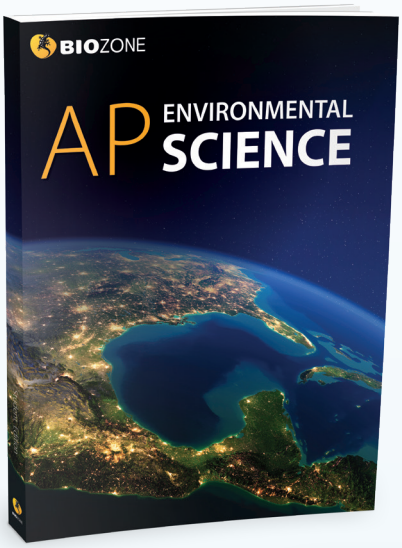
BIOZONE

AP ENVIRONMENTAL SCIENCE

FREE
SAMPLE
FOR CLASSROOM TRIAL

AP Environmental Science



BIOZONE's new AP Environmental Science is a dedicated title to address the new APES CED. Using current case studies and data, **BIOZONE**'s **AP Environmental Science** emphasizes the application of knowledge to understanding the Earth's systems and identifying and analyzing environmental problems and their solutions. This easily navigated resource addresses the two essential components of the course framework: science practices and course content. Its interdisciplinary approach and highly visual format encourage students to engage fully with the principles, ideas, and methodologies required to understand the natural world.

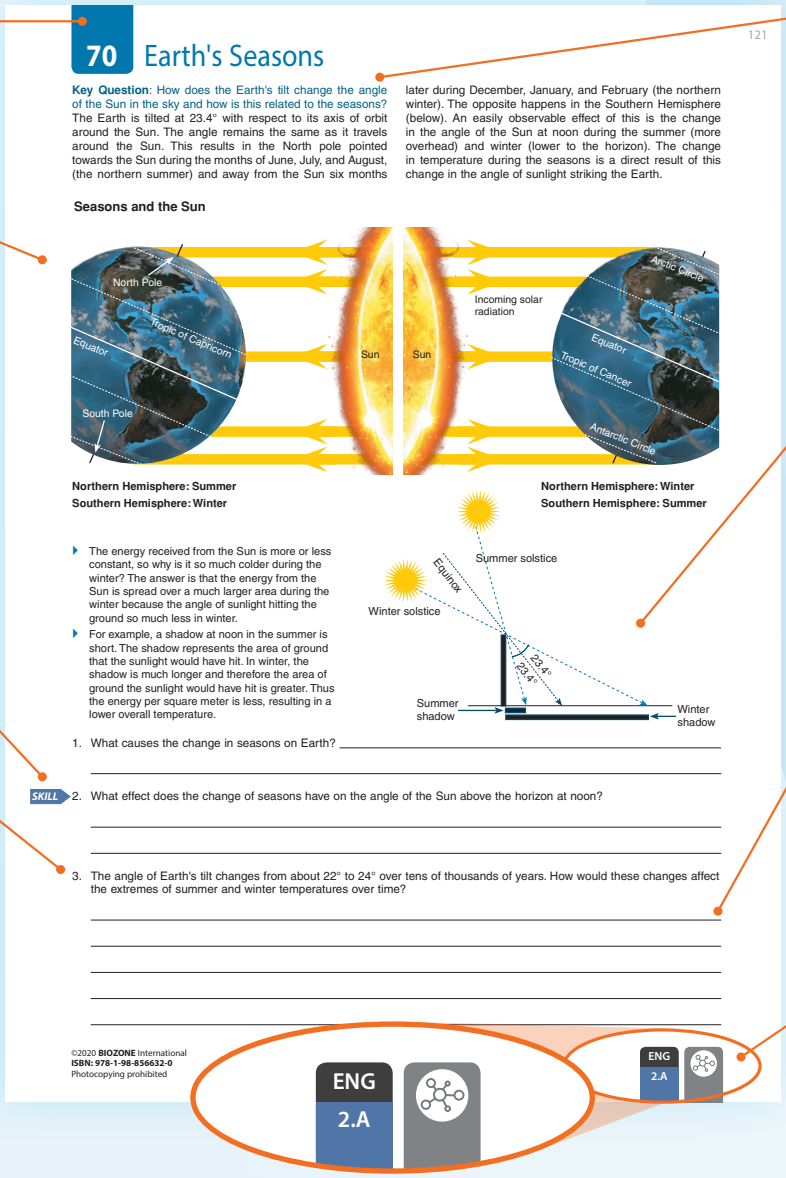
Activity Page

Activity number
Activities are numbered to make navigation through the book easier.

Comprehensive diagrams provide an engaging, highly visual delivery of the important information.

Data driven activities
Answering questions based on the analysis and interpretation of real world data develops core skills in evidence-based reasoning and logical thinking. Communicating these analyses effectively builds skills in literacy.

Critical thinking questions
A direct questioning style helps students to easily identify what is being asked. A wide range of tasks, including free response, data analysis and presentation, and interpretation and evaluation of evidence, scaffold student learning to build confidence and competence.



121

70 Earth's Seasons

Key Question: How does the Earth's tilt change the angle of the Sun in the sky and how is this related to the seasons?

The Earth is tilted at 23.4° with respect to its axis of orbit around the Sun. The angle remains the same as it travels around the Sun. This results in the North pole pointed towards the Sun during the months of June, July, and August, (the northern summer) and away from the Sun six months later during December, January, and February (the northern winter). The opposite happens in the Southern Hemisphere (below). An easily observable effect of this is the change in the angle of the Sun at noon during the summer (more overhead) and winter (lower to the horizon). The change in temperature during the seasons is a direct result of this change in the angle of sunlight striking the Earth.

Seasons and the Sun

Northern Hemisphere: Summer
Southern Hemisphere: Winter

Northern Hemisphere: Winter
Southern Hemisphere: Summer

- The energy received from the Sun is more or less constant, so why is it so much colder during the winter? The answer is that the energy from the Sun is spread over a much larger area during the winter because the angle of sunlight hitting the ground so much less in winter.
- For example, a shadow at noon in the summer is short. The shadow represents the area of ground that the sunlight would have hit. In winter, the shadow is much longer and therefore the area of ground the sunlight would have hit is greater. Thus the energy per square meter is less, resulting in a lower overall temperature.

1. What causes the change in seasons on Earth? _____

SKILL 2. What effect does the change of seasons have on the angle of the Sun above the horizon at noon?

3. The angle of Earth's tilt changes from about 22° to 24° over tens of thousands of years. How would these changes affect the extremes of summer and winter temperatures over time?

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ENG 2.A

Key question
Each activity has a key question summarizing its primary focus. It helps students to understand where the activity's emphasis lies.

Content organization
Logically organized content makes it easier for students to access and engage with the information.

Write-on answers
Students write their answers directly onto the page. This becomes their record of work and helps them when it is time to review for tests and exams.

Activity coding system
Tab codes indicate online support via BIOZONE's Resource Hub and identify the key science practices and big ideas that spiral across topics and units.

www.theBIOZONE.com/apes

Learning Objectives

4. Earth Systems and Resources

Developing understanding

Content: This unit explores Earth systems and the resources that support life, including the geological changes that occur at the boundaries of tectonic plates, the geological structures that result from these changes, soil, the atmosphere, and the role of the Sun's energy in the Earth's climate systems.

Skills: This unit emphasizes skills in analyzing and interpreting visual models and representations of Earth processes. Through analysis and interpretation you will develop an ability to explain relationships between Earth systems.

4.1 Plate tectonics ..... activities 58 - 61

☐ 1. Describe the basic structure of the Earth and relate its internal structure and composition to the processes that we see occurring at the Earth's surface.

☐ 2. Describe the geological changes and events occurring at different types of plate boundaries. Include reference to convergent boundaries, divergent boundaries, and transform boundaries. Describe the geological features associated with each of these types of boundary and their characteristics.

☐ 3. Explain how the theory of plate tectonics accounts for plate movement. Use maps showing the global distribution of plate boundaries to determine the location of volcanoes, island arcs, earthquakes, hotspots, and faults. Interpret data from active plate boundaries to visualize plate movements and explain the events occurring there, including earthquakes and volcanoes.

4.2 Soil formation and erosion..... activities 62 - 64

☐ 4. Describe the characteristics and formation of soil. Explain how soils are categorized by horizons based on their composition and organic material. Discuss the influence of the parent rock type and climate on soil type.

☐ 5. Explain how soils can be eroded by wind or water. Describe feedback mechanisms operating in the loss of soil and explain teh role of riparian vegetation in reducing soil loss and maintaining high water quality.

4.3 Soil composition and properties ..... activity 65

☐ 6. Describe similarities and differences in the properties of different soil types. These properties include water holding capacity, which (in turn) is influenced by particle size and composition. Explain how the properties of a soil affect soil productivity and fertility.

☐ 7. Use a soil texture triangle to identify and compare soil types based on their percentage of clay, silt, and sand.

4.4 Earth's atmosphere ..... activity 66

☐ 8. Describe the structure and composition of the Earth's atmosphere, including the relative abundance of the major gases. Identify the layers of the atmosphere and describe the basis for how they are determined.

4.5 Global wind patterns ..... activity 67

☐ 9. Explain the causes of the Earth's patterns of atmospheric circulation, including reference to the differential heating of the atmosphere and the rotation of the Earth itself. Describe the Coriolis effect and explain its cause. Use the tricellular model to describe patterns of atmospheric circulation and explain global climate patterns.

4.6 Watersheds..... activity 68

☐ 10. Explain what is meant by a watershed (also called a catchment or drainage basin). Identify the characteristics used to describe watersheds. Describe how these characteristics vary and explain their role in shaping the drainage system and the water it carries. Explain the different scales at which we can identify watersheds and describe the characteristics of different watersheds using maps and photographs.

4.7 Solar radiation & the seasons ... activities 69 - 70

☐ 11. Identify the Earth's main source of energy. Describe how the amount of insolation depends on season and latitude.

☐ 12. Describe the relationship between the angle of the Sun's rays and the intensity of solar radiation. Explain how this relationship accounts for the differences in the solar radiation received per unit area between the equator and the poles. Investigate this for yourself using a flashlight angled to illuminate graph paper. Recall that it is the difference in solar energy received at different latitudes that drives atmospheric circulation.

☐ 13. Using illustrations or diagrams, explain the cause of the Earth's seasons. Explain why the daylight hours and the solar radiation received at a particular location on the Earth's surface vary with the seasons.

4.8 Earth's geography and climate ..... activity 71

☐ 14. Most of the Earth's atmospheric processes are driven by input of energy from the Sun but weather and climate are also affected by geological and geographic factors. Describe some of these influences, including the occurrence of rain shadows and the effect of ocean currents on the weather and climate of coastal regions.

4.9 El Niño and La Niña ..... activity 72

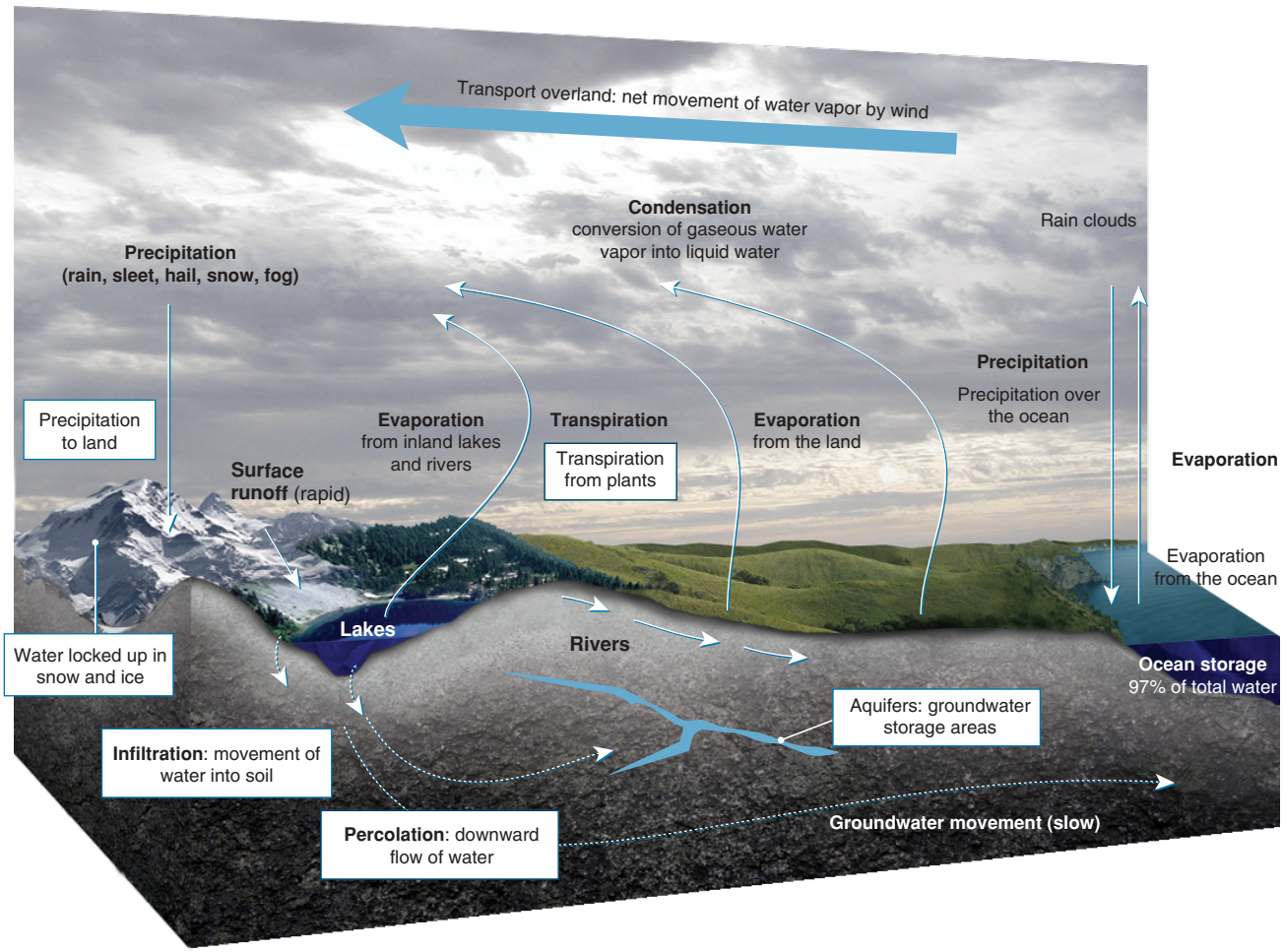
☐ 15. El Niño and La Niña are phenomena associated with changing ocean surface temperatures in the Pacific Ocean. They are part of a larger phenomenon called the El Niño-Southern Oscillation (ENSO). El Niño and La Niña are considered the ocean part of ENSO, while the Southern Oscillation is its atmospheric changes. Describe the environmental changes and effects that result from El Niño and La Niña events, including global changes to rainfall, wind, and patterns of ocean temperature and circulation.

☐ 16. Interpret diagrams of El Niño and La Niña climate cycles to account for the contrasting effects of ENSO on different geographic locations.

16 The Hydrologic Cycle

Key Question: What processes are involved in cycling water from the oceans to the land and back in the hydrologic cycle?

The **hydrologic cycle** (water cycle), collects, purifies, and distributes the Earth's fixed supply of water. Besides replenishing inland water supplies, rainwater causes erosion and is a major medium for transporting dissolved nutrients within and among ecosystems. On a global scale, evaporation (conversion of water to gaseous water vapor) exceeds precipitation (rain, snow etc.) over the oceans. This results in a net movement of water vapor (carried by winds) over the land. On land, precipitation exceeds evaporation. Some of this precipitation becomes locked up in snow and ice but most forms surface and groundwater systems that flow back to the sea, completing the major part of the cycle. Over the sea, most of the water vapor is due to evaporation alone. However on land, about 90% of the vapor results from plant transpiration. Animals (particularly humans) intervene in the cycle by utilizing the resource for their own needs.



1. Identify two ways in which water returns to the oceans from the land:

   (a) _____ (b) _____

SKILL 2. Describe three ways in which humans may intervene in the water cycle, and the effects of these interventions:

   (a) _____

   _____

   (b) _____

   _____

   (c) _____

   _____

3. Identify the main reservoir for water on Earth: _____

4. Identify the main reservoirs for fresh water: _____

5. Describe the important role of plants in the cycling of water through ecosystems: _____

   _____

ERT 2.B

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70 Earth's Seasons

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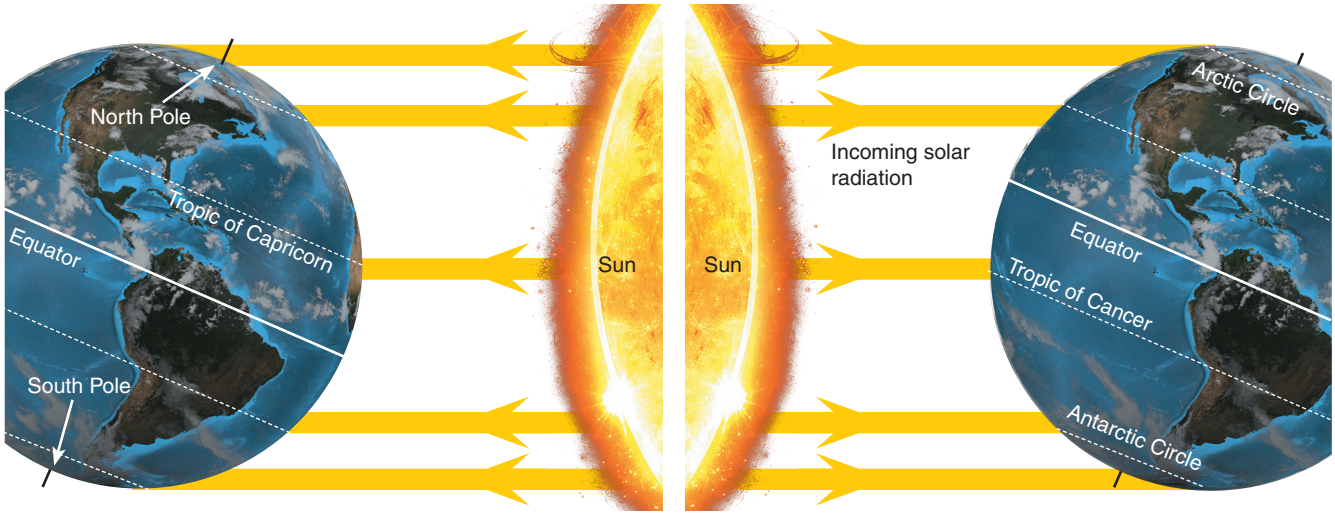
Seasons and the Sun



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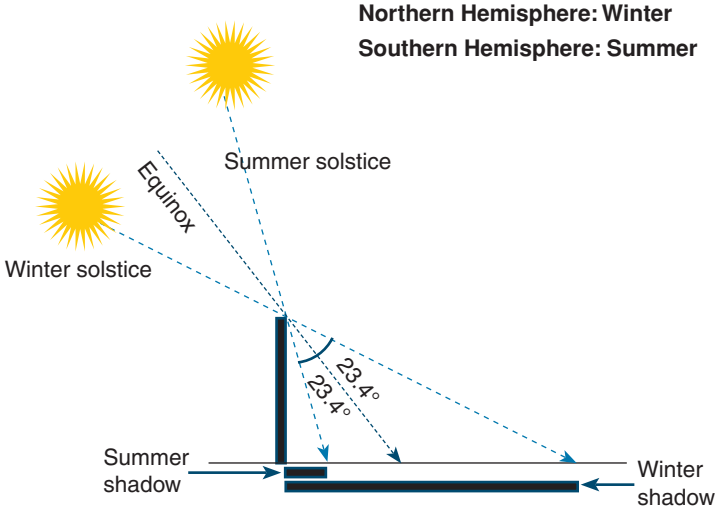

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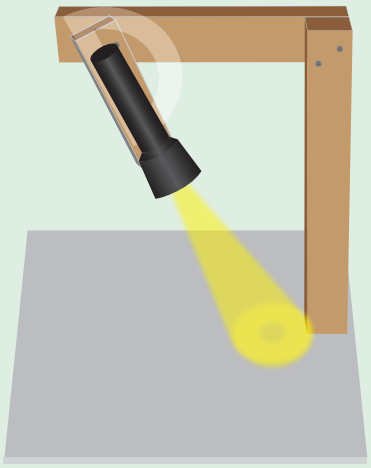
INVESTIGATION: 4.3 Measuring Energy

See appendix for equipment list.

1. Using a stand and protractor to measure angle, set up a flashlight pointing straight down (90° angle) at a piece of grid paper from a distance of 30 cm (a darkened room works best) as shown in the diagram below:

2. Draw around the illuminated part of the grid paper and then use the grid paper to help find the area illuminated.
3. Area illuminated (90°): _____
4. Tilt the clamp stand to a 66° angle, measuring 30 cm from the center of the flashlight front along the angle to the center of the illuminated area on the grid paper. Again, draw around and calculate the area of grid paper illuminated.



5. Area illuminated (66°): _____
6. Repeat this procedure for 45° and 33°.

   Area illuminated (45°): _____ Area illuminated (33°): _____

4. (a) How does the area of graph paper illuminated change with the angle of the torch? _____

   _____

   _____

   (b) For each angle of the torch, calculate the amount of light energy (watts) received per cm^2 on the grid paper. You could use a light meter to measure the light output of the flashlight if you don't know it or (assuming its output is constant) start with a general light output of 3 W. (Hint if the light bulb is a 3 W bulb, each square cm of paper is receiving how many watts?). Write you answers next to your outlines on the graph paper.

   (c) Attach all your graph paper records to this page.

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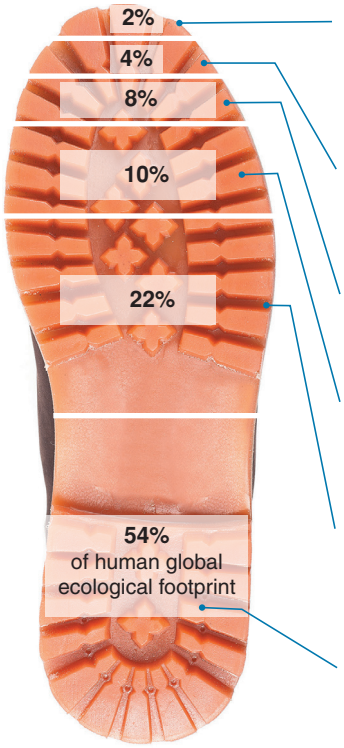
86 Ecological Footprints

Key Question: How can we use the concept of an ecological footprint to compare human resource demand with the Earth's capacity to regenerate those resources.

An ecological footprint is often expressed as the number of Earths required to sustain the human population or the amount of space (in hectares) needed to sustain one individual. The calculation of the footprint is based on the amount of land required to produce the amount of food and energy for a human and the amount of land required to absorb the carbon dioxide and other waste emissions produced. Currently the global ecological footprint is about 1.75 Earths, with each human requiring about 2.7 global hectares (globally standardized hectares with a world average productivity)

Components of an ecological footprint



Built-up land includes all the land required for human settlement, transport, industry, and energy.

Forest land is a measurement of the annual harvest of fuelwood and timber compared to the rate of forest replenishment.

Grazing land includes land used to support livestock in addition to livestock feed from cropland.

Fishing grounds are calculated based on the annual primary production required to sustain harvested species.

Cropland consists of all the lands required to produce crop products including livestock feed, oil crops and rubber.

Carbon footprint land is the land required to absorb the carbon dioxide waste produced by human activities and natural events (such as volcanic eruptions).

The calculations required to produce an ecological footprint can be simplified into two equations. The first calculates the land required to produce the food and materials used by a person, and the second calculates the amount of land required to absorb carbon dioxide waste. The sum of the two equations gives a very general measure of the ecological foot print per person.

Equation 1

$$\textit{per capita} \text{ land requirement for food production (ha)} = \frac{\textit{per capita} \text{ food consumption (kg/yr)}}{\text{mean food production per hectare (kg/ha/yr)}}$$

Equation 2

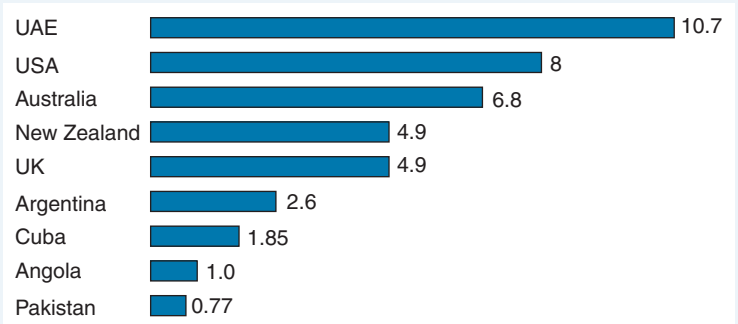
$$\textit{per capita} \text{ land requirement for absorbing } CO_2 \text{ (ha)} = \frac{\textit{per capita } CO_2 \text{ production (kg C/yr)}}{\text{net carbon fixation per hectare (kg C/ha/yr)}}$$

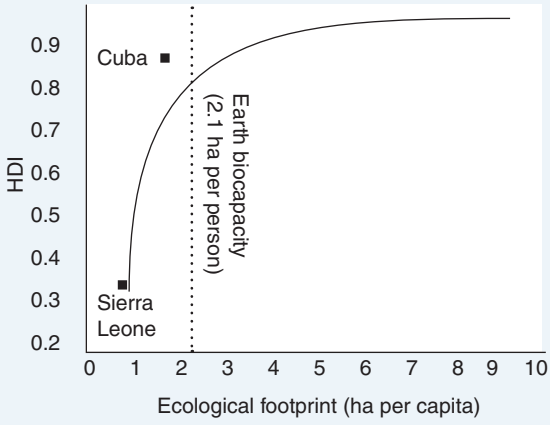
A global ecological footprint can be calculated by multiplying the answer by the global human population.

Ecological footprints and human development

The human development index (HDI) is an index based on national income, education, and life expectancy. The higher the index (from 0-1), the better a country's living conditions and development.

Ecological footprint for selected countries (hectares per capita)





SKILL

1. Describe the relationship between a country's HDI and its ecological footprint. Suggest a reason for this relationship:

_____

_____

_____

2. Calculate the area (in hectares) required to support the world population (6.7 billion) based on the ecological footprint of the countries below. Compare this to the size of the planet (13.4 billion productive hectares).

(a) USA: _____ (b) UK: _____

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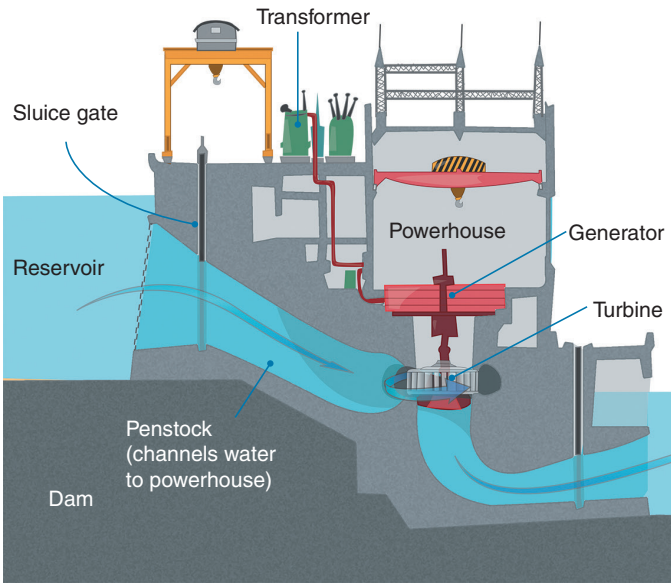
105 Hydroelectric Power

Key Question: How are hydroelectric dams used to provide electricity with little air pollution? What are the environmental effects of hydroelectric dams and can they be justified?

Hydroelectricity accounts for around 20% of global electricity production. Electricity is produced by utilizing the kinetic energy of water stored in reservoirs behind dams. Water is directed along pipes into the powerhouse where it drives turbines connected to a generator. The larger the volume of water and the further it has to fall, the greater the amount of energy it contains. Large dams can therefore produce large amounts of electricity. The generation of electricity itself produces no CO_2 emissions or other air pollution, but the construction of the dam requires massive amounts of energy and labor and often requires river diversions. Construction of large hydroelectric dams is controversial because creating a reservoir behind the dam often requires the submergence of towns and land. Dams constructed inefficiently can also fill up with silt and gradually reduce in generation capacity.



Hydroelectricity	
Advantages	**Disadvantages**
High net energy gain	High construction costs
High efficiency	River diversions during and often after construction
Produce reservoirs that can be used for recreation and irrigation	High initial CO_2 production from rotting material in reservoir
Provide flood control	Dams Interfere with fish migration
Long life spans	Drown river valleys behind dam

Using hydroelectric power

The mass of water and the distance it falls are important in determining the amount of electricity that can be produced. The power (the energy produced per second) produced by a hydroelectric power plant can be approximated from the mass of water flowing past the turbine and the height of its fall.

Water doesn't have to be stored in a dam for a hydroelectric power plant to work. Water can directed to flow past the turbine and simply use the force of the flowing water (called **run-of-the-river**). The dam is usually there either to divert water towards the intake or powerhouse or to store water in case of lower river levels.

Pumped storage is a useful way of storing excess energy in hydroelectric plants. During off-peak times, water flowing through the plant is used to pump water to a higher storage pond. During high demand, this water can be run through a separate powerhouse to provide extra electricity to the local grid.

1. (a) Explain how hydroelectric dams are used to generate electricity: _____

_____

_____

_____

(b) Describe the relationship between water volume, height of the dam and electricity production:

_____

_____

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The power (in watts) that can be delivered by a hydroelectric power plant when water is stored in a dam can be calculated using the equation right. Where water is not stored in a dam and a run-of-the-river turbine is used, the equation for power produced is depends on the radius of the water intake and the velocity and density of the water.

$$P = h \times g \times Q \times \eta$$

P = power (watts W), h = height (m), Q = flow rate (kg/s), g = the strength of gravity (9.8 N/kg), and
η = efficiency of the power plant (%).

2. (a) Calculate the maximum power produced by a power plant with a water fall of 30 m and a flow rate of 10,000 kg/s:

   (b) If the efficiency of the plant is 80% what is the actual power produced? _____

   (c) Why is efficiency important? _____

3. (a) Explain how pumped-storage hydroelectric power can help electricity production during periods of high demand:

   (b) Explain why pumped-storage hydroelectric power is an efficient use of electricity resources:

4. Explain why run-of-the-river type power plants are subject to highly variable power output:

5. Using specific examples, describe some advantages and disadvantages of large scale hydroelectric dams:

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Issues with hydroelectric power

The Yangtze River

All images NASA except where indicated

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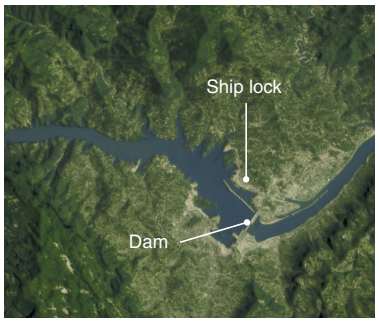
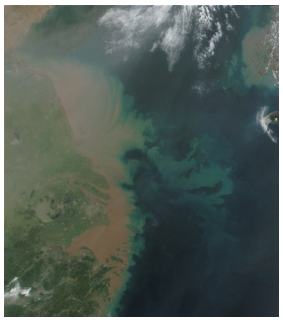


2006



Silt from Yangtze River

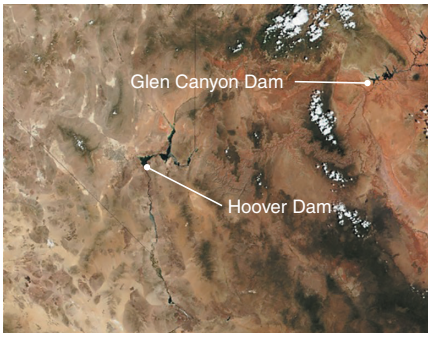
BS Thumer Hof

Siberian crane

The **Three Gorges Dam** (above) on the Yangtze river, China, is 2.3 km wide and 101 m high, with a reservoir 660 km long. It has a generation capacity of 22,500 MW. The construction of the Three Gorges Dam caused the river water level to rise by 100 m, and required the relocation of 1.2 million people.

Dams reduce flood risk by regulating downstream water flows. However, they also prevent deposition of fertile silts. Flooding land behind the dam to create a reservoir seriously disrupts the feeding areas of wading birds.

The Colorado River



A number of dams have been built on the Colorado River, which runs from Colorado to Mexico. The two largest hydroelectric dams on the river are the Glen Canyon Dam and the Hoover Dam. Together these dams have a generation capacity of over 3000 MW and provide irrigation and recreation for thousands of people. Both dams control water flow through the Colorado River and were controversial even before their construction.

The construction of **Glen Canyon Dam** effectively ended the annual flooding of the Colorado River. This has allowed invasive plants to establish and has caused the loss of many camping beaches as new silt is trapped behind the dam. The reduced flow rate of the river has severely affected native fish stocks. Controlled floods held in 1996 and 2004 have had beneficial effects on the downstream ecosystems.

Hoover Dam, which impounds Lake Mead, has a generation capacity of over 2000 MW. Water from Lake Mead serves more than 8 million people in Arizona, Nevada, and California. The dam has had a major effect on the Colorado delta, which has reduced in size from around 800,000 hectares to barely 73,000 hectares. Native fish populations have also been reduced.

SKILL 7. Using relevant examples, provide an evaluation the following statement: "*Hydroelectric power produces clean, environmentally friendly electricity*":

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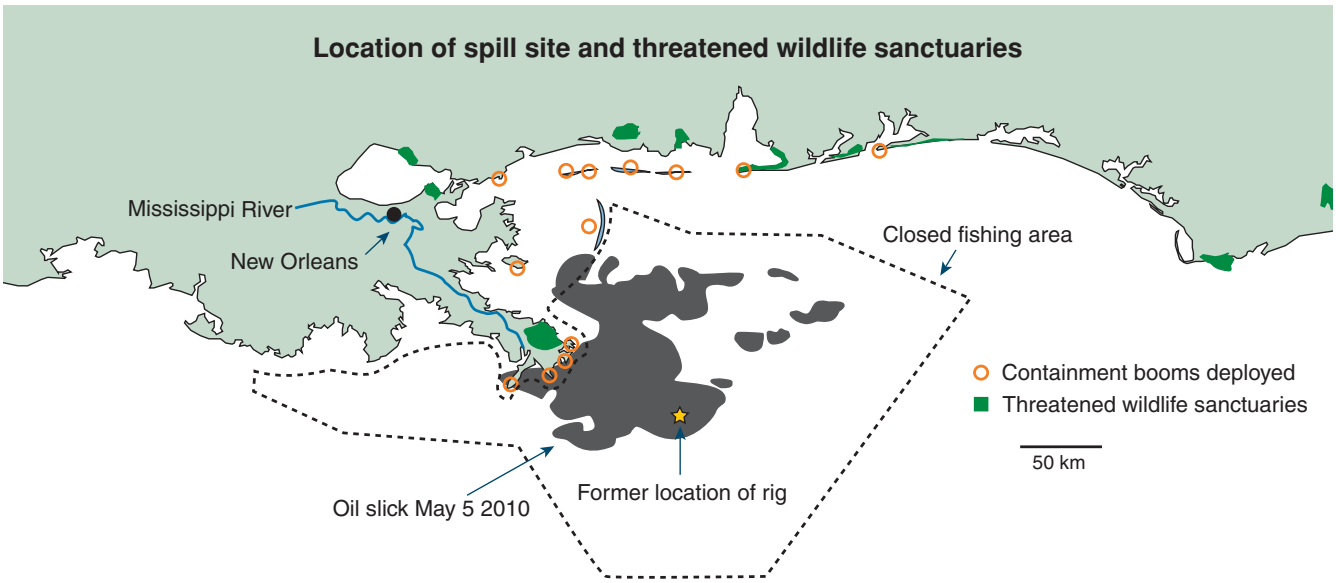
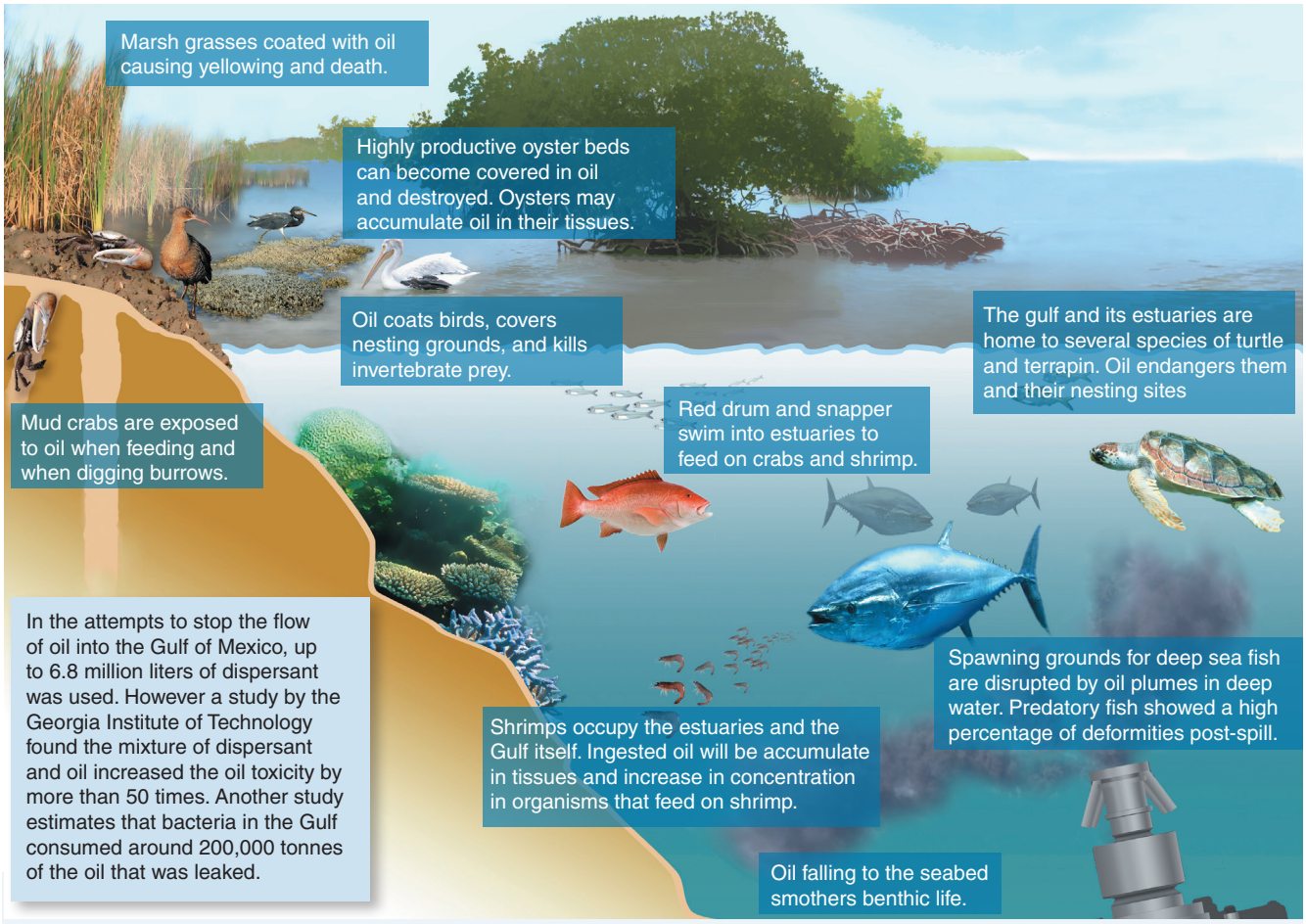
156 The Environmental Effects of Oil Spills

Key Question: What are the effects of oil spills on marine life and how do we quantify them?

The 2010 Deepwater Horizon oil spill in the Gulf of Mexico was the biggest and most disastrous oil spill in US history. It released 780,000 m^3 of oil into the Gulf, affected thousands of kilometers of shoreline, and killed tens of thousands of marine and estuarine organisms. The oil killed marshland plants and coastline erosion has increased substantially as a result. Ten years on from the disaster, the spill's long term environmental and economic effects are still being evaluated.



Effects of oil in estuaries and wetlands



Since the oil spill in April 2010, clean-up teams and researchers have collected data on the affected shorelines of Louisiana, Mississippi, Alabama, and Florida. Approximately 1770 km of shoreline showed oiling, with 354 km heavily oiled. Tarballs continue to wash ashore. Most of the impact has been on marine species, with the effects of petroleum toxicity, dispersant toxicity, and oxygen depletion causing the main damage. A NOAA study in 2012 indicated severe long term environmental effects, including the death of deep sea corals and ongoing effects on the health and reproduction of marine species.

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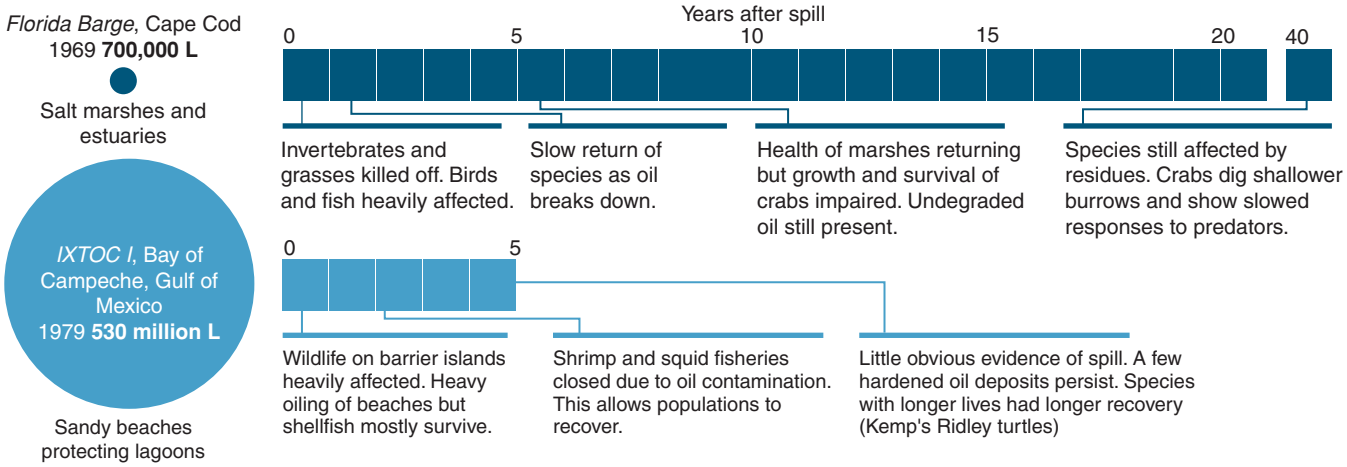
Ecosystem recovery time

Historical studies show that the rate of ecosystem recovery after an oil spill depends on the habitat, local climate and environmental conditions (such as temperature), and the type of oil spilled. To compare, the Deep water Horizon spill released 780 million L.



Blair Witherington, Florida Fish and Wildlife Conservation Commission/NOAA

Rehabilitation of marine organisms with oiling is lengthy and not always successful. The animals have to cope with the physical oiling of their bodies, petroleum toxicity, and the stress of capture, cleaning, and containment. Oil coats feathers and fur and destroys its insulating abilities, and the hydrocarbons in ingested oil can are toxic and cause immediate and long term health effects.
Image: Oiled juvenile Kemp's Ridley turtle

Louisiana GOHSEP

The heavy oiling of shorelines after the Deepwater Horizon disaster caused coastal marsh vegetation to die. Coastal habitats were assessed on the percentage of oiling on the stems of marsh vegetation. More than 1000 km of the Louisiana coastal marshland was oiled with nearly a third showing >50% stem oiling. The loss of consolidating vegetation has resulted in increased erosion along these coasts.
Image: Shore oiling, Bay Jimmy, LA.

NOAA

The Deepwater Horizon spill contaminated every habitat type occupied by marine mammals in the northern Gulf of Mexico. Marine mammals (and turtles) are exposed to oil through inhalation, ingestion (directly or by eating prey), and absorption through the skin. Surveys of dolphin species in the years following the spill indicate increased levels of fetal deformities, and liver and lung disease.
Image: Striped dolphins swim through oil.

1. (a) Describe some immediate effects of oil on the wildlife it comes in contact with: _____

(b) Describe and explain some of the longer term effects on marine and coastal communities: _____

SKILL 2. (a) Compare the extent and the recovery time for the two oil spills described at the top of the page. How do they differ?

(b) Explain why the extent of the ecological effect of a spill is not necessarily directly related of the volume of oil spilled:

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177 Ocean Acidification

Key Idea: Ocean acidification if the result of atmospheric carbon dioxide (CO_2) dissolving into ocean water in large quantities and lowering the ocean pH.

The oceans act as a carbon sink, absorbing much of the CO_2 produced from burning fossil fuels. When CO_2 reacts with water it forms carbonic acid, which decreases the pH of the oceans. This affects marine life, especially shelled organisms, which find it harder to obtain the calcium carbonate they need to build shells. Ocean acidification is relative term, referring to the oceans becoming less basic as the pH decreases.

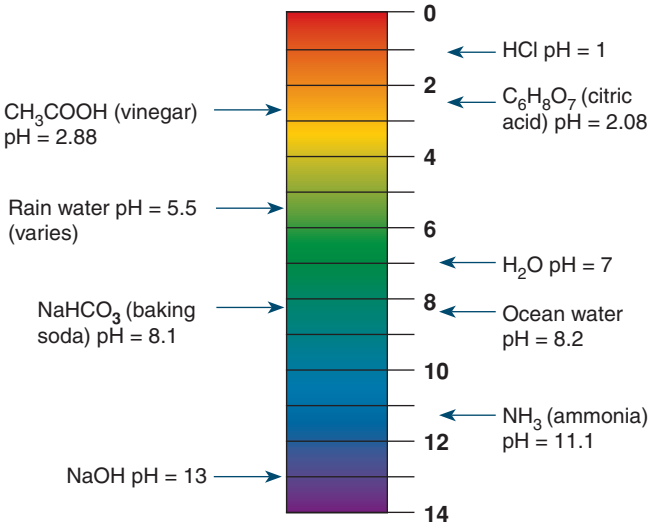
A pH comparison

An important part of talking about pH and acidity is understanding what pH is and the pH scale. pH refers tp the concentration of hydrogen ions(H^+) in solution. It is these H+ ions that affect acidity.

A neutral solution has an H^+ concentration of 1 x 10^{-7} moles per liter (mol/L) . The mole is an SI unit of measurement and refers to the number of atoms (or ions) present in a sample. One mole of hydrogen has a mass of 1 gram. Thus a neutral solution has a mass of about 1 ten millionth of the gram of hydrogen ions per liter.

Pure water neutral, but gases and ions dissolving into it can change its pH. Rain water is slightly acidic, ocean water is basic.

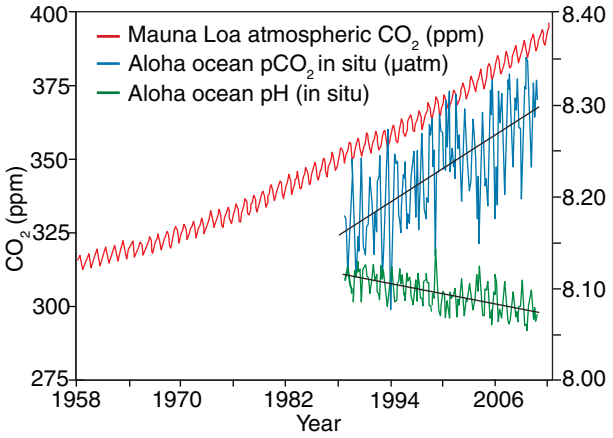
The pH scale is a logarithmic scale calculated using the negative logarithm of the H^+ concentration. Thus a neutral solution has a pH of 7. The scale shown right compares some the pH of some substances you may commonly come across.



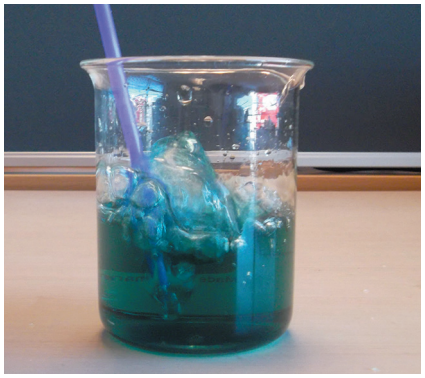
Carbon dioxide and pH

Oceans are a large reservoir of carbon because carbon dioxide from the atmosphere dissolves into them. This is evident in the graph right, which shows how the ocean constantly exchanges CO_2 with the atmosphere.

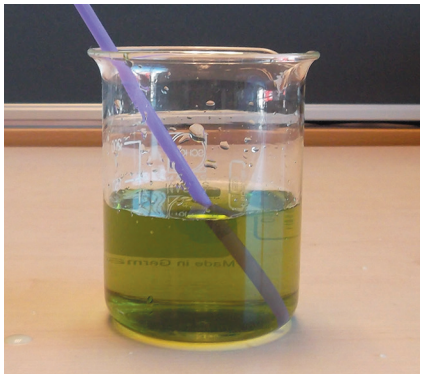
The effect of carbon dioxide on water can be seen by bubbling it through water containing a pH indicator. Bromothymol blue is an indicator that is blue in basic (alkaline) solutions, blue/green in neutral water and yellow/green in acidic solutions. Adding carbon dioxide to water containing bromothymol blue causes the solution to turn yellow/green as the carbon dioxide dissolves into the water (below).



Bromothymol blue in tap water



Bubbling CO_2 through water...



... produces an acidic solution and turns the bromothymol yellow/green.

1. (a) What do you notice about the peak and dips in ocean and atmospheric CO_2 in the Mauna Loa graph above?

   _____

   (b) What does this pattern indicate? _____

   (c) What is the trend over time in the CO_2 concentration in the atmosphere and ocean? _____

   _____

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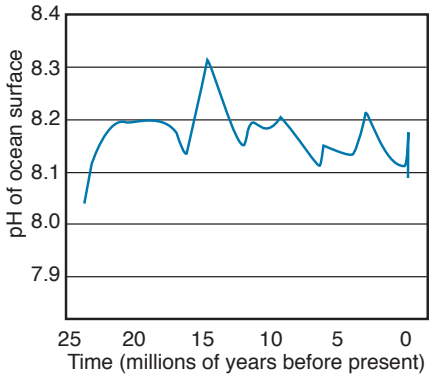
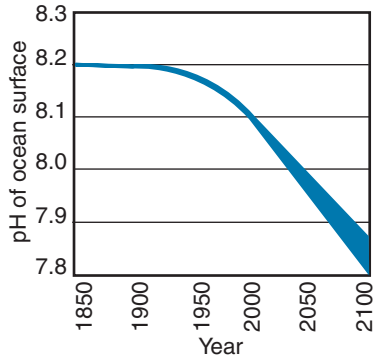
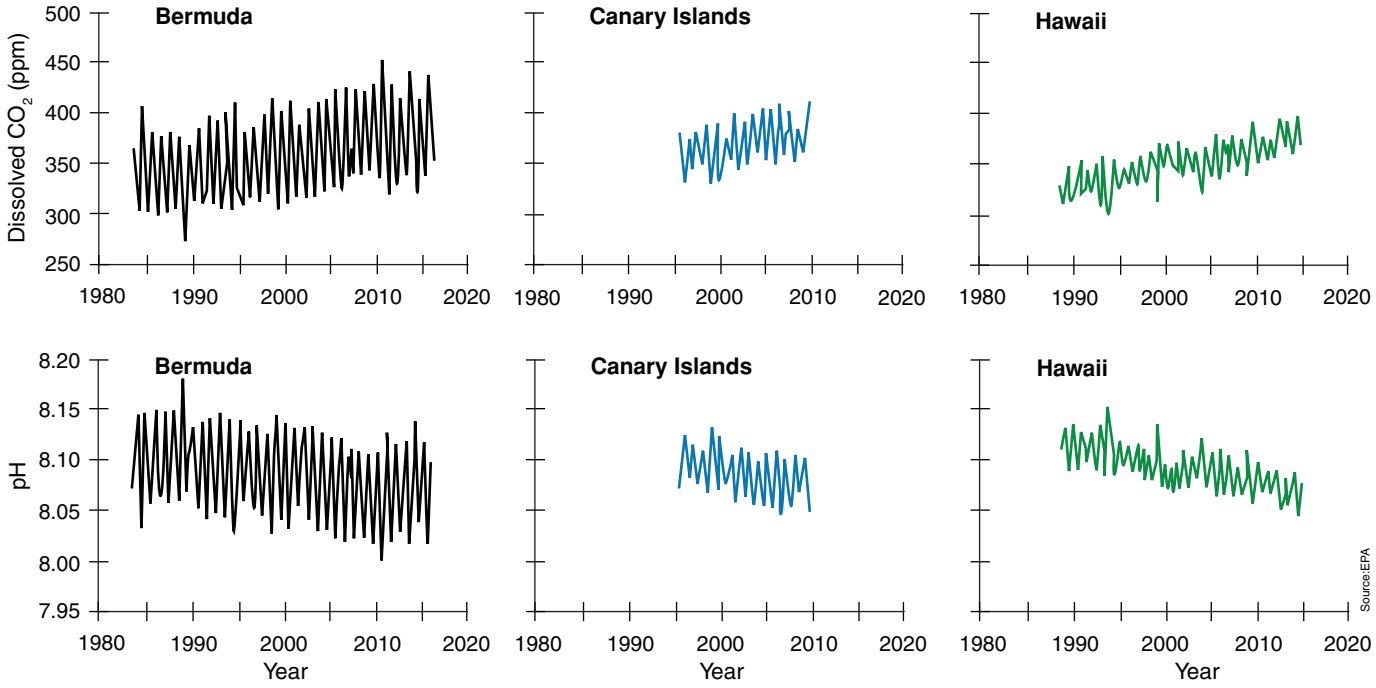
Ocean pH is about 8.2. However it has varied between 8 and 8.3 over the last 25 million years. In the last one hundred years it has dropped rapidly. It is projected to drop to a bout 7.8 over the next 100 years.





The graphs below show the effect of carbon dioxide on ocean water. The top row shows dissolved CO_2 at three locations and the bottom row shows ocean pH at the same locations. Vertical scales are the same in each case:



SKILL 2. (a) Are the oceans acidic or basic? _____

(b) What is the pattern in the data at each location? _____

_____

(c) What does this suggest about the effect of increasing dissolved CO_2 on the pH of the oceans? _____

_____

_____

3. (a) What is ocean acidification? _____

_____

_____

(b) The pH of the oceans are predicted to drop to about 7.8 by the year 2100.

i. Will this make the oceans acidic?

ii. Compare this drop in pH to the long term change: _____

_____

_____

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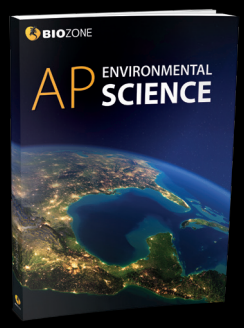

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