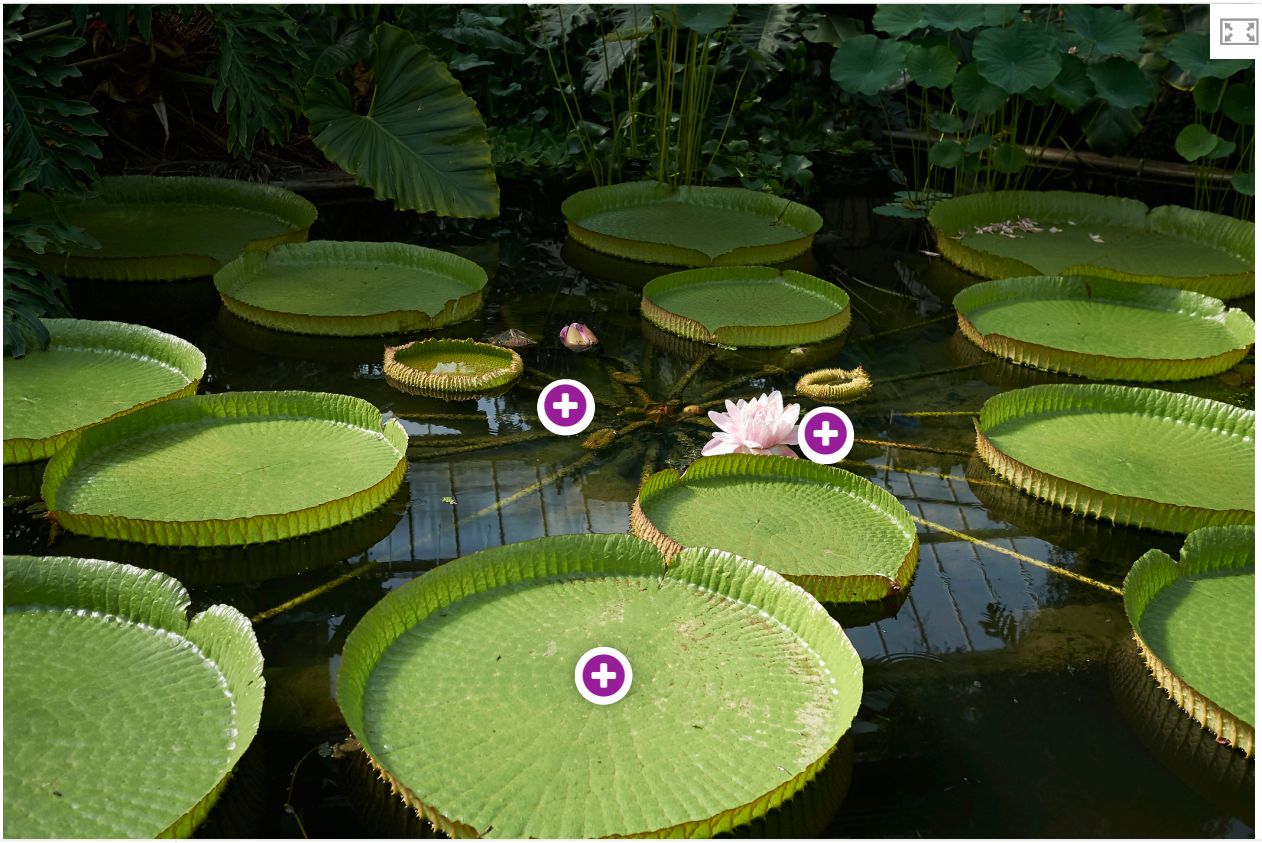
Student view

Overview (/study/ap 422-cid-755105/o

This photograph helps users understand the physical features of the Gila monster, along with its physiological traits and adaptations for moisture retention and food storage.

Adaptations to life in tropical rainforests

Rainforests are one of the most biologically diverse biomes on the planet, and are found in tropical regions around the equator. These forests are typically characterised by high levels of rainfall and warm temperatures throughout the year. This creates a humid and moist environment that is ideal for supporting a wide range of plant and animal species. The incredible diversity of plant life in the rainforest also supports an equally diverse range of animal species. Let us understand the adaptations of a plant and animal species that thrive in such harsh conditions (**Interactive 3** and **Interactive 4**).



Rights of use

Interactive 3. Adaptations of Giant Amazon Water Lily to the Amazon Rainforest.

More information for interactive 3

An interactive photograph depicts a giant Amazon water lily growing in a water body. The leaves of the lily are circular, flat, and have curled edges, floating above the water's surface. These leaves are connected to a central root system. A flower blooms in the middle of the plant.

Student view

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The photograph has three plus signs, representing interactive hotspots. Selecting a hotspot reveals a description of the corresponding part.

Hotspot on leaf reads, Large circular leaves, which can grow up to 3 metres in diameter are covered in a waxy coating that helps them repel water, allowing them to stay afloat on the surface of the water.

Hotspot on flower reads, The plant's large flowers open at night and emit a strong fragrance to attract pollinators.

Hotspot on the center of the plant (Near root) reads, Unique root system that allows it to anchor itself to the muddy bottom of the river and extract nutrients from the nutrient-rich soil.

This photograph helps users understand the unique adaptations of the giant Amazon water lily, including its leaf structure, flower behavior, and root system, which enable it to thrive in its aquatic environment.

Interactive 4 includes some adaptations of the harpy eagle. These include binocular vision to track its prey and strong talons to crush its prey.

Rights of use

Interactive 4. Adaptations of Harpy Eagle to the Tropical Rainforest.

More information for interactive 4

Student view

An interactive photograph features a Harpy eagle perched on a tree branch. It has a large white head, a hooked beak, and piercing eyes. Its chest and underside are white, while a thick black band of feathers runs across the upper chest. The eagle also has feathered legs with long, curved claws.

The photograph has five plus signs, representing interactive hotspots. Selecting a hotspot reveals a description of the corresponding part.

Hotspot on eyes reads, Binocular vision that allows it to accurately judge distances and track fast-moving prey.

Hotspot on beak reads, Sharp beak that allows it to capture and feed on large prey.

Hotspot on ear reads, Strong and sensitive hearing allowing it to detect the sounds of prey moving through the forest.

Hotspot on wings reads, Broad and strong wings that enable it to move through the dense forest canopy with ease and to glide through the air silently.

Hotspot on claws reads, Strong talons to crush the skulls of its prey.

This photograph helps users understand the unique adaptations of the Harpy eagle, including its binocular vision eyes and strong beaks and talons.

Try the activity below to learn more about the adaptations of animals that live in the rainforest.

Activity

- **IB learner profile attribute:** Thinker
- **Approaches to learning:**
  - Communication skills — Using terminology, symbols and communication conventions consistently and correctly, Presenting data appropriately
  - Thinking skills — Designing procedures and models
- **Time required to complete activity:** 15 minutes
- **Activity type:** Group activity

Objective

To research and understand the different adaptations of five rainforest animals and how these adaptations help them survive in their environment.

Materials

- Internet access
- Research resources.

Instructions

1. Divide into five groups, assigning each group one of the following rainforest animals: sloth, blue dart frog, green anaconda, chimpanzee and toucan.
2. In your groups research your assigned animal and identify at least three adaptations that help them survive in the rainforest.
3. Create a visual presentation to share with the class, highlighting the adaptations of your assigned animal and how they help them survive in the rainforest.
4. After each presentation, ask questions and discuss the similarities and differences in the adaptations of the different animals.
5. Conclude by reflecting on what you have learned and how these adaptations demonstrate the incredible diversity of life in the rainforest.

5 section questions

B4. Form and function: Ecosystems / B4.1 Adaptation to environment

Summary and key terms

- Habitat is the place where a community, species, population or organism lives.
- Organisms adapt to the abiotic environment of their habitat through various mechanisms including genetic or hereditary, physiological and behavioural adaptations.
- Example of plant adaptations in sand dunes: deep-root systems, water-storage tissues and structures to reduce water loss. Example of animal adaptations in mangroves: salt excretion, aerial breathing and mangrove crabs that feed on decaying mangrove leaves.
- Abiotic variables such as temperature, rainfall, soil type and light affect the distribution of species.

Overview (/study/ap 422- cid- 755105/o

- The range of tolerance of a limiting factor determines the boundaries of where a species can survive.
- Coral reef formation requires a temperature of 20–30 °C, alkaline pH, clear water, high levels of light and nutrients.
- Abiotic factors such as temperature and rate of precipitation determine the distribution of terrestrial biomes such as deserts, tropical rainforests and grasslands.
- Biomes are groups of ecosystems with similar communities due to similar abiotic conditions and convergent evolution.
- Plants and animals have strong adaptations which help them survive in hot deserts and tropical rainforests.

Student view

Overview (/study/ap 422-cid-755105/o

Student view

Key terms

Review these key terms. Do you know them all? Fill in as many gaps as you can using the terms in this list.

1. refers to the natural environment in which an organism or a population lives, while refers to the various mechanisms through which organisms adjust to their habitat.
2. A is a large community of plants and animals that occupy a particular type of habitat and are adapted to the local climate.
3. Range of refers to the limits of variables that an organism can tolerate and still survive. is a key abiotic factor that plays a crucial role in determining the distribution of species in a given habitat.
4. Hot and tropical are two examples of biomes with distinct abiotic conditions and species adaptations.
5. In hot deserts, where temperatures can exceed 45 °C and precipitation is , plants and animals have evolved strategies to water.
6. In contrast, tropical rainforests are characterised by rainfall, which supports a diverse array of plant and animal life. Plants in the rainforest have evolved strategies to compete for sunlight and nutrients, such as growing to reach the canopy or having leaves to capture sunlight.
7. In summary, organisms living in a habitat adapt to their through various mechanisms, which help them to survive within their range of tolerance for abiotic variables.

These adaptations are important for the formation of and biomes, which are characterised by specific abiotic variables that determine the range of organisms that can survive in them.

adaptation | scarce | tolerance | Habitat | ecosystems | Temperature | broad | abundant | conserve | deserts | rainforests | environment | biome | abiotic | tall

Check

Overview (/study/app/422-cid-755105/o

Interactive 1. Adaptation to Environment.

B4. Form and function: Ecosystems / B4.1 Adaptation to environment

Checklist

What you should know

After studying this subtopic you should be able to:

- Define habitat as a place in which a community, species, population or organism lives.
- Define adaptation and discuss various ways that organisms have adapted to the abiotic factors of their habitat particularly the sand dunes and mangrove swamp.
- Explain how abiotic variables affect a species distribution and contribute to its range of tolerance.
- Use transect data to correlate the distribution of an organism using sensors and data loggers.
- State the conditions required for coral reef formation.
- Describe how abiotic factors act as the determinants of terrestrial biome distribution.
- Recognise biomes as groups of ecosystems with similar communities due to similar abiotic conditions and convergent evolution.
- State the adaptations to life in hot deserts and tropical rainforest.

Practical skills

Once you have completed this subtopic, go to Practical 7: Measuring percentage cover to assess the distribution and abundance of plants in a habitat (/study/app/bio/sid-422-cid-755105/book/measuring-percentage-cover-id-46706/) in which you will use a quadrat to systematically sample a plant species.

Section Assign

Student view

Investigation

- **IB learner profile attribute:** Thinker
- **Approaches to learning:** Research – Evaluating information sources for accuracy, bias, credibility and relevance
- **Time required to complete activity:** 15 minutes
- **Activity type:** Group activity

Your task

To gain a deeper understanding of the adaptations and habitats of species in a particular biome by simulating the feeding adaptations of animals, using chopsticks.

Materials

- Selection of items to represent types of foods available in a particular biom, e.g. dry pasta, seeds, crisps or chips, coins, beads of different sizes, etc.
- Various ‘grabbing’ devices, such as chopsticks, tweezers, toothpicks, pipe cleaner pieces, tongs, forceps or similar
- Containers
- Stopwatch or timer
- Notepad.

Procedure

1. Divide into small groups, and assign each group a specific biome to study (e.g. rainforest, desert, grassland, etc.).
2. In your groups, gather the items that represent types of foods available in your assigned biome.
3. Using any one of the grabbing devices, simulate the feeding adaptations of animals in your assigned biome by picking up food items from one container and dropping them in another.
4. Set a time of 1 minute for the activity.

Overview (/study/ap 422-cid-755105/o

5. The teacher will record the number of objects lifted in 1 minute by each group in a notepad.
6. Once all groups have finished the activity, check for the group who could lift the most objects in one minute.
7. Discuss how the grabbing device used by the winning team helped them win.
8. Have a discussion on how the feeding adaptations of animals in each biome are shaped by the types of foods available in that habitat, and how the abiotic factors of a biome influence the adaptations of species that live there.

Questions

- What types of adaptations did you observe when using the grabbing device to simulate the feeding adaptations of animals in your assigned biome?
- How are the adaptations of animals in your assigned biome shaped by the types of foods available in that habitat?
- What abiotic factors of your assigned biome do you think influenced the adaptations of species that live there?

B4. Form and function: Ecosystems / B4.1 Adaptation to environment

Reflection

Section Student... (0/0) Feedback Print (/study/app/bio/sid-422-cid-755105/book/reflection-id-46879/print/) Assign

Teacher instructions

The goal of this section is to encourage students to reflect on their learning and conceptual understanding of the subject at the end of this subtopic. It asks them to go back to the guiding questions posed at the start of the subtopic and assess how confident they now are in answering them. What have they learned, and what outstanding questions do they have? Are they able to see the bigger picture and the connections between the different topics?

Students can submit their reflections to you by clicking on 'Submit'. You will then see their answers in the 'Insights' part of the Kognity platform.

Student view

Reflection

Overview (/study/ap 422- cid- 755105/o

Now that you've completed this subtopic, let's come back to the guiding question introduced in The big picture (/study/app/bio/sid-422-cid-755105/book/big-picture-id-43536/).

- How are the adaptations and habitats of species related?
- What causes the similarities between ecosystems within a terrestrial biome?

With these questions in mind, take a moment to reflect on your learning so far and type your reflections into the space provided.

You can use the following questions to guide you:

- What main points have you learned from this subtopic?
- Is anything unclear? What questions do you still have?
- How confident do you feel in answering the guiding questions?
- What connections do you see between this subtopic and other parts of the course?

⚠ Once you submit your response, you won't be able to edit it.

0/2000

Submit

Rate subtopic B4.1 Adaptation to environment

Help us improve the content and user experience.

☆ ☆ ☆ ☆ ☆

Student view