LIVING PLANET
UNIT FOUR

SUMMARY OF UNIT FOUR MATERIAL

The videotapes to watch for this unit are:
Video Program 7 – The Sky Above
Video Program 8 - Sweet Fresh Water

For each video episode in this unit:
read the **CONCEPTS** section in the study guide
answer the **Concepts Study Questions**
watch the Video Episode
answer the **Video Study Questions**

OVERVIEW OF UNIT 4 LEARNING OBJECTIVES

Video Episode 7 - Community in the Skies
To become acquainted with:

1. characteristics and layers of the atmosphere
2. human effects on the atmosphere
3. the carbon cycle
4. the water cycle
5. comparisons between bird wings, bat wings and insect wings
6. various atmospheric conditions: tornadoes, hurricanes, etc.
7. ways that organisms use the wind for transportation
8. gliding and animals that use gliding
9. powered flight and animals that use powered flight
10. the concept of lift
11. the problems of takeoff and various solutions
12. thermals and how organisms use thermals
13. adaptations of birds to flight
14. echo-location and organisms that use echo-location
15. migration

Video Episode 8 - Sweet Fresh Water
To become acquainted with:

1. fresh water
2. ecology of rivers
3. changes that occur in a river from beginning to end: currents, nutrients, sedimentation, temperature, oxygen, plant life, animal life
4. the two breeding strategies of fishes
5. the concept of surface tension and how animals exploit surface tension
6. the changes that occur in the Amazon River
7. types of lakes
8. zonation in lakes
9. succession in a lake
10. ecology of Lake Baikal
11. ecology of deltas

CONCEPTS FOR EPISODE 7: The Sky Above

WINGS

Three groups of living animals can fly: the insects, the birds, and the bats. Each of these animals have evolved wings, but the wings differ in structure.

In insects, the wings are outgrowths of the rigid covering of the body. Most insects have two pairs of wings (for a total of 4). The wings are made of a thin membrane reinforced by struts called veins. The wings flap in a figure-eight motion, generating lift as the wings move down and forward. During the recovery stroke, the wings move up and back. Coordinating all four wings without their smacking into or otherwise interfering with each other demands a high level of nervous system control.

In both birds and bats, one pair of legs, the forelegs, has evolved into the wings. Insect wings did not evolve from legs. They probably evolved from small flaps used by terrestrial insects to soak up heat to raise their body temperature, or by aquatic insects to absorb oxygen from the water.

In birds, the feathers of the wing form the surface that generates lift. The bones of the wing are strong, with some of the fingers fused together for additional strength. As the wings flap, they move in a figure-eight motion. During the downstroke the wing moves down and forward, generating lift. During the upstroke, or recovery stroke, the wing moves up and back. As explained in the video, the feathers can slide over each other, so the shape of the wing surface can be changed. Insects and bats cannot change their wing shape.

In bats, the wing surface is formed by a membrane of skin that is stretched between the neck and the thumb, from there to the third, fourth and fifth fingertips, then to the feet, and from there to the tail. The fingers are very long, to provide support for the wing membrane. The tip of the wing travels in an oval shape instead of a figure-eight as the bat flaps its wings. The wing membrane is often used to help the bat catch insects, serving as a scoop used to bring the food to the bat's mouth.

References:

Grzimek, Bernhard, ed. 1984. Grzimek's Animal Life Encyclopedia. Volume 2: *Insects* and Volume 11: *Mammals II.* Van Nostrand Reinhold, NY.

Harris, C. Leon. 1992. *Concepts in Zoology*. HarperCollins, NY.

Trewartha, Glenn T. and Lyle H. Horn. 1980. *An Introduction to Climate*. 5th ed. McGraw-Hill, NY.

Williams, Jack. 1992. *The Weather Book.* Vintage, NY.

THE ATMOSPHERE

The **atmosphere** is an envelope of gases that blankets the Earth. The most common gases in the atmosphere are nitrogen (78%), oxygen (21%), argon (1%) and carbon dioxide (0.04%). The amount of water vapor, also a gas, varies considerably, with concentrations of almost zero in desert and polar regions to 0.03-0.04% in the hot humid jungles.

The gases are distributed in a number of layers. Most of the gases are found close to the surface of the earth, in the **troposphere.** The troposphere extends to 5 miles above the surface. (Watch Attenborough explore the troposphere in the high altitude balloon. By the time he reaches the edge of the troposphere, he has to use an oxygen mask to breathe, because the amount of gases decreases as he ascends.) The troposphere is the layer in which weather occurs: winds, storms, and air currents such as the jet stream.

Above the troposphere lies the **stratosphere.** It extends from 5 to about 30 miles above the ground. The stratosphere is poor in gases compared to the troposphere, but it does contain an important gas that is normally missing in the layer below: **ozone.** The ozone is formed when oxygen molecules are struck by sunlight. The stratospheric ozone absorbs rays of ultraviolet (UV) light and prevents most of them from reaching the surface of the planet. UV light has a high energy level. When a ray of UV light strikes a living cell, it rips into the important biological molecules of which the cell is composed. It can damage the genetic material of the cell, resulting in changes that can lead to cancer.

Human activities have damaged this protective layer of stratospheric ozone. **Chlorofluorocarbons** (CFCs) are chemical compounds used in air conditioner coolants such as Freon. They have many other uses as well. When CFCs leak into the atmosphere, they are carried up to the stratosphere where they break down the ozone molecules. Weakening the stratospheric ozone layer may lead to an increase in skin cancer rates in people and, more seriously, a disruption of food chains as the increased amount of UV light seriously affects plants, algae, and animals. The 1987 Montreal Protocol, an international plan to reduce or ban the production of certain ozone-destroying compounds, mandates the reduction of CFCs and other compounds manufactured in developing countries. (You can find more information about this topic and current concerns in “Geophysicists Probe the Solar System’s Cold Spots” in *Science*, 19 January 2001, pp. 422-423.)

Above the stratosphere is the **mesosphere** (30 to 50 miles above the surface). The main feature of the mesosphere is a serious drop in temperature to almost -100° C, which is colder than any temperature ever recorded on the surface. Water vapor freezes, forming ice crystal clouds that may be visible after sunset if conditions are just right. The shooting stars you see are usually meteors that are burning up as they go through the mesosphere.

The **ionosphere** is the layer above 50 miles, where solar radiation ionizes atoms; hence, the name and the formation of the aurora borealis (northern lights) and aurora australis (southern lights). The **auroras** are brilliant flares of colored light that flash and flicker silently across the clear polar skies. They are formed when charged atoms emitted by the sun and carried to Earth on the solar wind hit the surface of the atmosphere and collide with the gases there, emitting flashes of light. Sadly, here in Austin, the northern lights are rarely visible.

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CLARIFICATION: The ozone effect is NOT the same thing as the greenhouse effect. They both involve the atmosphere but the causes are different. Both issues are discussed when people talk about global climate change.

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GLOBAL WARMING

One of the most important gases present in the troposphere is carbon dioxide. Carbon dioxide lets in light from the sun, but traps heat trying to return to space. Thus, the concentration of carbon dioxide in the troposphere, along with a few other gases such as methane, determines the temperature at the surface of the planet. The more carbon dioxide there is in the troposphere, the more heat is trapped and the higher the surface temperature will be. This process is called the **greenhouse effect.**

Carbon dioxide is released to the atmosphere by all organisms as they use oxygen to burn fuel to run the biochemical reactions of their bodies. It is removed from the atmosphere by plants and algae during photosynthesis. In a real sense, photosynthesizers determine the carbon dioxide content of the atmosphere, and through that, the surface temperature. Any disturbance to the balance of carbon dioxide release and removal will alter the surface temperature.

Human activities over the last 200 years have altered that balance. Fossil fuels, such as oil and coal, were formed from an incredible number of photosynthesizers that picked up carbon dioxide and stored it in their tissues millions of years ago. Burning fossil fuels releases a large amount of carbon dioxide to the atmosphere each year. Clearing the land of forests and other plant communities for cropland and dwellings decreases the removal of carbon dioxide by plants, so more carbon dioxide stays in the atmosphere. The combined effects of fossil fuel burning and land clearing is **global warming,** the warming of the surface of the planet.

Global warming may have serious consequences. It will change the patterns of climate and weather around the world. Areas that used to receive enough rainfall to produce crops may become dry, leading to disruption in the food supply. Other areas may receive more rainfall than normal, leading to flooding. The plants and animals of all the communities may be unable to adapt quickly to the changes in climate and temperature. Thus, many organisms may go extinct. The ice of the polar regions may melt, raising sea level worldwide. Scientists who study global warming may disagree about the details but they all agree that we should be deeply concerned about possible impacts on the planet.

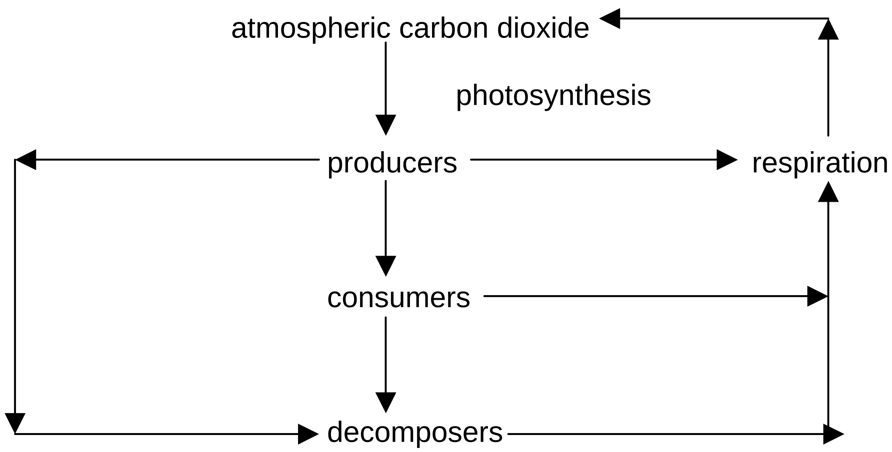
Global warming may also be changing migratory patterns, as discussed in this web article: http://news.nationalgeographic.com/news/2005/11/1122_051122_winter_birds.html

THE CARBON CYCLE

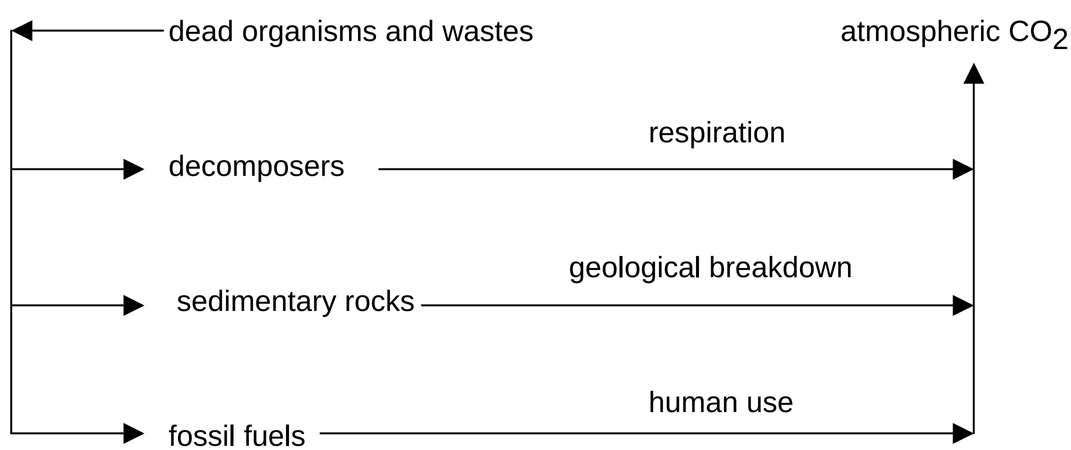
If you read the section above carefully, you will notice that this is another nutrient cycle: the carbon cycle.

Some carbon is found in the atmosphere, in the form of gases such as carbon dioxide. Some carbon is found in the living bodies of plants, animals and organisms in the form of molecules such as carbohydrates, fats, proteins and nucleic acids (DNA, RNA). Some carbon is found in sedimentary rocks or in fossil fuels.

The following diagram is a brief overview of how carbon moves through living organisms.



There is another alternate pathway to the carbon cycle that takes more time to recycle the carbon. In this pathway, carbon is stored in geological formations, such as sedimentary rocks (like limestone) and fossil fuels (oil, gas, coal and peat).



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Additional Information about the carbon cycle:

Several students have asked for more information about the carbon cycle. If you feel that you already understand the carbon cycle, then skip on down to the water cycle. Otherwise, here goes! Let's start with a closer look at the "Brief Overview of carbon cycle" on this page.

First, all organisms have cells and cells undergo respiration in which sugar is burned as fuel. In the process, most give off carbon dioxide as a gas. This applies to photosynthesizers (producers) and consumers and decomposers. So, as almost all organisms go through their daily life, carbon dioxide gas is added back into the atmosphere by these organisms. (For example, look at us. When we exhale, carbon dioxide goes back into the atmosphere. As your houseplant undergoes daily activity, it too adds carbon dioxide gas back into the atmosphere.)

All living things need carbon in their cells to make carbohydrates, fats, proteins and nucleic acids. So, somehow, organisms need to get the carbon out of the atmosphere (in the form of carbon dioxide) and into their bodies so they can make these molecules that they need.

That's where the producers come in. Producers (plants, cyanobacteria, etc) take carbon dioxide out of the atmosphere and, in the presence of sun and water, convert carbon dioxide into sugar (carbohydrates). This process is called photosynthesis.

Almost immediately, the cells of the producer uses some of that sugar as fuel. (This process is cellular respiration). The excess sugar goes into building plant bodies. (To make it simple, I'm just going to talk about plant producers. The same will apply to any producer.)

So, now the plant is building its body – its leaves, flowers, fruits, roots, stems, whatever. As these activities are taking place, the plant cells are using carbohydrates as fuel -- and giving off carbon dioxide gas.

Now the consumers (such as animals) come along and eat the plant body. They are eating the plant tissues that contain carbohydrates, proteins, nucleic acids and fats. In this way, carbon now leaves the plant body and enters the animal body. The animal processes what it can (the rest becomes waste products) and now the carbon becomes available to the animal cells. In the process, carbohydrates are used as fuel by the animal cells – which form carbon dioxide gas in the process.

Throughout a plant's life, parts of the plant fall off or are broken. Limbs, grass stems, leaves, etc. fall off the plant and often onto the ground. Animals give off waste products (urine, feces) and also die. As these waste products, dead plant parts and dead animals become available to the decomposers, the decomposers start using these things to provide their bodies with carbohydrates, etc. As the decomposers (bacteria, fungus) live, their cells are also using their new carbohydrates as fuel for their cells – which returns carbon dioxide gas to the atmosphere.

Now, let's go to the alternate carbon pathway. Students have asked the question: "Is the relationship between decomposers and respiration similar or the same as the relationship between decomposers and respiration in the alternate Carbon Cycle?" The answer is yes. This cycle just adds another layer to the picture. This part occurs if the decomposers don't get a chance to break down all of the plant and animal bodies before they are covered with sediments and turned into rock. (Remember the giant horsetails that were turned into peat, covered with sediments and became coal? Unit 3?)

So, if these plants/animal parts do not decompose quickly, they may be converted into sedimentary rocks or fossil fuels. As the rocks are broken down (through wind, water activity and human mining) and fossil fuels are burned in our engines, the carbon trapped in the rocks and fossil fuels gets added back into the environment.

Here are some quick concept check questions.
(1) How does carbon leave the atmosphere?
(2) How does carbon enter the atmosphere from plants, animals and other organisms?
(3) Where is carbon stored?
(4) How does carbon stored in the bodies of organisms return to the atmosphere?
(5) How does carbon stored in sedimentary rocks or fossil fuels return to the atmosphere?
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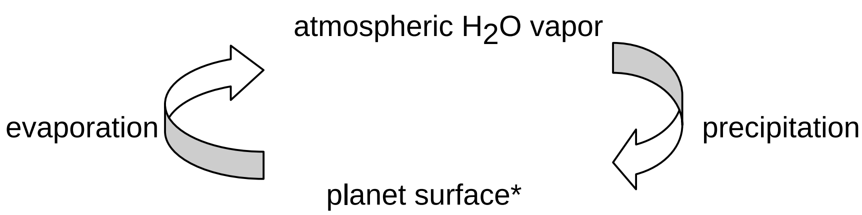
THE WATER CYCLE

Another important gas in the troposphere is water vapor. This gas is the source of all the precipitation that falls on the planet's surface. **Precipitation** means rain, snow, sleet, hail or any other form of water falling from the sky. The **water cycle** is the process by which water vapor and precipitation are converted endlessly from one form into the other.

The water vapor in the troposphere forms as liquid water evaporates from the surface of the oceans, bodies of fresh water, and plants. As the air is heated by the sun, it rises, carrying the water vapor aloft. But as the air rises, it cools. Cool air cannot hold as much water vapor as warm air, so the water begins to condense to form small droplets of liquid water. If the droplets become large and heavy enough, they drop from the sky as rain.

The rain will eventually return to the ocean. It may return in a number of ways. It may fall on the ocean itself, or it may flow over the surface of the land into the rivers which carry it to the sea. Or it may soak into the ground, joining the pools of water underground that flow very slowly towards the rivers and the sea.

Here's a diagram of the short version of the water cycle:



*Planet surface: ocean surface, surface of lakes and rivers, surface of the land, surface of plants and animals

WEATHER: TORNADOES AND HURRICANES

The atmosphere is a place full of change. Air is moving everywhere as winds rush from place to place. The winds tend to flow from areas of high air pressure to areas of low pressure, and the earth's rotation gives the whole system a twist, so that the winds tend to spiral into the low pressure areas. If a low pressure area is strong, the winds speed into it at high velocities. A very strong low pressure area generates winds with speeds of over 75 miles an hour, at which point the system is called a hurricane.

The strongest winds of all are not found in hurricanes, however. They are found in tornadoes, where wind speeds in excess of 300 mph have been recorded (one can assume by a "foolhardy" person, as Attenborough might say). Tornadoes are found in association with intense thunderstorms. At the core of the thunderstorm is a column of rising air that twists in a spiral as it rises. It is this area of the storm that gives rise to tornadoes. A tornado consists of a small but violent column of rapidly spiraling air called a vortex. Scientists are not sure whether air sinks inside the vortex, or exactly how the vortex forms. They are sure, however, that the vortex acts like a giant vacuum cleaner hose, sucking up air from near the ground, and any cows or cars that may be in the way as well. The air is carried up rapidly, and the traveling cows and cars carried with it are deposited some distance away.

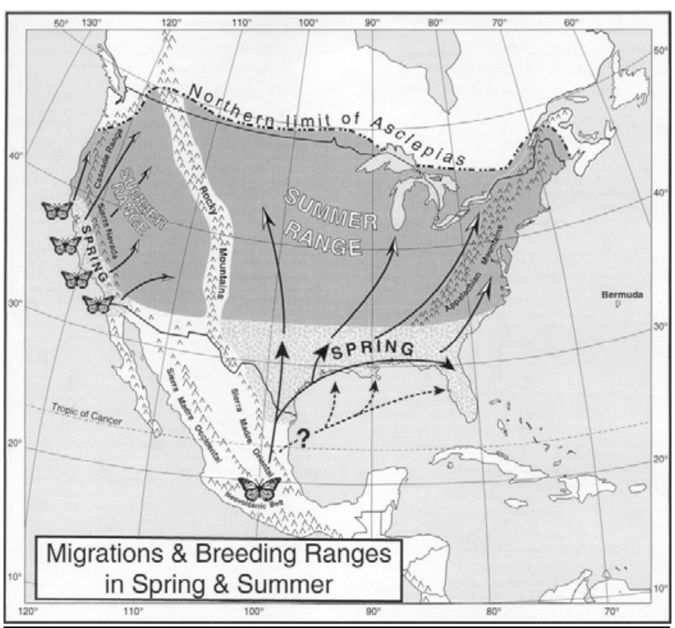
MONARCH BUTTERFLIES AND MIGRATION

The migration of monarch butterflies has been intensively studied in the years since Attenborough produced LIVING PLANET. The monarch butterflies described in the video are found east of the Rocky Mountains. Monarch butterflies are the only type of butterflies that make long, two way migrations every year. The total journey can be up to three thousand miles. Individuals only make the round trip once. The next journey will be made by their distant descendents (their great-grandchildren).

Not every monarch butterfly migrates. The ones that emerge from their chrysalides in the summer usually live only a few weeks. The monarch butterflies that emerge in late summer or fall are different. These are the monarchs that will migrate to Mexico to overwinter and then begin the return migration north in the spring. The monarchs will mate, lay eggs and die during late spring and summer. [Please note: not all butterflies make it back to their starting point. Many mate and lay their eggs along the way. The next generation may continue migrating north.] Several generations later, their descendents will leave in large numbers to migrate southward to the same wintering roosts.

More information is available about monarch butterflies from Monarch Watch, a research project at the University of Kansas. Visit their web site at http://monarchwatch.org. Thousands of volunteers monitor the monarch butterfly migrations every year. You can also get information about citizen monitoring projects involving monarch butterflies (and other species) at www.learner.org/jnorth/. Biologists at Texas Parks and Wildlife monitor monarch butterflies and encourages the public to report monarch butterfly adults or larvae to their hotline (1-800-468-9719 or 326-2231 in Austin). Watch your local paper in the fall for news stories about monarch butterflies.

So, what about those monarch butterflies born west of the Rocky Mountains? They migrate to coastal California and spend the winter in trees.



http://www.kindermagic.com/backyard_bugs.html

CONCEPTS STUDY QUESTIONS FOR EPISODE 7 – The Sky Above

1. Describe and compare the wings of insects, birds and bats.

2. Describe the chemical composition of the atmosphere.

3. Describe the layers of the atmosphere including any special characteristics of each layer.

4. Explain how damage to the ozone layer occurred and describe the consequences for living things.

5. Describe the normal greenhouse effect.

6. Describe the sources of additional atmospheric carbon dioxide produced by humans and explain how this has affected the rate of global warming.

7. Describe the consequences of global warming.

8. List and define the processes involved in the carbon cycle. Diagram the cycle and explain how the processes are related.

9. List and define the processes involved in the water cycle. Diagram the cycle and explain how the processes are related.

10. Explain how hurricanes and tornadoes are formed .

11. Describe the migration patterns of monarch butterflies.

VIDEO STUDY QUESTIONS FOR EPISODE 7 – The Sky Above

1. What is the impact of gravity on living things?

2. How do some organisms manage to avoid the impact of gravity?

3. How are dandelions seeds carried by the wind?

4. How do milkweed, cotton grass, willow herb and thistles distribute their seeds?

5. How are pollen grains distributed?

6. How are fungal spores distributed? How many are shed at one time?

7. How do tiny spiders use the wind?

Locator: Venezuela

8. Describe the seeds of the tall trees. How do the seeds of the tall trees exploit the wind and glide to new locations?

9. Describe the flying frog of Central America.

10. Describe the flying gecko (a type of lizard) of Southeast Asia. How is it different from the other flying lizard of Southeast Asia?

11. Describe the flying squirrel. In horizontal flight, how is lift generated?

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ADDITIONAL INFO. Lift occurs whenever there is a difference between air pressure on two sides of a wing. The air pressure **above** the wing is slightly **lower** than the air pressure **beneath** the wing, which is **higher.** As a result, the air pressure pushes upward on the wing, and the animal rises in the air. This is the force called **lift.** In his book, Attenborough discusses the concept of lift on pages 170-173.
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12. What are the limitations of gliding?

13. What is the most demanding portion of powered flight?

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ADDITIONAL INFO. "True powered flight" means that muscles are used to generate lift. Larger animals, as a general rule, can only fly using muscle power. Powered flight is very energy-intensive. As a result, anything that flies must eat a lot of food to sustain it. Birds, for example, eat a lot of food, despite that old misused cliche about "having the appetite of a bird." Also, weight becomes a problem, since larger animals are going to have a harder time powering themselves off the ground. Birds, for example, have bodies especially designed to weigh less. Bird bones are hollow. Their large intestine is tiny, so they cannot store wastes. Birds have replaced heavy jaws and teeth with light-weight beaks. Why? Heavy birds don't get off the ground!
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14. How do insects solve the problems of takeoff?

15. How do birds solve the problems of takeoff? What additional problems face very large birds when they try to take off?

16. What activities are accomplished in the air by damselflies?

17. How do hawkmoths lay their eggs? What do they eat and how?

18. The tiny bee hummingbird must beat its wings ________ times per second in order to remain stationary.

    What does it eat?

19. How can birds use their feathers to change the shape of the wings and facilitate flying?

20. Describe the way that kestrels hover.

21. How does the albatross get lift?

22. Where does an albatross fly in order to go against the wind? Why?

23. When are albatrosses not in the air? How big are their wings? What is the shape of their wing?

24. How do albatrosses take off? How does a flying albatross slow down?

Locator: Coast of Peru

species mentioned in this section: condor

25. How are thermals created by cliffs that lie along the coast?

26. Which bird is the heaviest of all flying birds? How do they manage to stay in the air for hours without effort?

27. What other climatic condition generates thermal currents?

Locator: Serengeti Plains of Africa

28. What parts of the plains generate heat thermals?

29. Why are vultures dependent upon thermals? How do the thermals regulate the activity of the vultures?

30. How do vultures locate carcasses?

Locator: African mountains

31. Describe the African vulture, the lammergeier, and its diet. How do the birds open the bones?

32. What are the white collared ravens learning from the lammergeier?

33. How does the pied kingfisher find food?

34. Describe the diving technique of the terns and gannets.

35. Describe the flying techniques of the peregrine falcon. What is its maximum speed during a dive?

36. Describe the flying techniques of the owls. What is unusual about the flight feathers of the owls? What is the shape of the wing? How do owls locate prey?

37. How do bats navigate?

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ADDITIONAL INFO: Bats use sonar because they are nocturnal, <u>not</u> because they are blind. Sonar is used to catch insects at night when there is less competition from insectivorous birds for the same food. Some bats do not use sonar, such as fruit bats. All bats have excellent vision, even bats that regularly use sonar to hunt.

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38. How many birds have also developed sonar navigation?

Locator: Cave in Venezuela

39. Describe the oil-birds. How does their sonar differ from the sonar of bats? What do they eat? How do they locate their source of food?

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ADDITIONAL INFO: The other bird with sonar is the swiftlet of Southeast Asia. It also lives in caves and uses clicks as its source of sonar. Its clicks are higher than those of the oilbird, so it can detect smaller objects.
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Locator: Skies Above Panama

40. Why do hawks and turkey vultures migrate?

41. How do the hawks and turkey vultures use the thermals in their migration? What do they use as food during their migration?

Locator: Atlantic Coast of United States

42. How do the phalaropes and sandpipers prepare for their migration? Why are they not able to feed along the way?

Locator: Scandinavia

43. Why do many of the migratory birds cross the narrow straits between southern Sweden and Denmark?

44. Where do small birds fly while crossing the straits? Where do buzzards fly while crossing the straits? Why?

45. Describe the migratory patterns of the red-breasted geese.

46. What other group of animals makes long transcontinental migratory flights?

Locator: South America

47. Describe the migratory patterns of the monarch butterfly.

48. Describe the migratory routes that run through the Americas. Compare these migratory routes to the migratory routes of Europe-to-Africa and Asia-to-Africa.

49. How thick is the Earth's atmosphere?

50. How is the aurora borealis formed?

51. What causes the colored sunsets and sunrises?

52. What causes rainbows?

53. As the altitude increases, what happens to the atmospheric gases? What happens to the temperature? What happens to the air pressure?

Locator: 8000 feet

54. What living organisms have been found in the atmosphere at altitudes of 4 miles?

55. How do organisms, such as spiders and winged aphids, manage to survive the extreme cold at very high altitudes?

56. How are clouds formed? Where do the water droplets in the clouds come from?

57. How are hurricanes formed?

58. How are storms formed?

59. How is hail formed? What is the difference between black ice and white ice in a hailstone?

60. How are tornadoes formed? How wide is the vortex of the tornado?

61. What is unusual about the type of water that falls as rain?

<u>CONCEPTS FOR EPISODE 8: SWEET FRESH WATER</u>

CHARACTERISTICS OF FRESHWATER HABITATS

Temperature

The temperature of a body of fresh water depends on (1) the climate of the region in which it is found, (2) the amount of sunshine it receives, and (3) the volume of water. Because of its molecular structure, water tends to resist warming and cooling. The larger the volume of water, the more slowly it changes temperature.

Shallow bodies of water normally have less volume than deeper bodies. As a result, they warm up and cool down more quickly. Also, sunshine can reach more of the water in a shallow lake or stream than it can in a deep lake or river. The more water that is exposed to the sunlight, the warmer the water will become..

Here is a problem for you to solve: You are monitoring the water quality in the Austin area. You measure the temperature of Bull Creek and Town Lake in August. Which body of water will have the higher temperature?

Oxygen

The amount of oxygen in a body of water is also important. Most aquatic animals require relatively high levels of oxygen to survive. The amount of oxygen in the water is determined by three things: (1) the absorption of oxygen from the air through the surface of the water, (2) the amount of oxygen formed by photosynthesis of aquatic plants and algae, and (3) the temperature of the water.

The absorption of oxygen from the air can be enhanced by the flow rate of a stream or river. For instance, waterfalls and rapids mix in additional oxygen, so that the water downstream has a higher oxygen level than the water upstream. (This is similar to whipping cream - you are adding air to the cream.)

Photosynthetic aquatic plants and algae produce oxygen during the day, when the sunlight necessary for photosynthesis is available. At night, the plants and algae do not produce oxygen. Instead, they use oxygen, just like animals do, to produce energy to run the biochemical reactions of their bodies. Thus, the oxygen level in a body of water that contains many plants or algae tends to vary during a twenty-four hour period. The oxygen levels will reach a maximum during the daytime, and drop at night as both the photosynthesizers and the animals consume oxygen.

The temperature of the water determines the amount of oxygen that can dissolve in the water. As the temperature increases, the amount of oxygen dissolved in the water decreases. You have probably seen fish in August at the surface of the water, trying to gulp air. That is because the water temperature is high and there is less dissolved oxygen.

Now, let's return to Bull Creek and Town Lake in August. If you said that Bull Creek should have a higher temperature than Town Lake, you are correct. Bull Creek is shallower than Town Lake, so it contains a smaller volume of water and sunlight can reach all of the water, warming it considerably. Now figure out which body of water will have the highest oxygen level.

Nutrient Levels

Another important aspect of freshwater habitats is the level of plant and algal nutrients. The most important plant nutrients in fresh water are nitrogen and phosphorus which are released by the decomposition of organic matter. When nutrients are abundant in the water, the plant and algae populations grow rapidly and become very abundant, and the water is said to be **eutrophic.** When nutrients are scarce, the numbers of plants and algae are low, and the water is said to be **oligotrophic.**

Many bodies of water are naturally eutrophic, such as a lake that receives nutrient-rich water from streams that travel through forests (a rich source for organic material). Sometimes, (too often, actually) human activities raise the nutrient levels of a lake or river. The nutrients may come from fertilizers from lawns, parks and golf courses. Or they may be released by decomposition of organic materials, such as sewage (raw or treated), erosion of rich soils, drainage from cattle feedlots, or dead animals dumped into the body of water by people who are too lazy to dispose of them properly. The process of nutrient enrichment by human activities is called **cultural eutrophication.**

An **algal bloom** occurs when algae become very abundant in a body of water. The water will look green and be very cloudy. When there is an algal bloom, oxygen levels in the water during the day are very high. But at night, the algae consume a lot of oxygen. They may consume so much that the oxygen is completely used up. Then the animals that live in the water cannot obtain oxygen and die. Also, some algae make toxic compounds, and if they become too abundant, the toxins can kill fishes and other animals directly. Algal blooms often occur during cultural eutrophication.

Now let's return to Bull Creek and Town Lake in Austin. If you said that the oxygen levels will be higher in Town Lake, you are correct, if we are considering only the effects of temperature on oxygen levels. As we determined before, the temperature should be higher in Bull Creek because it is shallower, and because warm water holds less oxygen than cool water, you might have said the oxygen should be lower. However, this is really a pretty tricky question. Temperature isn't the only thing to consider here. What if the water in Bull Creek is flowing rapidly over a surface, causing waves and ripples in the water? Will the oxygen level be higher or lower than in Town Lake? And what if there is an algal bloom in Town Lake? What will that do to the oxygen levels during the day? During the night?

RUNNING WATER: STREAMS AND RIVERS

A river may begin in the mountains, as rain falls on the high peaks and begins to flow toward the sea. At its source, the land is steep and the river, really a small stream at this stage, flows swiftly over and around rocks and boulders. The water is cold and flows rapidly, so the oxygen levels are high. Nutrient levels are low because (1) the plant communities of alpine regions do not make much organic matter to give to the river, and (2) the river has not gathered water yet from other streams and rivers, which would add to its own organic material.

The force of the water is so strong that rocks and boulders can be moved as easily as if you were moving a pillow. As the rocks and boulders roll along, they grind away at the rock bottom, wearing away deep grooves called gorges and canyons. The process of wearing away rocks and soil and carrying the small particles away is called **erosion**.

As the water flows toward the sea, more and more streams and rivers add their loads of water, nutrients and suspended soil and rock particles to the main river. The river grows larger and larger, and more nutrient rich. The amount of soil and rock particles brought down from the mountains becomes so large that the river begins to get cloudy. By the time it reaches the sea, the water will be the color of hot chocolate.

As the river reaches the lowlands, the climate becomes warmer, and the temperature of the river water begins to rise. The land begins to level off and the river slows down. As the river slows, it begins to drop its rocks and soil particles. At first only the heaviest particles drop out of the water. The very smallest particles of mud and clay remain suspended in the water. The nutrients in the river water support large populations of algae which give the river water a green color. Aquatic plants such as cat tails and rushes become established along the shore, now that the river has slowed enough that they will not get swept away.

When the river gets close to the sea, the land becomes level. The river, which is very large now, is also very slow. It winds back and forth across the level plain, seeking the path of least resistance. As water flows around a bend, the water on the outside of the bend moves faster and wears away the river bank. The water on the inside of the bend slows down and drops some of the sand and mud it is carrying, forming shoals. By this process, the river travels across its flood plain, carving away at the rich soil on the one hand, and adding nutrient rich soil from upstream on the other.

Very near where the river releases its water into the sea, the land is so level that the river finally begins to drop the smallest particles of mud. Vast deposits of mud are created as the river literally builds land out into the sea. The area of land created by the river is called a **delta.** In places where humans haven't built their own homes, the deltas are covered with marshes, vast areas of rushes and grasses where millions of birds and other animals nest and raise their young.

STILL WATER: LAKES AND PONDS

There are at least four different kinds of lakes, based on how they are formed. These include:

1. **Lakes formed by geological faults.** When large sections of the earth's surface are fractured and broken apart, deep depressions are often formed. These collect water to form lakes. Examples of lakes formed in this fashion include Lake Baikal (Russia), Lake Tanganyika (East Africa), Pyramid Lake (Nevada) and Lake Tahoe (California).

2. **Lakes formed by damming rivers.** Rivers can be dammed by volcanic activity, landslides, natural log jams (such as the one that formed Caddo Lake, the only natural permanent lake in Texas), and of course, people. The depth of a lake formed in this way depends on the landforms surrounding the river. If the river is flowing through a deep gorge, the lake that forms may be very deep. If the river is flowing through low hills, the lake will be shallower. Lakes formed in this way tend to have an irregular outline, as water is backed up into the river's tributaries. For a good example of this type of lake, look at a map of Lake Travis.

3. **Lakes formed by glaciers.** Glaciers are large bodies of ice that move slowly down slopes under their own weight. As a glacier moves along, it grinds away at the rock surface

underneath. After it melts, depressions remain that collect rain water to form lakes. The Great Lakes of North America are an example of very large lakes formed by glaciers during the last Ice Age about 10,000 to 20,000 years ago.

4. **Lakes formed by meandering rivers.** As a large river wanders around on its flood plain, the bends in the river change shape. Once in a while, the bend comes back around very close to the upstream section. During a flood, the river carves a new course, taking the shortest route, and the bend in the river is cut off from the rest of the river, forming a shallow lake. This is shown in the videotape.

AQUATIC LIFESTYLES: PLANKTON, NEKTON AND BENTHOS

Plankton are organisms that float or are weak swimmers. They go where the water currents take them. Plankton are usually divided into two broad categories: **phytoplankton** (producers) and **zooplankton** (consumers). The plankton are the basis of **open** water food webs.

Nekton are organisms that are strong swimmers. They go where they want, regardless of the currents. In freshwater systems, fishes are the main type of nekton. Nekton are consumers.

Benthos are organisms that live on or in the bottom. The bottom is called the benthic region and may be mud, sand, gravel, rocks, etc. Typical benthic animals are worms, insect young and crustaceans (such as crayfish). Other benthic organisms include bacteria, algae and protozoans. Benthic food webs include grazers, predators, scavengers and decomposers. If algae are present, they are the base of the food web. This occurs when sunlight reaches the bottom. If the bottom is dark and will not support producers, then the food webs are dependent on decomposers. The decomposers (bacteria and fungi) must rely upon material that falls onto the bottom.

LAKE ZONATION

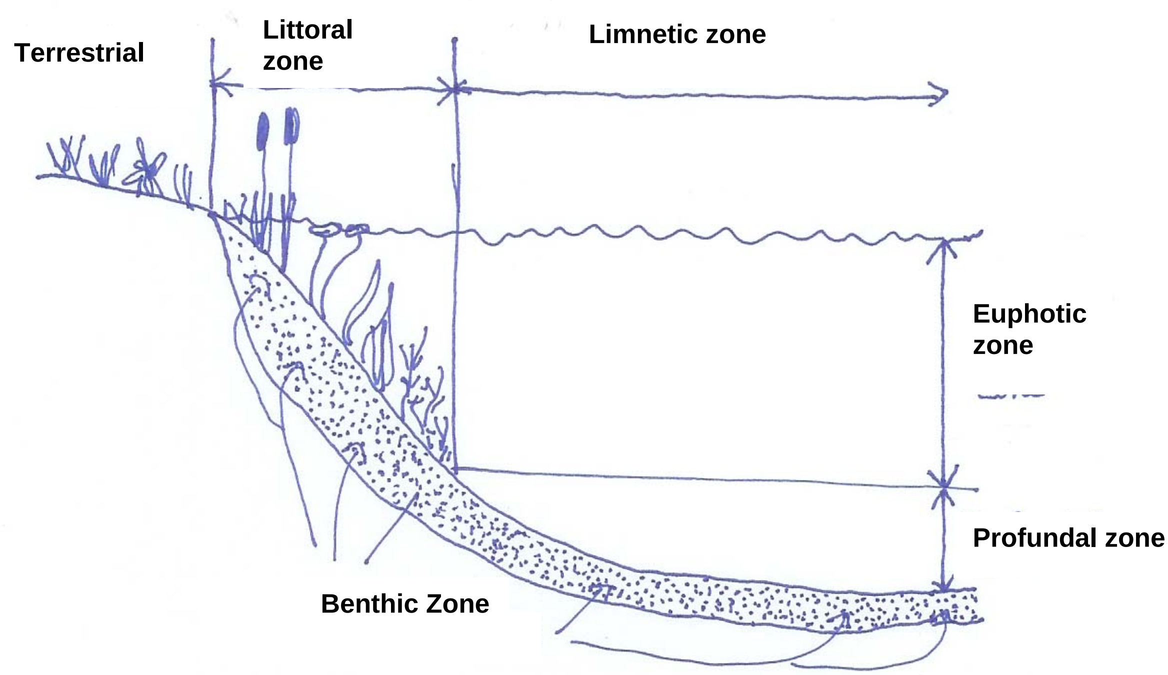
Lakes, especially deep ones, contain many different types of habitats for organisms. Along the shore of the lake, where the water is so shallow that light can hit the bottom, there is a zone of aquatic plants rooted in the mud on the bottom. This zone is called the **littoral zone.** There are lots of food and hiding places for fishes and other animals in this zone. The littoral zone has an **open water region** and a **benthic region.** The littoral benthic region is rich with organic matter, nutrients and life forms.

In deeper water where the sun does not strike the bottom, the zone of open water lit by the sun is called the **limnetic zone.** It is occupied by floating algae and cyanobacteria (the phytoplankton) and many protozoans and small animals that feed on them (the zooplankton). The zooplankton are in turn eaten by fishes (the nekton) and other large animals (such as diving ducks and otters).

In the deep parts of a very deep lake, it is always dark. All the light is absorbed by the water before it gets down to the deep parts. This dark zone is called the **profundal zone.**

Unlike the littoral and limnetic zones, where photosynthesis is the ultimate source of food, the organisms that live in the profundal zone depend on dead and dying organisms that settle out of the limnetic zone for food. Bacteria and fungi decompose the dead organisms, and protozoans and small animals eat the bacteria and fungi. Some animals are scavengers and eat the dead organisms themselves. The profundal zone has an **open water region** and a **benthic region.** Virtually all trophic activity occurs in the benthic region of the profundal zone. The profundal benthic region is quite variable depending on the lake. It usually has fewer life forms than the littoral benthic region because there are fewer nutrients and no light. In very deep lakes, the profundal benthic region can be anoxic (without oxygen).

This is a simple diagram of lake zonation.



Website for Lake Zonation:
http://trc.ucdavis.edu/biosci10v/bis10v/media/ch31/lake_zonation.html

SUCCESSION: THE LIFE OF A POND

Lakes and ponds are not permanent. In a sense, they have a lifespan just like animals, with birth, youth, middle age, old age, and death. Bodies of water undergo succession, as do terrestrial ecosystems. (Remember Unit 1?) Let's follow the "life" of a beaver pond as an example.

Birth: The pond is born when a family of beavers dam a stream. Water pools behind the dam. At first there is little life in the pond. The bottom of the pond lacks organic material to provide nutrients for plant growth. It takes a while for the algae that make up the phytoplankton to colonize the new pond.

Youth: As the stream continues to bring organic material into the pond, organic material begins to build up. Now enough nutrients are available for rooted aquatic plants to move into the littoral zone.

Middle Age: As the phytoplankton and aquatic plants die and fall to the bottom, more and more organic matter builds up in the pond, which provides more and more nutrients for more and more plants. The littoral zone begins to move farther and farther into the center of the pond.

Old Age: The stream brings in soil and rock particles as well as organic material. The combination of dead organic matter produced within the pond and the sediments brought in by the stream begin to fill in the pond. As the profundal zone fills in, the bottom eventually is close enough to the surface to be exposed to the light. Now the aquatic plants can cover the bottom of the whole lake, forming a marsh.

Death: Dead plant materials and sediments continue to build up, until the lake fills in entirely and a beaver meadow is formed.

BREEDING STRATEGIES OF FISHES

Like all other organisms, fishes must reproduce. The main goal of an organism in reproducing is to maximize the number of fertile offspring it has over its lifetime. There are a number of different strategies that fishes use to achieve this goal.

One strategy an organism may use is to feed and grow for most of its life, then use all of its stored energy to produce a large number of offspring at once, and then die. An example of a fish that uses this strategy is the Pacific salmon. A Pacific salmon hatches from an egg laid in a cool freshwater stream. The young fish feeds and grows among the rocks and gravel of the stream. When it is large enough, it begins to make its way to the ocean. After it reaches the sea, it continues to feed and grow in size for a number of years. Eventually, it reaches maturity. The fish, now very large, begins a journey that will take it back to the stream in which it hatched. As a young fish, it had memorized the smell of its birthplace. Now, the salmon uses its sensitive sense of smell to find the right stream. As it journeys up the rivers and streams to its birthplace, it must fight its way up rapids and waterfalls.

When the fish reaches its old home, it mates. If it is a male, it must fight with other males for the females. If it is a female, it lays thousands of eggs, and then the male spreads sperm over the eggs. The journey and the mating process are so difficult that the males and females are exhausted at the end. They die soon after mating, and their dead bodies provide nutrients that will nourish the algae and other organisms that their young will eat.

The young must be able to survive on their own with no help from their parents. Most of the eggs and young fish don't survive; they are eaten by various predators, or starve to death. But enough eggs hatch and enough young grow that a few of the male and female's offspring make it back to the ocean again, and return themselves to the stream to take their turn at mating.

Another strategy an organism can use is to have fewer offspring at one time, and to invest the energy it could have used to make more offspring in taking good care of the few it did have. In the videotape, you will see a couple of fishes called sticklebacks being eaten by various predators. During the breeding season, a male stickleback changes from silver all over to having a bright red throat and breast and a bright blue-green back. This color pattern indicates that he is ready to breed. He finds a suitable place to build a nest and defends it against other males. The nest is built by digging a depression in the sand and covers it with a tent made of pieces of plants he glues together with a sticky substance.

After he finishes building the nest, he begins to court females. When he sees a female with a swollen belly indicating that she is ready to lay eggs, he starts to zig and zag through the water. She responds to his dance by swimming toward the male. He turns around and leads her to the nest. She enters the nest and lays her eggs and he spreads sperm over them.

When all the eggs have been laid, the male drives away the female and any other females and males that approach the nest, protecting the eggs from being eaten. He fans the nest with his fins to make sure the developing eggs have enough oxygen. After 6-10 days, the eggs hatch. The young stay in the nest until they have used up their yolk supply. After a few days, groups of young begin to venture out of the nest, but they are still too small to defend themselves. Dad picks them up in his mouth and spits them back into the nest. He continues to do this until the young are big enough to take care of themselves.

While you watch the videotape, look for other fish species that take care of their young, such as the discus fish and the splashing tetra. How do these two fishes differ from each other and from the stickleback in the manner in which they care for the young?

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EVOLUTIONARY ASPECT: Scientists have tried to classify these breeding strategies into two main categories: **r strategy** and **K strategy**. [We are not going to discuss where the r and K comes from. If you are interested, check out an ecology book.]

r strategy: the plan is to have many, many offspring and invest as little energy as possible into each. Most of the offspring will die; however, there are so many of them that at least a few will survive. The ones that survive carry your genes into the next generation.

K strategy: the plan is to have very few offspring and invest as much energy as possible into each. Each offspring has a very good chance of survival because the parents spend a lot of time and energy providing food, protection, care, etc. for the offspring. However, because the parents spend some much time and energy on each offspring, they cannot afford to have very many. The ones that survive carry their genes into the next generation.

Obviously, both strategies work for different organisms, including both plants and animals. Bluebonnets are a good example of a plant with r strategy. The coco-de-mer palm tree (see Episode 10) is an example of a plant with K strategy. (The nut is kept on the parent tree for seven years until it is mature; the parent tree provides the nut with time, food and energy -- parental "care" for its offspring.)

You should also have gotten the message by now that nature does not pay any attention to categories created by hopeful scientists. There are many different breeding strategies that do not nicely fit into either of these two categories.
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CONCEPTS STUDY QUESTIONS FOR EPISODE 8 - Sweet Fresh Water:

1. Describe how factors such as geographical location, sunshine, and volume affect water temperature.

2. Describe how turbidity, photosynthesis and temperature affect the amount of oxygen dissolved in the water.

3. Describe how decomposition and runoff affect water nutrient (nitrogen and phosphorus) levels.

4. Compare eutrophic and oligotrophic bodies of water with respect to nutrient level, oxygen level, algae level, and turbidity (cloudiness).

5. Describe changes that occur in a river as it flows from the mountains to the sea, especially speed of current, nutrient level, temperature, oxygen level, erosion, suspended silt, and turbidity.

6. Describe what happens at the inner and outer banks at the curve of a meandering river.

7. List and compare the four processes by which lakes are formed.

8. Describe and compare phytoplankton, zooplankton, nekton and benthos.

9. Describe and compare the three main zones of a pond or lake.

10. Describe the process of succession in a beaver pond from "birth" to "death".

11. Describe and compare the two main breeding strategies (r and K) used by fish (and other organisms).

VIDEO STUDY QUESTIONS FOR EPISODE 8 - Sweet Fresh Water:

Locator: Venezuela

1. What are the effects of rainwater on mountains?

2. What is extraordinary about water? How much of the water on this planet is salty? How much is fresh water? How is the fresh water formed?

3. Describe the rivers that pass through the Andes on their way to the Amazon River. What are the problems that face organisms that live in these waters?

4. Describe the torrent ducks. What body adaptations allow them to live in these waters?

5. Describe torrent moss. What organisms live in the moss?

6. How do the caddisfly larvae live in these waters? What other strategies are used by insect larvae to keep them from being swept away by currents?

7. Describe the black fly larva. What is its strategy?

8. What other strategy is used by caddisfly larvae?

9. Describe the dipper. Where are these birds found? How do they propel themselves under water?

Locator: North America

10. Describe the hellbender. How does it avoid the currents? What does it eat? (For more info, see http://www.dec.state.ny.us/website/dfwmr/wildlife/endspec/hellfs.html)

Locator: Malaysia

11. How does the big headed turtle move through the waterfalls?

Locator: West African waterfalls

12. Describe the hairy frog. What is unusual about this amphibian? How does it keep its grip on the rocks?

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CLARIFICATION: These are not true claws like reptiles have but are really "pointy" toes.
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Locator: Amazon

13. What is carried by brown water? How do the waters manage to erode mountains?

Locator: China

14. What is unusual about the Yellow River? How many pounds of soil and mud are carried in a cubic yard?

15. When a young vigorous river encounters hard rock, what happens?

Locator: Iguazu Falls

16. How are the falls moving upriver?

17. Why do swifts perch behind the waterfalls?

18. As the rivers leave the mountains, what happens to the shape of the river? How does this change the character of the river?

19. How many different species of fish are found in the Amazon? How large does the arapima grow?

20. How have the fish evolved to suit the various conditions of the water? Use the catfish family to describe some of the varieties that have evolved to suit the various conditions.

21. How does the Discus protect its young fry?

22. What two kinds of electric charges are produced by the electric eel? What is each used for?

23. Describe the splashing tetras. How do they protect their eggs from the many predators?

24. Describe the piranha.

25. As the river gets older, it begins to loop and meander. What causes these loops? How are isolated lakes formed?

26. Describe the great Amazon lily. How do they avoid competition from other water plants? How fast can they grow?

27. Describe the flower of the giant Amazon lily. How are they pollinated?

28. Describe the jacana. What does it eat?

29. What is surface tension? How does it form?

30. Many organisms take advantage of surface tension. Describe the particular adaptations of the following:

    a. pond skater

    b. whirligig beetle

    c. larvae of the great diving beetle

    d. water boatman

    e. camphor beetle

    f. fishing spiders of Europe

31. How do the lakes and ponds that are formed by geological faults differ from the lakes and ponds that are fed by streams or created from cut-off rivers?

32. What happens to the sediments carried by a river when the river enters a lake? What conditions change for the animal life?

33. Where is the most fertile part of the lake? Why are they so fertile?

34. What problem faces organisms that try to live on the bottom of a lake?

35. Why do new species evolve in isolated lakes?

Locator: Russia

36. Describe Lake Baikal. How many unique organisms are found in this lake only? Why?

37. Describe the Baikal seal. How did it get here?

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ADDITIONAL INFO: There is an interesting article on Lake Baikal in the June 1992 issue of *National Geographic.*

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Locator: Amazon

38. What happens when the Rio Negro meets the Amazon?

39. Describe the capybara. What do they eat?

40. Describe the Amazonian otters.

Locator: India

41. Describe the gavial. What does it eat? How is it adapted for its diet?

42. Describe the hooded merganser. What does it eat? How is it adapted for its lifestyle?

43. What other animals use fish as food?

Locator: Africa.

44. What body adaptations are found in the fishing owl of Africa?

Locator: Amazon, last phase of life

45. Describe the floods that occur yearly.

46. How are the trees adapted for these flooded conditions?

47. What does the matamata turtle eat?

48. What does the herbivorous piranha eat?

49. Where is sand deposited? What type of plants grow thickly on the banks?

50. Describe the bittern.

51. How are river deltas formed? Why are they fertile?

Locator: Twin deltas of Tigris and Euphrates in Iraq

52. Describe the lifestyle of the Marsh Arabs.

53. The deltas are very rich in nutrients. Where are the following birds found?

a. snow geese

b. magpie geese

c. brolga cranes

d. scarlet ibis

e. stilts & plovers

f. flamingos

g. spoonbills – distributed over most of the world

54. Describe the Amazon delta. How much of the world's river water is contained in the Amazon alone? How wide is the mouth of the Amazon? How far into the ocean does the fresh water of the Amazon retain its identity?