19.   The Carbon Cycle

The Carbon Cycle and the Biosphere

Removal of CO_2 from atmosphere	Addition of CO_2 to atmosphere
• Photosynthesis begins the storage process by converting CO_2 into sugars. • reforestation ◄	• Respiration and fermentation, processes that break down molecules to release useful energy return CO_2 to the atmosphere. • Decomposition of dead matter return CO_2 to the atmosphere • Deforestation and forest fires also pump CO_2 into the atmosphere.

All of the following exchanges occur on a short–term scale. (daily or seasonal)

CO_2

respiration

photosynthesis

deforestation,
forest fires
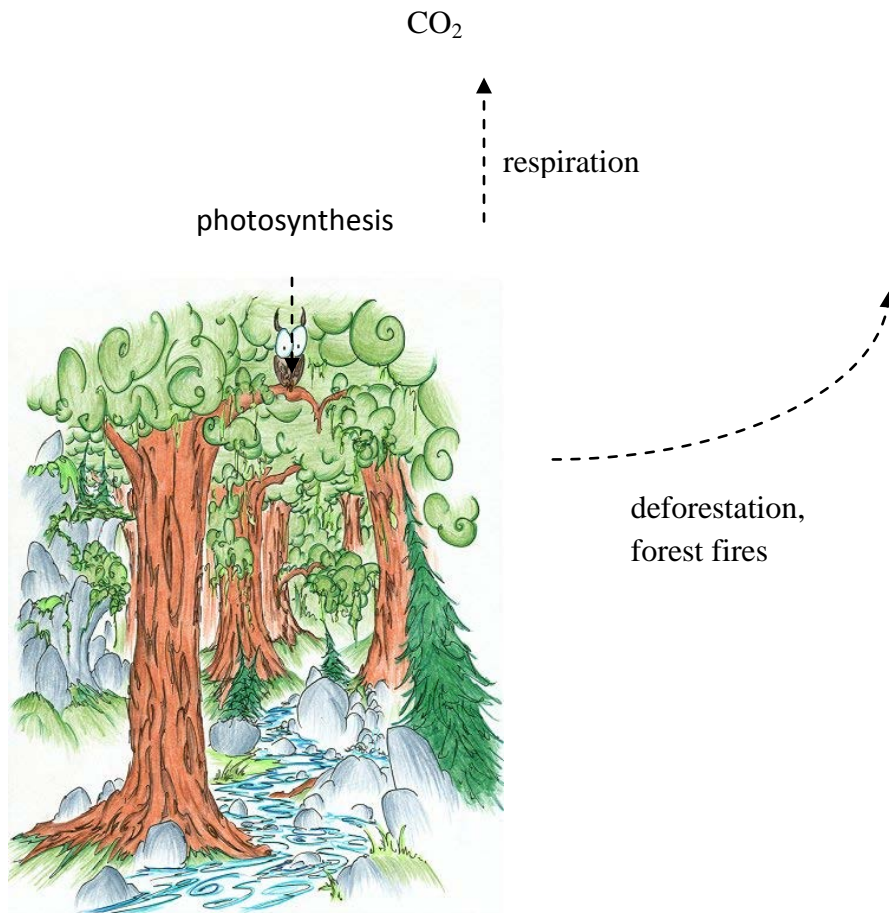
(2)   The Carbon Cycle,the Lithosphere and the Ocean
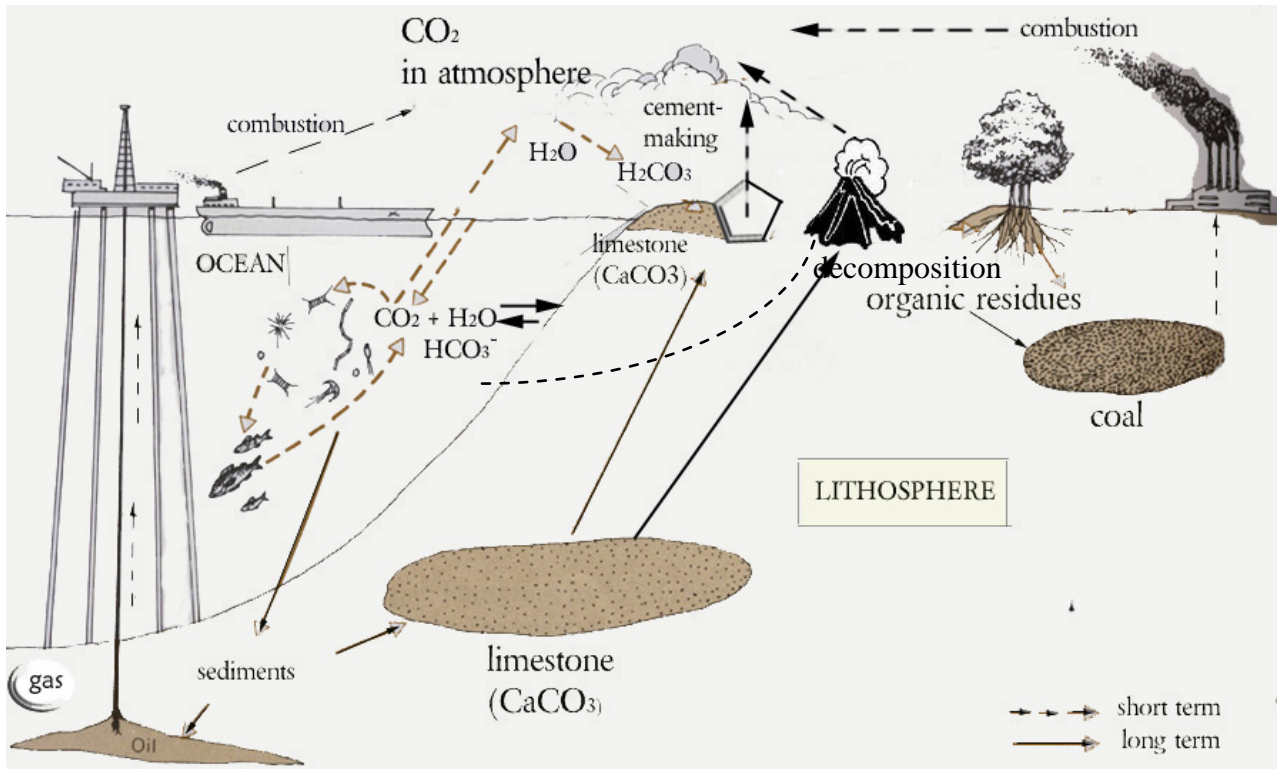
Example 1:

a)   The diagram shows four processes that remove carbon from the lithosphere or ocean
        and add it to the atmosphere as carbon dioxide. List them. Then make the table
        complete by adding three more sources of CO_2 from the biosphere.

Process adding CO_2 to atmosphere
a)

| b)From biosphere: |
| --- |
| |
| |

Example 2:

What two natural processes shown above remove CO_2 from the atmosphere? Then make the table complete by adding processes that remove CO_2, one of which is shown in the biosphere-diagram.

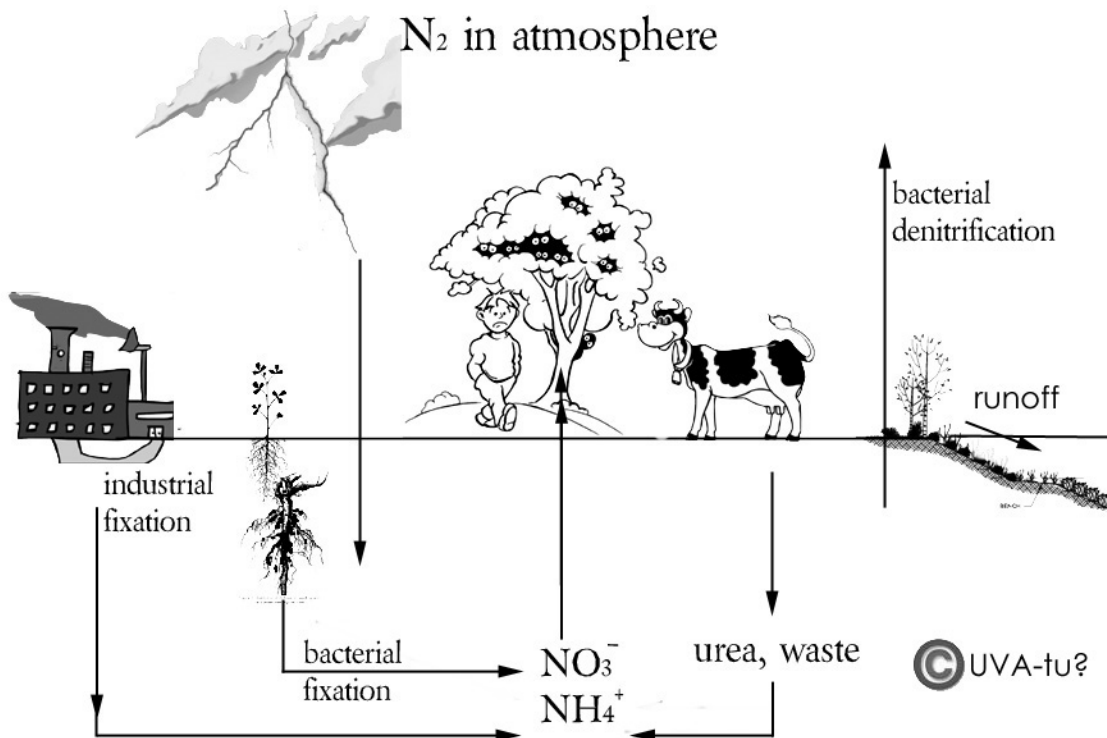| Process removing CO_2 from the atmosphere |
| --- |
| a) |
| |
| |
| b)From biosphere: |
| |
| |

<u>Exercises</u>

1.   a)   List 3 ways by which humans add carbon dioxide to the atmosphere.

     b)   In each case, list what can be done do reduce the amount of CO_2 emitted.

2.   What processes added CO_2 to atmosphere, even when there were no human beings around?

3.   Recall that the amount of carbon dioxide in the atmosphere has, for millions of years, been proportional to the average temperature on earth. How does life in general play a major role in acting like a thermostat, in that it regulates the temperature of the planet?

4.   What forest industry activity helps **remove** carbon dioxide from the atmosphere?

5.   Why does CO_2 accumulate in the atmosphere? Doesn't the excess amount get absorbed by the oceans and eventually get converted to limestone and petroleum?

6.   Why does the combustion of fossil fuels release CO_2? (What do fossil fuels contain?)

7.   Why does cement production release carbon dioxide? (Cement is made from $CaCO_3$)

8.   According to a hypothesis put forth by Raymo, the formation of the Himalayan mountain range million years ago caused an ice age. The newly exposed rocks from the large mountain range exposed vast amounts of calcium silicate which reacted with carbonic acid according to the following:

     $CaSiO_3 + H_2CO_3 \rightarrow H_2SiO_3 + CaCO_3$
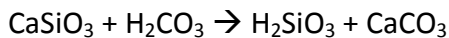
     a) Removing H_2CO_3 implies that a good deal of CO_2 was removed from the atmosphere. See the carbon cycle diagram, and explain the connection between CO_2 and H_2CO_3.
     b) Why did reduced levels of carbon dioxide spur an ice age?

20.   **The Nitrogen Cycle**

N_2 in atmosphere

bacterial denitrification

runoff

industrial fixation

bacterial fixation

NO_3^-
NH_4^+

urea, waste

©UVA-tu?

Example 1: What three natural processes add nitrates to the soil either by oxidizing nitrogen from the atmosphere or by producing a compound which bacteria later convert into nitrates?	Sources of Nitrates
	1.
	2.
	3.

| Example 2: The diagram shows two natural chemical processes that remove nitrogen from the soil. (1) The first process relies on bacteria	How Nitrates are Removed from the Soil

|	
that first convert nitrates(NO_3^-) into atmospheric nitrogen(N_2). (2) Secondly, what organisms rely on ammonium(NH_4^+) and nitrates to produce amino acids and eventually proteins? (3) What *physical* process removes nitrates from the soil?	1. 2. 3.

Problems Associated with Nitrogen Cycle

1. Soil Depletion: If the same crop is planted in the same area and it has no ability to fix nitrogen, then after many cycles the soil will be depleted in that nutrient. Erosion due to wind and water can remove more than just nitrogen but soil in general.

2. Runoff: Runoff is the process by which water runs over land before it ends up in a body of water. When runoff flows along the ground, it can pick up soil contaminants such as pet waste, petroleum, pesticides or fertilizers that become pollution.

3. Eutrophication   **is** an increase in nitrogen or phosphorus in water. As a result there is an increase in the ecosystem's primary productivity. Algae and other organisms grow in excess, depriving the water of oxygen and reducing

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the fish populations. In addition blue-green algae can produce neurotoxins.

NH$_2$

B-N-methylamino-L-alanine
BMAA
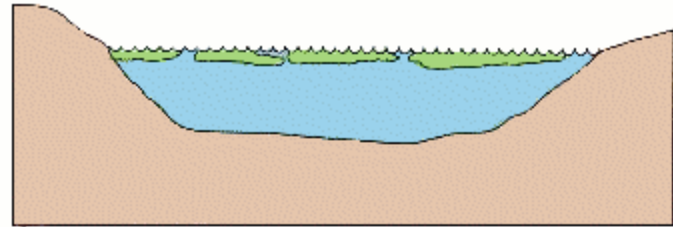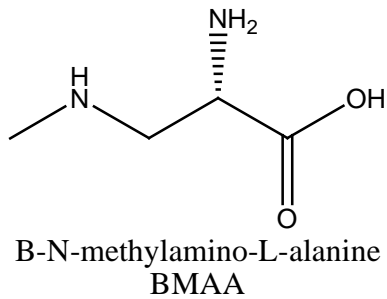
A.
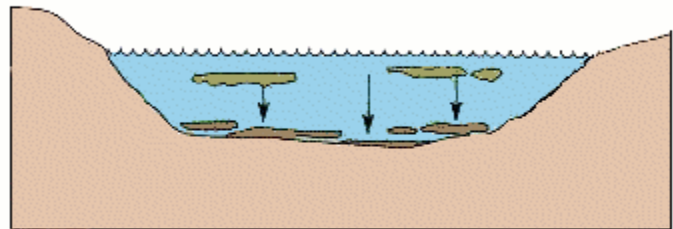
B.
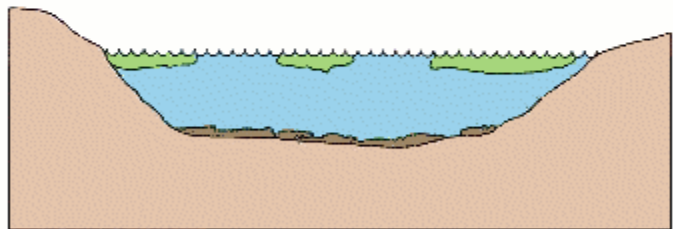
C.

Schematic Diagram showing effects of algal bloom on water quality. (A) Abundant growth of algae in sunlit shallow water when nutrients are abundant. (B) In colder weather, algae die and sink to the lake bottom. (C) The next growing season, more algae thrive at the surface while older material decays at the bottom, increasing BOD and releasing more nutrients to fuel new growth.

Example 1:   During which stage of eutrophication is oxygen depleted?(see diagram)

Example 2: What can be done to prevent the above problems?

Exercises

1.   List two human activities that add nitrates or ammonium to the soil.

2.   List two non-human activities that add nitrates or ammonium to the soil.

3.   List three non-human activities that remove nitrates or ammonium from the soil.

4.   Why do plants need nitrates and ammonium?

5.   Animals continuously excrete urea, which contains nitrogen. Animals do not eat
         fertilizer, so where do they get their nitrogen?

6.   When industry creates fertilizer, they not only participate in the nitrogen cycle but also
         make an undesirable contribution to the carbon cycle. How?

Problems Associated with Nitrogen Cycle

7.   What is the difference between runoff and soil depletion?

8.   You can think of eutrophication as an increase in the rate of algae production. What
          factor that influences the speed of a reaction is at work in eutrophication? (See section
          on electrolytes if you forgot the four factors.)

9.   How does the decay of old algae make it harder on other organisms? List two factors.
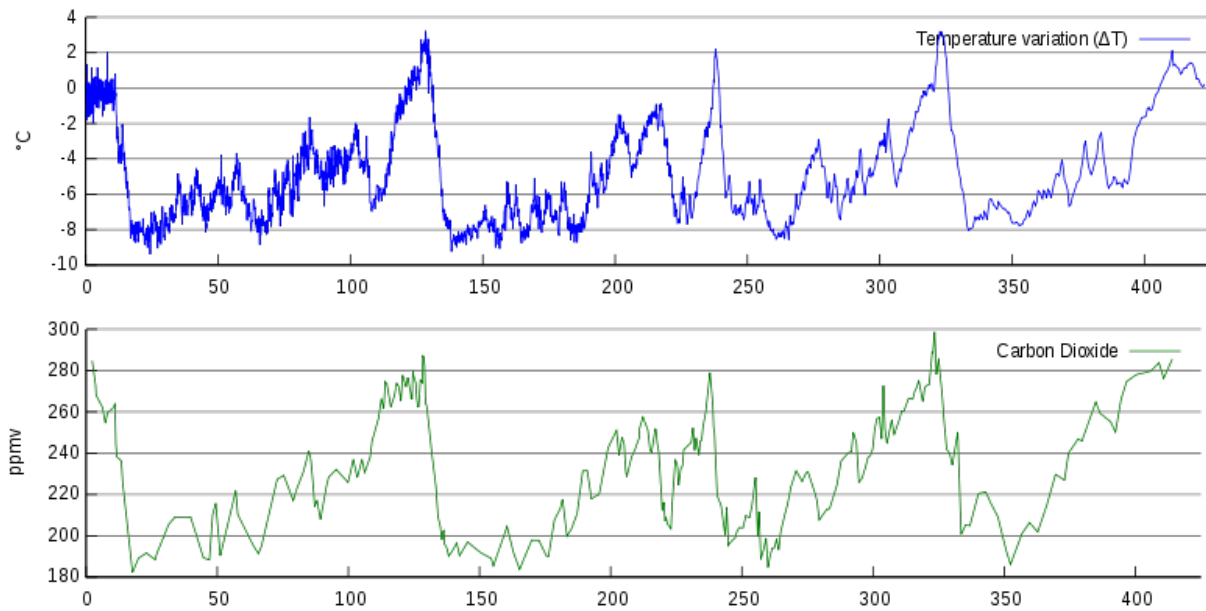   (See diagram on preceding page for hints.)

21.   Greenhouse Gases

1. What are they? Give **examples** and their **sources**.

2. Use a greenhouse to explain global warming.
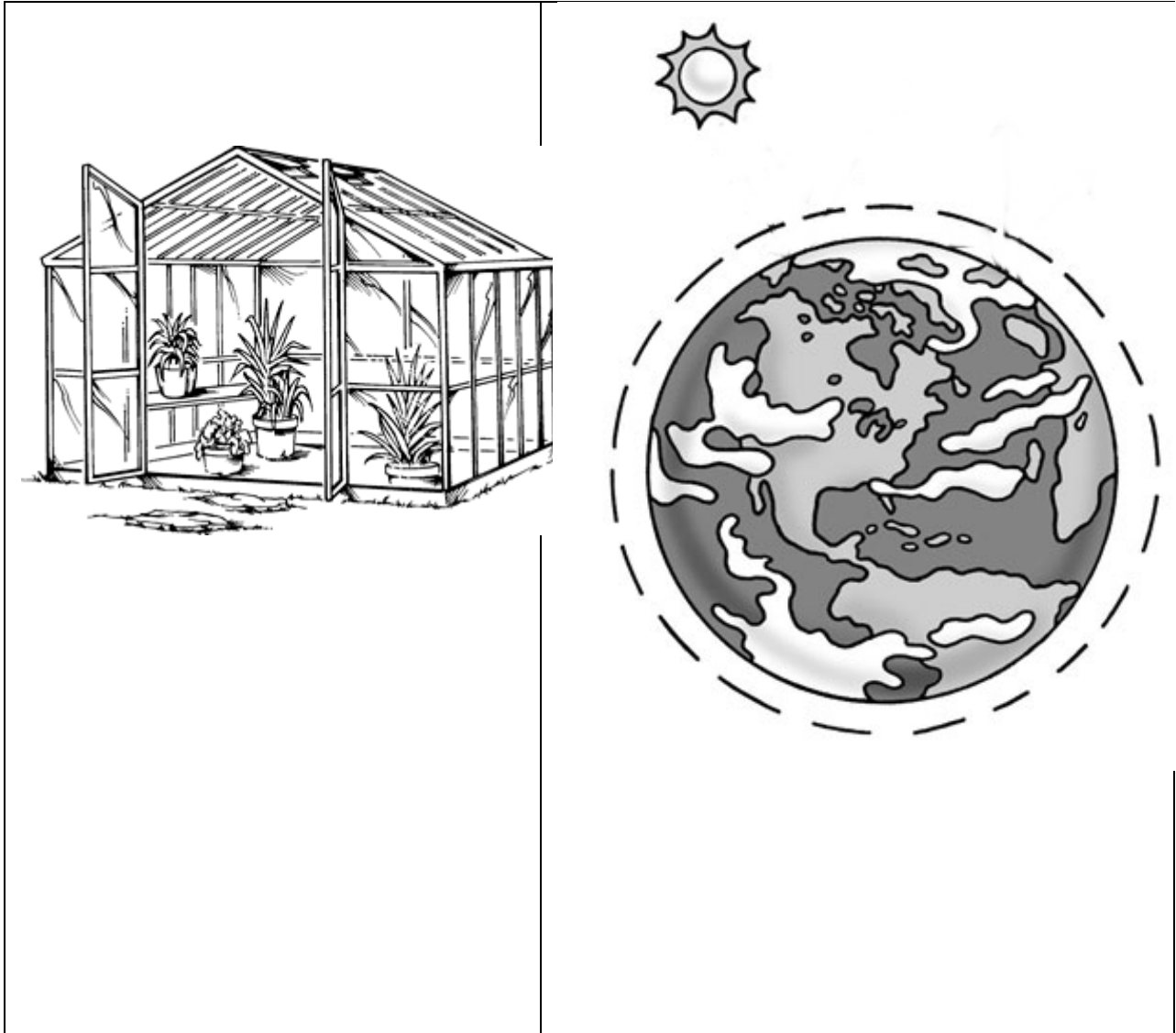
3. Evidence for Global Warming?

4. What are the consequences of Global Warming?

5. How can the problem be solved?

Exercises

1.   a.   List the two main gases that cause global warming.

      b.   What human activities release these gases in large quantities?

2.   Use 2 diagrams to explain what is meant by the greenhouse effect.

- The first diagram should include a sketch of the earth and the gases that cause global warming.
- The second diagram should include a diagram showing how an actual glass greenhouse traps heat.
- Then include a written explanation of what you've drawn.

3.   What evidence do we have for global warming? Mention data from both the recent and distant past.

4.   How is global warming a threat to society?

5.   Explain how we can fix the problem. Include two solutions that do not involve a change in lifestyle.

Glaciers

6.   What causes a glacier to form?
7.   A) What happens to the level of the sea when many glaciers slide into it?
      B) What happens to the level of the sea after many icebergs melt? (Remember an iceberg is already in the water)

22. <u>Biodiversity</u>   **textbook p 303**

a- <u>**Definition**</u>: Biodiversity describes the variety of species living in a community.

What is a species?

Two things have to be considered when measuring biodiversity:

      (1) Species richness (how many species live in a community)
      (2) The relative abundance of each species (how many there are of each compared to the total.

For biodiversity to be high we need a high number 1 and similar ratios for number 2.(while keeping in mind that there is usually a lot more speciation for smaller organisms)

Example 1   Why is biodiversity important? What could you do to increase it in your own backyard?

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Example 2:   Determine which community has a higher biodiversity.

| Community	Species	Number of species	Total number	Relative abundance
Section of Parc National de la Yamaska	Spiders	210	8000	
	Maple, balsam fir, hemlock, birch	40	100 000	
	mammals	35	2000	
	birds	230	?	
20 Square km in Montreal	Homo sapiens	1	18000	
	Maple trees	1	1000	
	spiders	12	9000	
	linden	1	800	
	Sewer rats	1	18000	
	birds	5	?	

Exercises

1.   Why do all humans belong to the same species? List evidence.
2.   What is biodiversity?
3.   How is biodiversity measured?

4.   a) Give examples of the different species of plants found in a lawn that has not been treated with weed killer.
        b) Do the same for a lawn that has been treated.
        c) Which has the greater biodiversity?

23.   Dynamics of Ecosystems
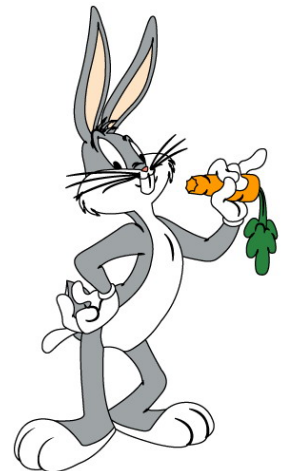
A- Trophic Relationships

-   Describes the trophic levels (producers, consumers, decomposers)
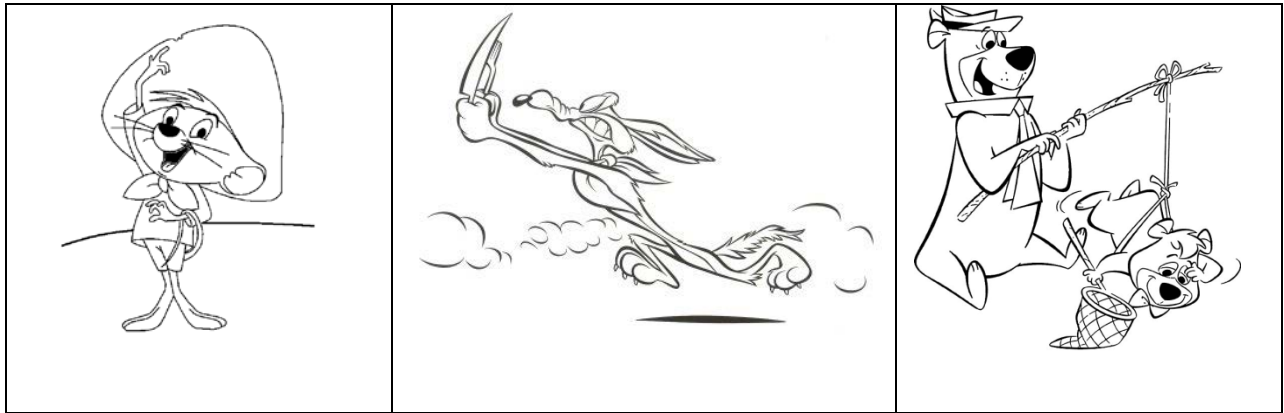-   Explains the relationships between the trophic levels of a food web
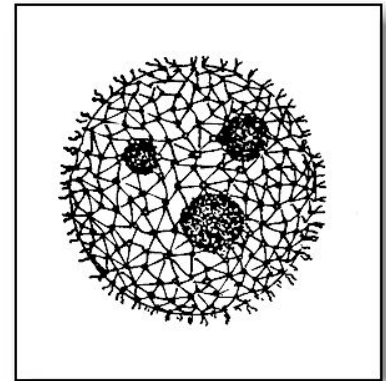
1. a) What is a **producer**? Give examples.

b) Why is a producer said to convert inorganic matter into organic matter? Give examples.

2. a) What is a **consumer** in an ecological context?

b) What is the difference between a first order, second order consumer and an omnivore?

3.   What is a **decomposer**? Give examples.

4.   **Trophic relationships** are the feeding connections among the living organisms in an ecosystem.

Example   Draw a food web for the following:

Hare, fox, snake, fungi, bacteria, grasshopper, termite, autotrophs (photosynthesizers), shrew, woodpecker, field mouse,

B-   Primary productivity

1. What term is used to describe the quantity of organic matter produced by plants in a given territory?

2. Explains the effects of certain factors on primary productivity (e.g. bees help pollinate fruit trees, pathogenic microorganisms hinder plant growth; other factors: light, water, temperature, fertilizer)

C- Material and Energy Flow

1. How do materials and energy flow in an ecosystem?

2. How does energy efficiency relate to the transfer of energy between trophic levels?

3. Is energy recycled? If not where does can the continuous supply come from? Give two examples.

Exercises

1. What is the energy source of producers?
2. What carbon -containing inorganic gas is needed by most producers?
3. What nitrogen containing ion is also needed by producers?
4. What organic material is the primary product of producers?
5. Give an example of the primary producer found in deserts.
6. What first order consumers are found in temperate forests?
7. What first order consumers are found in coral reefs?
8. A road runner`s diet consists of 90% of animal matter (insects, scorpions, lizards, snakes, rodents and other small birds) and the remainder is fruit and seeds.
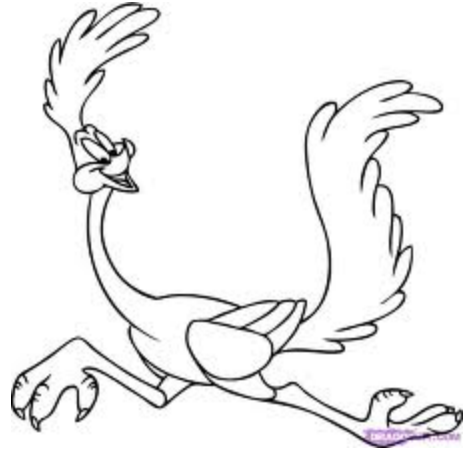
   Why isn`t the roadrunner a second order consumer?

9. a)   Aside from fungi, what other decomposers exist in nature?
   b)   In what cycles do decomposers play a role in? Give examples.

10. Use the food web to identify two mammals that are secondary consumers.
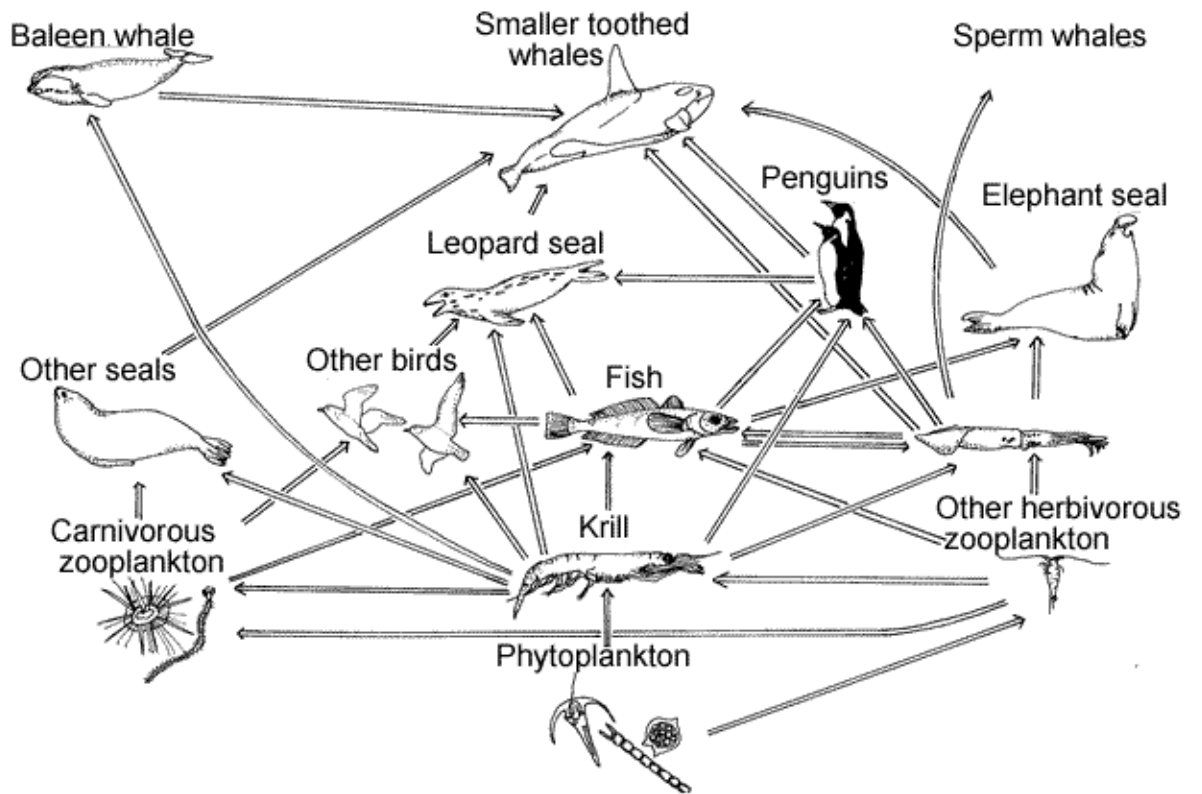
11.   Which animal wastes the most energy if you consider all the trophic level exchanges needed to feed it?

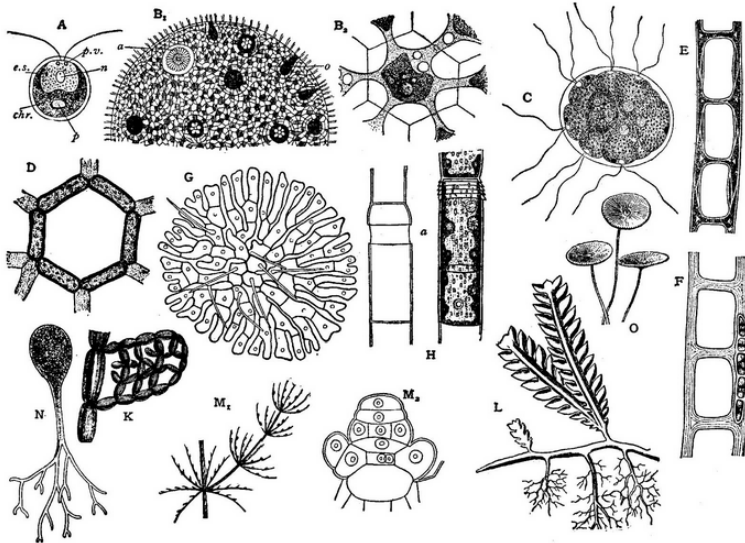12.   What factors can affect primary productivity in the sea?

1. **Oceans**

   a) **Basic facts**:   There are five oceans on earth, making up about 72% of the planet's surface and holding 97% of the hydrosphere. Oceans supply the planet with most of its oxygen, play a vital role in the carbon cycle, weather and climate. Deep oceans are largely unexplored.
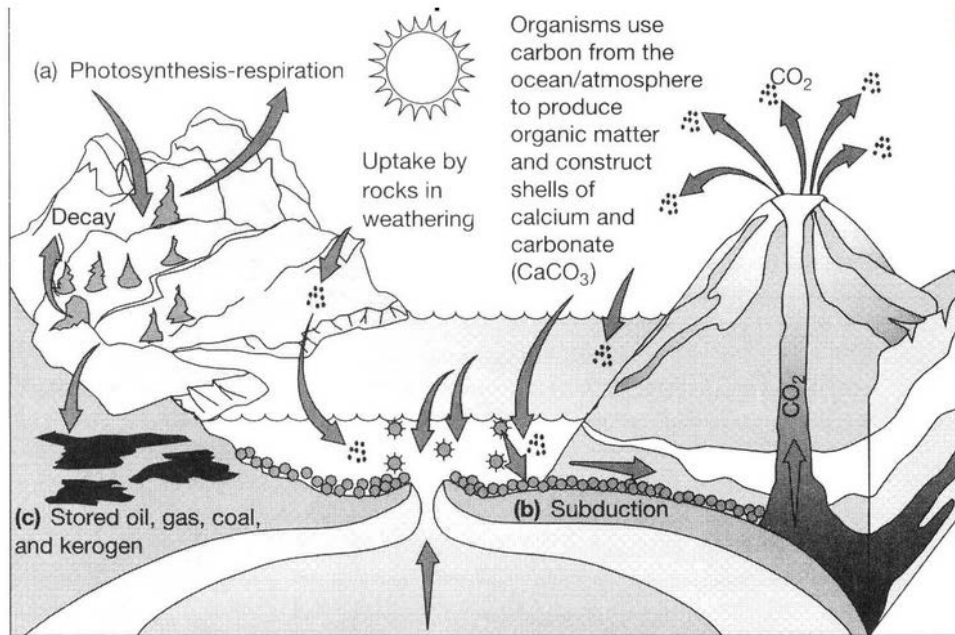
      Example 1   Identify the 5 oceans.

      Example 2   What organisms in the ocean supply the Earth with oxygen and how?

<u>**Example 3**</u>   How do oceans play a role in the carbon cycle?

(a) Photosynthesis-respiration

Decay

Uptake by rocks in weathering

Organisms use carbon from the ocean/atmosphere to produce organic matter and construct shells of calcium and carbonate $(CaCO_3)$

CO_2

CO_2

(c) Stored oil, gas, coal, and kerogen

(b) Subduction

1. They take in hydrogen carbonate ions form weathering of _____
2. They have _____ which photosynthesize.
3. Their shelled organisms deposit the ion_____
4. The carbonate gets converted into _____gas by volcanoes.
5. Oil and _____ is formed from the slow decomposition of marine organisms.
6. They dissolve _____gas from the atmosphere.

<u>**Example 4**</u>   How do oceans affect weather and climate?

1. Water has a high c value = _____. That means it absorbs heat slowly but then also releases its heat slowly so it stabilizes the temperature of keeps nearby_____
2. Through ocean currents, heat from equatorial areas is _____

3. Warm moist air rising from the sea can also lower _____ and cause tropical storms and _____
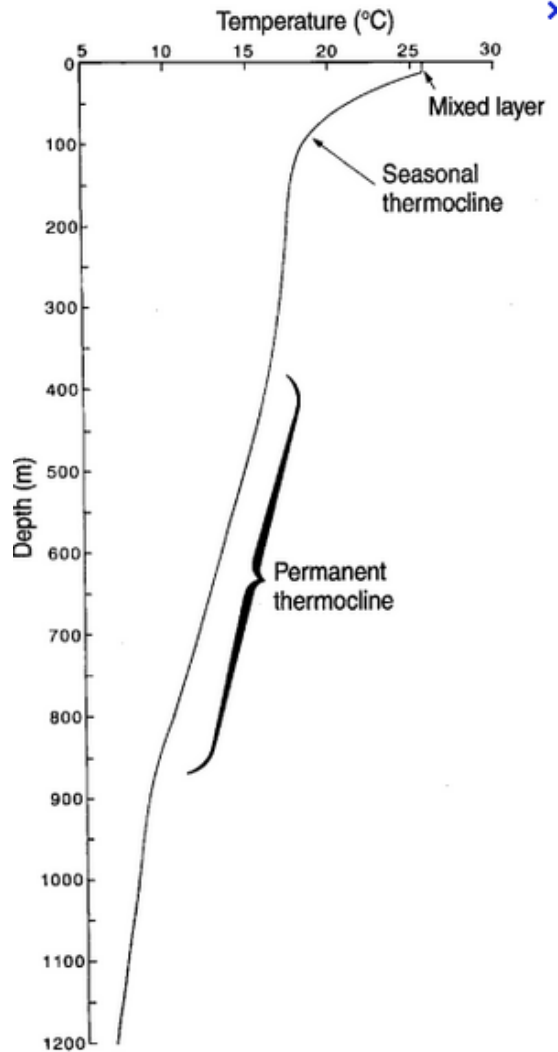

b) <u>Ocean Temperature</u>

Three factors affect ocean temperatures:

(1) Depth
(2) Season
(3) Latitude

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Example 1 The following data was collected in 1983 at 33°N and 43°W. Which ocean was it taken from and during what season?

Example 2 What do you notice about the mixing layer's temperature? Why is this so?

Example 3 Why is the temperature so low at a depth of 1100 m?

Example 4 How will seasons affect the curve in the previous example?

Example 5 How do seasonal ocean temperature changes compare to those from the continent?
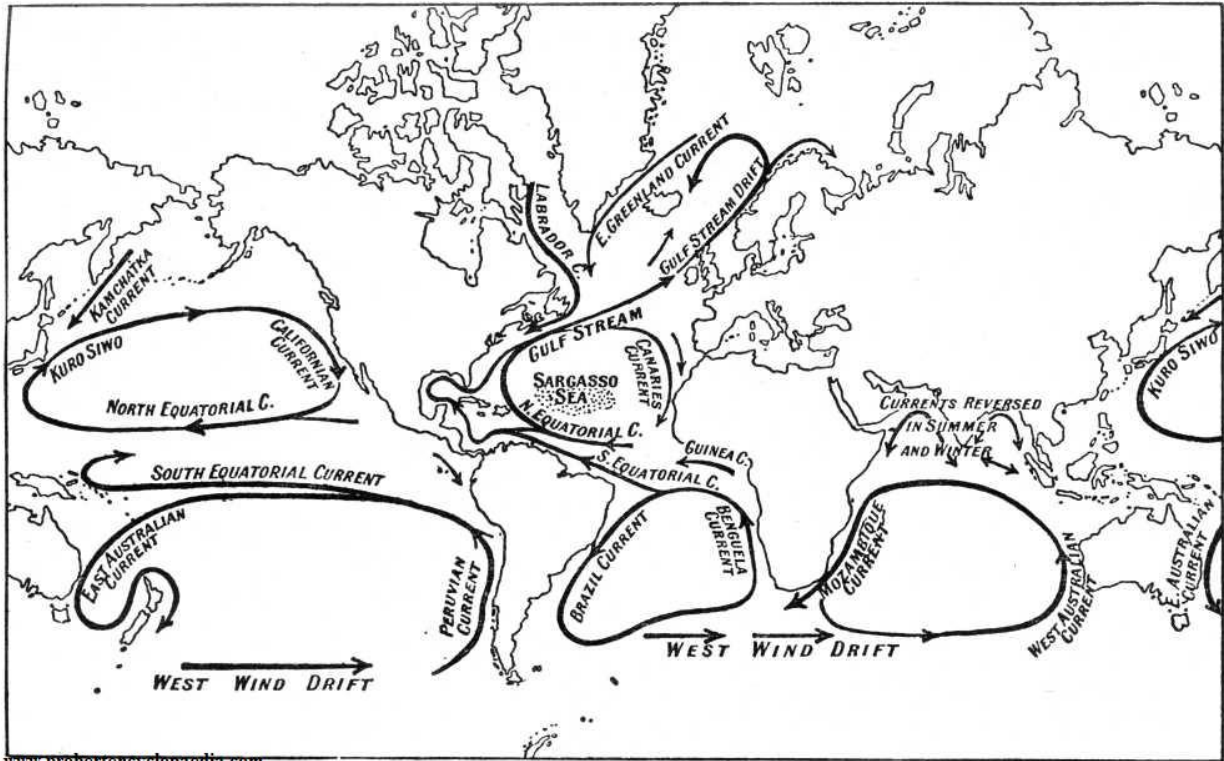
Example 6 Which latitudes will have the warmest ocean temperatures?

c) **Ocean Currents**

1. Definitions:
   - An ocean current is the movement of the seawater in a certain direction and over a large distance .
   - Ocean circulation refers to the combined movement of several ocean currents.

Example 1   Which current bring cold waters to Quebec and Maritime beaches?

Example 2   What will be warmer in the winter: eastern or western Florida waters? Why?

2. **Factors Affecting Currents**

   Oceanic currents are driven by several factors.

- One is the rise and fall of the **tides**, which is driven by the gravitational attraction of the sun and moon on Earth's oceans. Tides create a current in the oceans, near the shore, and in bays and estuaries along the coast. These are called "tidal currents." Tidal currents are the only type of currents that change in a very regular pattern and can be predicted for future dates.

- A second factor that drives ocean currents is wind. **Winds drive currents that are at or near the ocean's surface**. These currents are generally measured in meters per second or in knots (1 knot = 1.15 miles per hour or 1.85 kilometers per hour). Winds drive currents near coastal areas on a localized scale, and in the open ocean on a global scale.

- A third factor that drives currents is thermohaline circulation - a process driven by density differences in water due to **temperature (thermo) and salinity** (haline) in different parts of the ocean. **Currents driven by thermohaline circulation occur at both deep and shallow ocean levels and move much slower than tidal or surface currents**.

Example 1   What kind of tide would result in a tidal current away from the land?

Example 2   What movement of the planet combines with wind to create the curved effect of ocean currents?

Example 3   Will warm water near the equator sink or will it remain above colder water to the north? What effect does this have on the water in Northern latitudes?

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Exercises

1. Classify as freshwater or sea water (sea water > 3% salt)

a) Water with 700 ppm of salt. Convert to % first.
b) Water with a m/V concentration of 0.03%.
c) The water in Lake Superior
d) The St-Lawrence River between Quebec city and Montreal
e) The St-Lawrence River near Gaspe
f) The Southern Ocean

2. What three types of freshwater do inland bodies include?

3. Where is most our water found?

4. Give two reasons why Boston is generally warmer than nearby Worcester, especially in late fall and winter.
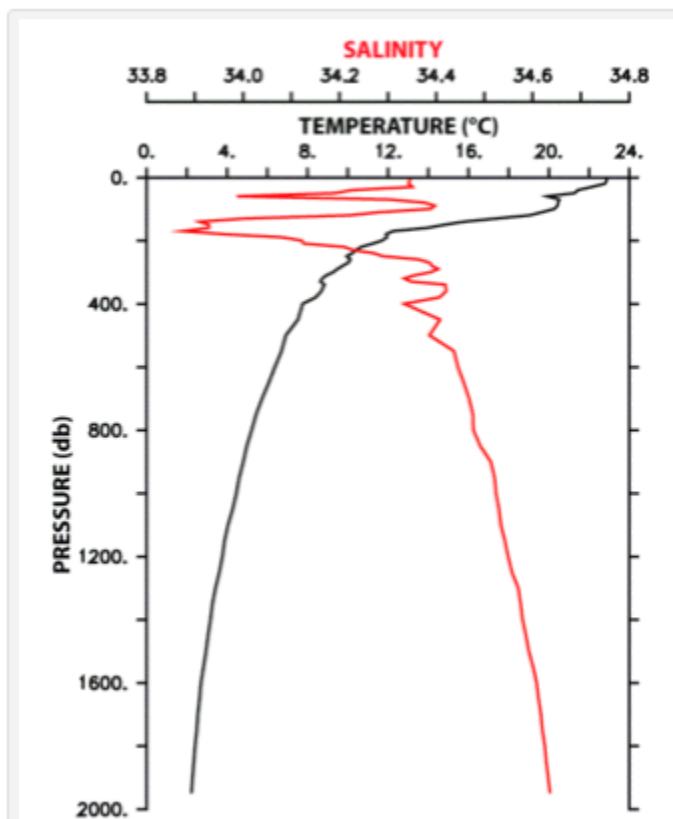
5. The data shown was collected at 20N, 121 W, between Asia and N America.

a) Which ocean was measured?
b) Which season was the water's temperature recorded in?
c) Why is it so cold past a couple of hundred meters in depth?
d) Are deeper waters saltier?
e) Why?

9.

a) Which are the two coldest oceans?
b) Which is the warmest of the 5 oceans?

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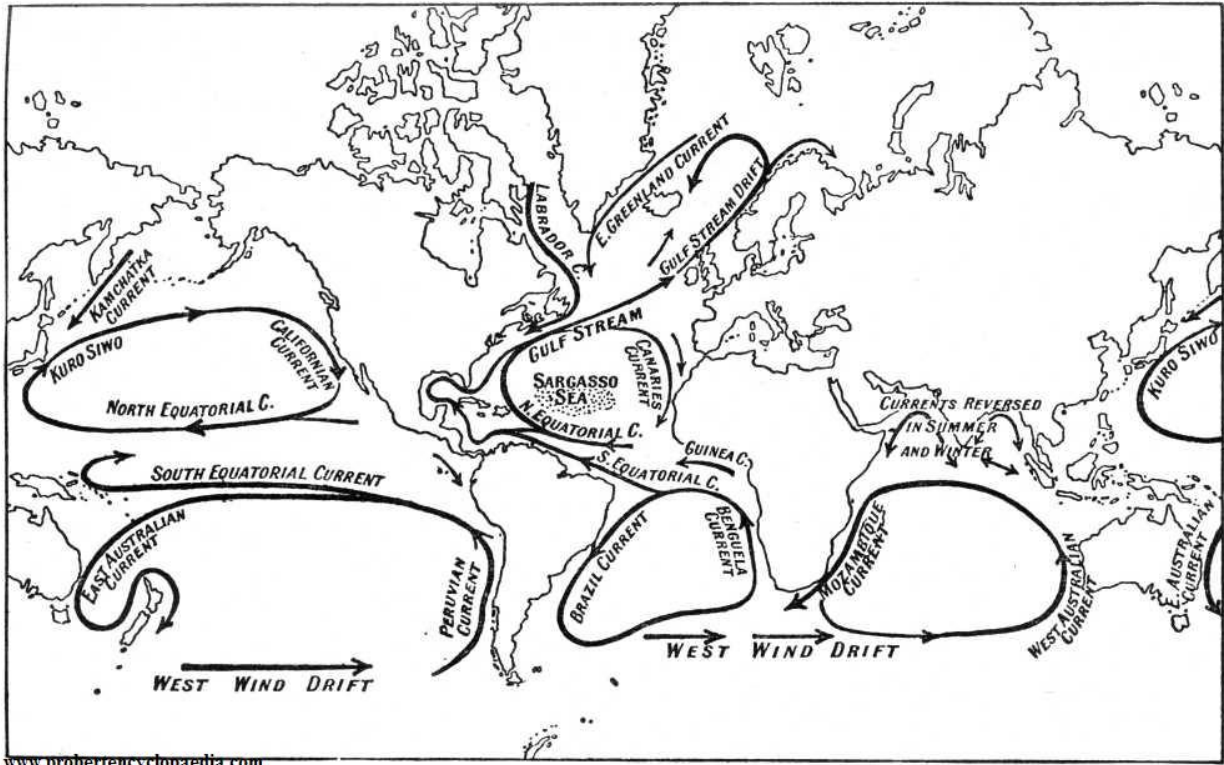
10.   a) Examine the above map and figure out why California waters are cold in the winter.

b) In which ocean does the Labrador current originate?

11.   What three factors affect ocean currents?

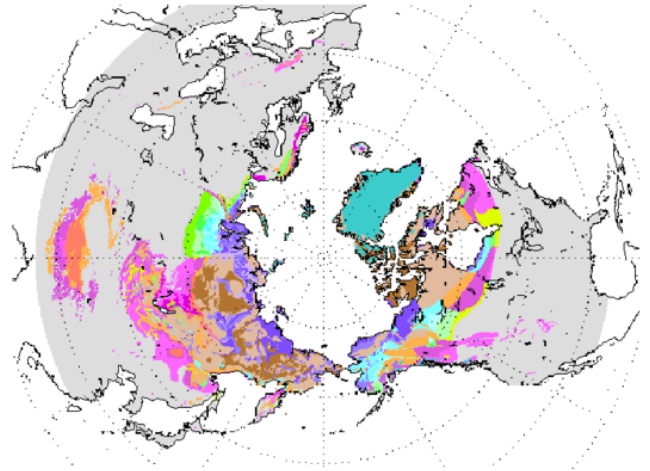12.   Why is Arctic water less salty than the Indian Ocean?

25. **Permafrost**

1. What is permafrost?

2. Large parts of northeastern Russia and almost 50% of Canada's land can be frozen up to a depth of 0.5 km.

Where else is this permafrost found?

3. What can happen to the top part (active layer)of permafrost during summer?

4. a) How could climate change lead to large amounts of methane being produced?

b) What's wrong with releasing methane into the atmosphere?

26. **WATERSHEDS= Catchment Areas**

1. A catchment area or drainage basin or watershed is an area of land where all inland waters from rain and snow drain into the same lake, river or sea.

2. Explain how the following factors can affect how water flows within a watershed:
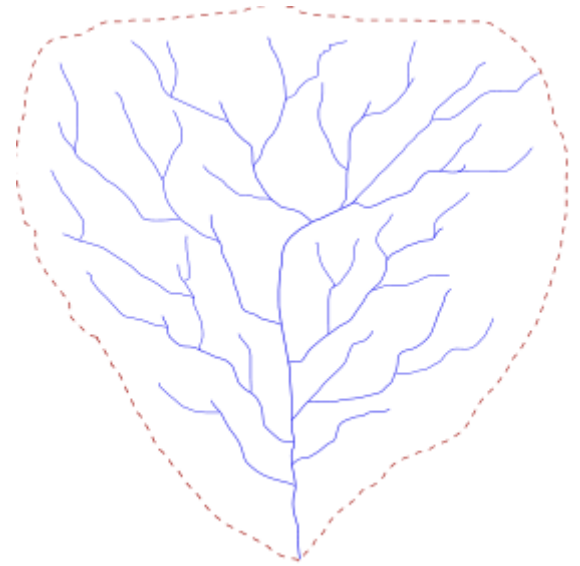
a) **Topography:**

b) **Geology:**

c) **Climate:**

d) **Vegetation:**

e) **Development:**

3. How does catchment (the amount of water actually absorbed by land) affect towns, cities and the economy?

27. **Glaciers**

1. How do they form?

2. a) How are they related to icebergs?

   b) Prove that over 90% of an iceberg is submerged. The density of ice is 0.917 g/cm^3. Use the idea that the buoyant force is the product of g and the **mass of water displaced** by a floating object. The buoyant force balances the weight of the floating object. Assume 1.00 g/cm^3 for water's density. (STE diversion)

   displaced water
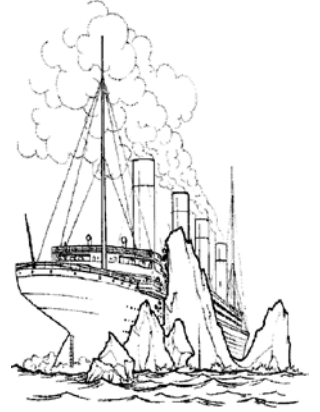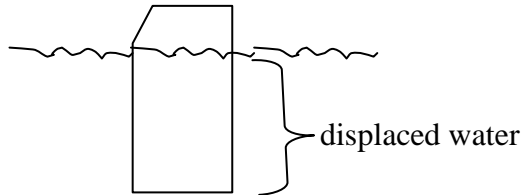
3. When does sea level rise?

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EXERCISES

1. Why do parts of British Columbia have permafrost even though its northern boundaries are south of the Arctic Circle?
2. a)   How is methane released from permafrost?
   b)   What actually produces it?
   c)   What do the microorganisms act as in the food chain?

3. a) What is the active layer of permafrost?
   b) Is it possible for the active layer not to exist in certain areas?

4. Is a sandy area less likely to be flooded? Why or why not?
5. a)   How do storm drains help during heavy rainfall?
   b)   What can act as a natural storm drain?
   c)   How does deforestation affect the amount of water that ends up in a river?

6. What is the difference between a glacier and an iceberg?

7. If sea water has a density of 1.027 g/cm^3, what percentage of an iceberg will be submerged if ice's density = 0.917 g/cm^3.

8. What can cause ice sheets to leave land? What will subsequently happen to sea level?

9. a)   What happens to the volume of water if an already submerged ice cube melts?
   b)   In what way does this not contradict the answer from #8?

10. How do topography and geology each affect the way water flows within a watershed?

11. Which watershed extends from northern Quebec to the northeast into Ontario and Manitoba?

12. What part of the hydrosphere supplies the Earth with most of its oxygen?