LIVING PLANET
UNIT TWO

SUMMARY OF UNIT TWO MATERIAL

The videotapes to watch for this unit are:
Video Episode 3 - The Northern Forests
Video Episode 4 - Jungle

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 2 LEARNING OBJECTIVES

Video Episode 3 - The Northern Forests

To become acquainted with:

1. characteristics of conifers
2. differences between conifers and flowering plants
3. reproductive cycle of conifers vs. flowering plants
4. layers of a typical forest
5. food chains and food webs
6. types of temperate forests
7. ecology of coniferous forests: location, climate, characteristics, life forms and adaptations
8. relationship between conifers and fungi
9. relationship between voles and owls
10. characteristics of broad-leaved deciduous trees
11. ecology of temperate deciduous broad-leaved forest: locations, characteristics, life forms and adaptations
12. effects of fire on forests

Video Episode 4 - Jungle

To become acquainted with:

1. nitrogen cycle
2. ecology of jungles: location, climate, characteristics, life forms and adaptations
3. the layering (stratification) of jungles
4. the kapok trees, including location, characteristics, climatic differences, life forms and adaptations
5. the canopy, including location, characteristics, climatic differences, life forms and adaptations
6. relationship between flowering trees and animals
7. the jungle floor, including location, characteristics, climatic differences, life forms and adaptations

CONCEPTS FOR EPISODE 3: THE NORTHERN FORESTS

TREES

In forest communities, trees dominate the vegetation. There are many different kinds of trees, of course, and we can look at these in several ways. One way is to look at their growth habits. For instance, some trees are **deciduous** and others are **evergreen.** **Deciduous** trees lose all their leaves for part of the year, usually during the winter. **Evergreen** trees always have leaves. They lose leaves, but only a few at a time. Another way is to look at their evolutionary relationships. In this respect, trees fall into two main groups: the **conifers** and the **broad-leaved flowering** trees.

Conifers are **cone**-bearing trees. Their seeds develop inside cones instead of flowers. (Even though Attenborough uses the term "flower" to describe the cones, this is incorrect.) The reproductive cycle of a typical conifer, such as a pine tree, takes two years to complete. During the first year, both male and female cones are produced. The **male cones** are very small and are grouped together in clusters. They produce enormous amounts of pollen. The **female cones** are larger than the male cones, but still smaller than mature female cones. They are soft, and the eggs are located within the cone, between the scales.

The male cones release their pollen, which is carried by the wind to the female cones. Since the pine relies on the wind to spread its pollen, the male cones produce abundant pollen. Most of the pollen never reaches a female cone. The wind carries it everywhere (including our noses) instead of directly and efficiently to the female cones. The male cones must make enormous amounts of pollen to be sure some of it will reach a female cone.

The scales of the female cone have separated just enough to allow pollen to fall between the scales. When the wind-blown pollen reaches a female cone, the pollen grains fall between the scales and reach the ovules of the female cone, where the eggs are located. After pollination, the female cone closes up. So ends the first year.

During the second year, the pollen grains eat away at the ovule tissue until they reach the eggs. Then the pollen produces sperm that fuse with the eggs to form zygotes, cells that will divide to form the embryos inside the seeds. The ovules develops into seeds, and the female cones grow and mature until they are as large as the familiar pine cones used as decorations during the winter holidays.

Conifers are usually evergreens that have leaves shaped like **needles.** The shape and structure of the needles are adaptations for dry conditions. The long thin shape of the needles decreases the amount of surface from which water can evaporate. (Note: this also means there is less leaf surface for light, which decreases photosynthesis.) The leaves have a thick waterproof layer (called a rind in the videotape) that protects them from drying out. The leaves have holes through which gases enter and exit. These holes are sunken into pits, which reduces evaporation. As you will hear in the videotape, conifers often live in areas with long cold winters when water is frozen and cannot be used by the trees. So, adaptations for dry conditions, such as the structure of their leaves, help the conifers survive the winters.

Most of the conifers live in regions just south of the tundra. The summers are very short there, so the growing season may be as short as 90 days. Because the conifers are evergreen, they do not need to waste time in making new leaves in the spring. Instead, their needles can start producing food right away, allowing the conifers to maximize their growth during the short summer.

Broad-leaved trees produce their seeds inside **flowers.** They are much more closely related to other flowering plants, such as daisies and roses, than to conifers. Typically, their leaves are thin and broad, which means more light can strike the leaf (more photosynthesis). The reproductive cycle of a typical broad-leaved tree, such as an oak tree, is completed in a much shorter time than in conifers. Oak trees in the Austin area, for instance, produce flowers in the spring (March and April) and produce fruits (acorns) by September and October. Thus, broad-leaved trees can reproduce in a matter of months instead of years.

Although most flowering plants use animals to transfer pollen from flower to flower, most temperate broad-leaved trees rely on the wind instead. The wind-pollinated flowers of broad-leaved trees are inconspicuous with green petals. And they produce enormous amounts of pollen, just like in the conifers, and for the same reasons. Some broad-leaved trees have large, brightly colored flowers, such as peach trees and magnolias. These trees rely on bees and other animals to transfer pollen instead of the wind. The brightly colored petals of the flowers are signals used to attract the animals.

In the temperate regions of the planet where there are four distinct seasons, plants must get through the winter somehow. Here, broad-leaved trees are deciduous. As the nights get longer in autumn, biochemical changes in the tree trigger the dropping of leaves. All the recyclable parts of the leaf are removed and stored in the trunk and roots, so the green color disappears, revealing the brilliant oranges, reds, and golds of unrecyclable pigments. Eventually, the stalk that holds the leaf to the tree weakens and it separates from the tree. Why lose leaves just before winter? Water is not available during the winter months. Large amounts of water would be lost across the broad surface of the leaves. During the winter, lost water cannot be replaced by the absorption of water from the soil by the roots. So, it is better to get rid of the leaves all together.

This means that every spring, deciduous trees must produce new leaves. This is only possible in areas where the summers are long enough for leaf replacement, growth and reproduction. Broad-leaved forests are thus generally restricted to areas south of approximately 45 degrees North latitude.

TROPHIC RELATIONSHIPS: FOOD CHAINS AND FOOD WEBS

Trophic relationships are about food. To keep it simple, plants make food by photosynthesis. Since plants produce food from carbon dioxide and water, using sunlight as an energy source, plants are called **producers.** Any organism that utilizes the food originally produced by a producer is called a **consumer.**

Primary consumers eat living plants. You can also call them herbivores. Think of a cow or a deer or a rabbit or the flamingo from the Rift Valley (Unit 1). Secondary consumers eat primary consumers. Tertiary consumers eat secondary consumers. And so forth. So, what do you call a consumer who eats another consumer? You can either call them **predators** or **carnivores.**

Put these together and you get a simple, straight-line relationship of "who eats whom" called a **food chain:**

grass ➔ mouse ➔ snake ➔ hawk

producer ➔ primary consumer ➔ secondary consumer ➔ tertiary consumer

Are all trophic relationships this simple? Well, by now, your answer should be "no way." What do you do with the hawk that eats the snake but will also gladly take a nice juicy mousie for lunch? How do they fit into a food chain?

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grass → mouse → snake
              ↘       ↙
              hawk
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This is no longer a simple food chain, since it is not a straight-line relationship. This is the start of a **food web**, which maps out more complex eating relationships.

Now, let's add a new type of trophic relationship. What do you call a consumer that eats both plant material **and** other consumers? They are called **omnivores** (omni = all, vore = eater).

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                        fox
                     ↗       ↖
grass and berries → mouse → snake
                          ↘       ↙
                           hawk
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What about an organism that eats dead plant and animal material? If the organism is eating recently killed animals, they are called **scavengers. Scavengers** include vultures eating road kill, lions that steal a recently killed antelope from cheetahs or gulls that harass pelicans until they drop the fish from their bill pouches.

So, remember what we said earlier about relationships not always fitting into our categories? Look at the lion. You know from numerous TV programs that lions are predators. However, no self-respecting lion would pass up a free meal. Hence, they become scavengers when the pride runs across a meal caught by someone else who can be intimidated into leaving. (Which isn't too hard to accomplish, since lions are **very** big and run in gangs. What would you decide to do?)

So, what do you call an organism that breaks down long-dead plant and animal matter? It is called a **decomposer**, since the dead tissues will ultimately be broken down into small molecules such as carbon dioxide, nitrate and phosphates. Decomposers include fungi and bacteria. Decomposers are critical to an ecosystem because they return the nutrients that were "trapped" in the body of a plant or animal to the soil. Once in the soil, new producers can reincorporate them into living tissue or the nutrients can run off the soil into water where algae and water plants can use them.

Decomposers are **usually** not included in a food chain or food web based on living plants. However, many scientists often set up decomposer food webs where the dead plant and/or animal materials represent the **beginning** level. Decomposers fill the primary consumer slot. Then, there are other organisms that feed on the decomposers; they are the secondary consumers. Then tertiary consumers eat the secondary consumers and so forth. Since these are **food webs**, some consumers eat at more than one level.

CHARACTERISTICS OF TEMPERATE FOREST COMMUNITIES

One major feature of temperate forests is the presence of multiple layers of vegetation. A mature, established temperate forest usually has five layers: canopy, understory, shrub layer, ground layer and forest floor.

The tallest trees form the **canopy**. Their branches reach out and meet the branches of their neighbors, making a more or less uninterrupted layer that shades everything below, like a giant umbrella or tent. Beneath the canopy is a layer made up of the branches and leaves of smaller trees, the **understory** layer. Below the understory lies the **shrub layer**, made up of woody plants that are too short to qualify as trees. The shrub layer in its turn is taller than the **ground layer**, which consists of tender green herbs that are the shortest members of the forest community. The ground layer covers the **forest floor**. The floor is made of soil covered by a layer of leaf litter.

Leaf litter is composed of dead leaves from all the plants that extend above the forest floor. As the leaf litter decomposes it is turned into **humus** that adds texture and nutrients to the soil. The texture of the soil is important because it determines how much space there is between soil particles and that determines the ability of plant roots to grow and obtain oxygen. The more space there is between soil particles, the easier it is for the roots to grow deeper into the soil, and more air can get into the soil for the roots to use. (We're talking about **soil humus**, not a yummy Middle Eastern dish more commonly spelled as hummus.)

The types of trees in the forest determine the nature of the soil, since they determine the nature of the leaf litter. Conifer needles make leaf litter that is acidic. The acidity of the leaves hampers decomposition, so the leaf litter builds up into a thick layer that makes it difficult for young plants to get established. The slow rate of decomposition also means that less humus is made. Because there is less humus, the soils are less rich in nutrients. Thus, these forests can support fewer species of plants and the understory, shrub and ground layer are less developed than they are in broad-leaved deciduous forests. The decomposers present in the soil are the food for many different kinds of soil invertebrates. Since coniferous forest soils have fewer decomposers, fewer soil invertebrates can live there.

In contrast, the thin leaves of broad-leaved deciduous trees are easily decomposed and do not acidify the soil. The leaf litter breaks down rapidly and a lot of humus is added to the soil. The soil is thus richer in these forests than in coniferous forests. With richer soil, more plants can grow and these forests have well-developed understory, shrub and ground layers. With many decomposers happily decomposing all that lovely leaf litter, there is an ample food supply for many different kinds of soil invertebrates.

TYPES OF TEMPERATE FORESTS

Boreal Coniferous Forest

Most of the coniferous forests belong in this category, also called northern coniferous forests or the taiga. This type of forest is found south of the Arctic tundra throughout North America and Eurasia. The climate is always cold and is wet during the short summers which last really for only 1 to 3 months. Of all the forest types, the northern coniferous forest has the lowest diversity, and consists mostly of large, monotonous expanses of spruces and firs. Look for this in the video.

Montane Coniferous Forest

The coniferous forests extend south from the boreal forest along the major mountain ranges, such as the Rocky Mountains in Canada and the US, and to the Alps in Europe. In these areas, the forest is called the **montane coniferous forest.** Below the alpine vegetation is a region that looks similar to the boreal forest, although it contains different species of spruce and fir. At lower elevations, the number of conifer and other plant species (aspen, pine) increases, so the lower montane coniferous forests are more diverse than the boreal forest. The increase in diversity is due to a less rigorous climate and to the longer growing season in these more southern regions.

Temperate Rain Forest

Along the west coast of Alaska and British Columbia, extending down into Washington, Oregon, and northern California, is a very special kind of coniferous forest, the **temperate rain forest** (also called the north coast temperate coniferous forest). This region experiences high rainfall (200-300 cm per year) and cool, but rarely cold, temperatures (2-20 degrees C). Because of the abundant rainfall and relatively mild climate, the trees here grow to be giants. The canopy trees are commonly 50-75 m tall. In the redwood groves of California, the trees grow to 100 m and are over 2000 years old. Look for redwoods in the video.

This region is an important timber region, and many of the oldest, grandest trees have been cut down. Still, at this time, large regions of undisturbed (old-growth) forest remain, and environmentalists and the timber industry are involved in a bitter contest over their fate. This type of forest is found nowhere else on Earth. And it would take thousands of years for a cut-over area to return to its former glory. That is too long for the unique animal species that depend on the old growth forests to survive. If the old growth forests are removed, they will go extinct. Hence, the dilemma of the spotted owl and marbled murrelets who nest in the tall old-growth trees.

Coniferous forests are not restricted to cold climates. They are also found where the soils are poor or so well-drained that water availability is a problem. For instance, the Lost Pines of Bastrop County is a stand of loblolly pines located in an area where the soil has a high sand content. The sand makes the soil drain quickly, so the soil tends to be dryer than in the neighboring prairie areas with clay-based soils. Since conifers are better adapted to dry conditions, the loblolly pines can outcompete the broad-leaved trees in this area.

Pine Savanna

On the coastal plain of the Carolinas, Georgia and Florida, the vegetation consists of pine trees scattered over a wide area of grassland. The trees do not grow close enough together to form a closed canopy, and that lets in enough light for the grasses to grow luxuriously. This type of vegetation is called **pine savanna.** These are the forests of Florida and Georgia described in the video.

Pine savannas are maintained by fire. Broad-leaved tree seedlings are quickly destroyed by fire. But pine seedlings and grasses are protected from the fire by their structure. The growing buds of pines are protected within tufts of leaves. The growing points of the grasses are below the ground. Without fires, the broad-leaved trees would invade and eventually shade out the pines and grasses, turning this area into a deciduous forest. The fires are usually caused by lightning. What do you think the effect of humans would be on this type of vegetation? Humans tend to put out fires because fires endanger lives and dwellings. (They also tend to start them, which is another story.) In a pine savanna area inhabited by people, the naturally occurring fires are put out by the people, and the broad- leaved trees survive. Eventually, the pine savanna disappears.

Temperate Deciduous Forest

The **temperate deciduous forests** of the Northern Hemisphere once covered northeastern North America, most of Europe, and northeastern China and the Korean peninsula. Both deciduous broad-leaved trees and conifers can be found in these forests, although they are dominated by the broad-leaved trees. The tree species that make up the greatest proportion of plants in the forest differs in different areas. For example, in the northeastern United States, the deciduous forest is dominated by maple and beech trees. To the south, the dominant trees were oak and chestnut. (Most of the chestnut trees have disappeared, wiped out by an introduced fungus, the chestnut blight.) To the west, the dominant trees are oak and hickory. This type of forest is what Attenborough calls the broad-leaved forest.

Most of the deciduous forests of the world have been cut down by humans. In the United States at this time, the deciduous forest is increasing in area, as forest returns to the pastures cleared by European colonists and abandoned when their descendants moved west. In Europe and Asia, the deciduous forests are almost completely gone, and have been replaced by pastures, farmland, towns and cities.

SYMBIOTIC RELATIONSHIP BETWEEN PLANTS AND MYCORRHIZAL FUNGI

Most plants have a symbiotic association between their roots and fungi. These associations are called **mycorrhizae.** Just as in the lichens, it is the combination of both the plant root and the fungus together that is the mycorrhiza. The plant roots are connected to a mat of fungal threads that extends out from the roots into the surrounding soil. The fungi expand the amount of soil that is contacted by the roots of the plant, enabling the plant to take up greater levels of nutrients than it could by itself. In addition, the fungi secrete acids into the soil, which release certain nutrients chemically bound to the soil particles into a form that can be taken up by the mycorrhiza and sent on to the plant.

So what does the fungus get from the relationship? The fungus is supplied with food by the conifer, as well as a physical home. Thus, the fungus benefits as well as the conifer.

Mycorrhizae are very important to the nutrition of most plants. In fact, many biologists think that the first plants that moved out onto the land already had mycorrhizae, and could not have invaded the land without them. All tree species have mycorrhizae. The conifers of the boreal forest cannot survive under the rigorous conditions of the Great White North without their mycorrhizae, and the mushrooms so common in deciduous forests are usually the reproductive bodies of the mycorrhizal fungi of the forest trees. Watch for this in the video.

References: Barbour, Michael G., Jack H. Burk, and Wanna D. Pitts. 1980. *Terrestrial Plant Ecology.* Benjamin/Cummings, Menlo Park, CA.

McNaughton, S. J. and Larry L. Wolf. 1979. *General Ecology*, 2nd ed. Holt Rinehart Winston, NY.

Vankat, John L. 1979. *The Natural Vegetation of North America: An ntroduction*. Wiley, NY.

CONCEPTS STUDY QUESTIONS FOR EPISODE 3:

1. Explain the difference between deciduous trees and conifers with respect to how long they keep their leaves and why deciduous trees drop their leaves in autumn.

2. Explain how these organisms are related to each other in terms of food chains:

   a. producer, primary consumer, secondary consumer, tertiary consumer

   b. plants, herbivores, carnivores, omnivores, scavengers, decomposers

3. Describe the function of decomposers.

4. Describe zonation in a typical temperate forest.

5. Describe the process of decomposition on the forest floor.

6. Compare decomposition in temperate conifer and broad-leaf forests.

7. Describe and compare these types of temperate forest: boreal conifer, montane conifer, temperate rain forest, pine savanna, temperate deciduous forest.

8. Describe mycorrhizial associations.

VIDEO STUDY QUESTIONS FOR EPISODE 3:

1. What are the three things that living forms require in order to survive?

2. What keeps the northern forests from inhabiting the lands that are north of their boundaries?

3. Why do pine trees need to conserve water during the winter? How do they conserve water?

4. What part of the pine tree is used as food by birds and small rodents?

5. Describe the crossbill. What does it eat? How?

[NOTE: The small animals that make runways through the snow are called “voles”.]

6. What do moose use as food?

7. Describe the great gray owl and its adaptations to snow.

8. What do the other hunters eat during the winter?

    a. lynx

    b. eagle owl

    c. wolverine

9. Using the example of the lynx, explain what "cost efficiency" means to a predator.

10. Thought question: Why do many of the animals in the northern coniferous forests have large bodies?

11. Where are the northern coniferous forests located?

12. Why are the trees and the permanent inhabitants in these forests very similar to one another, even though the forests are on different continents?

Locator: Scandinavia

13. Where does the hawk owl spend the winter? Where does it nest? How is the hawk owl different from most owls?

14. Describe the capercaillie. Where are they found? What do they eat?

15. Where is the black woodpecker found?

16. Which group of birds digs their own nests out of a tree? What else do they use their sharp beaks for?

17. What insect is used by woodpeckers for food during the winter?

18. Where does the eagle owl nest?

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CORRECTION FOR THE VIDEO: Remember, conifers do not produce flowers. They produce male and female **<u>cones</u>.**
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19. Why do the northern forests have so many birds during the summer months? What do they use for food?

20. How do the caterpillars of the pine beauty moth protect themselves from their predators, the shrews? Why don't they have any defense against the wood ants?

21. Describe the sawfly caterpillar and its defense against ant predators.

22. What does the wryneck woodpecker eat? How is the wryneck different from other woodpeckers?

23. Describe the reproductive cycle of the voles.

24. Why does the vole population crash every 5-6 years?

25. How does the vole population affect the great gray owl population?

Locator: Finland

26. What is an owl pellet? Why do owls produce owl pellets?

27. Identify two reasons why birds begin to move south at the end of the summer.

Locator: Forests of Broad-leaved Trees

28. Identify four types of trees found in these forests.

29. How are the climatic conditions different in these forests from the coniferous forests of the north?

30. What shape do the broad-leaved trees have? How is their shape different from the shape of conifers and why?

31. Describe the leaves. How are they different from the leaves of conifers?

32. Which organisms use the leaves for food?

33. Why are there more birds in these forests during late summer than at any other time of year?

34. Describe the defense mechanisms that are used by the insects to protect themselves from their predators.

35. What is the difference in the way a tree creeper and a nuthatch hunt for insects on a tree?

36. Describe the woodpeckers. How are they adapted for their life style?

37. How many species of woodpeckers are found in Europe? How many species are found in North America?

38. What does the sapsucker eat? How does it collect its food?

[NOTE: A fledgling is a young bird]

39. What other animals eat sap?

40. How do acorn woodpeckers store food? Does each bird have its own store?

41. How do the plants tempt animals to transport the seeds?

42. Thought Question: What benefit does an oak tree get out of a squirrel taking its acorn? How does the squirrel benefit?

43. What does the black bear eat?

44. The possum is more closely related to ________________________ than to rats or chipmunks or other rodents.

45. Why do the broad-leaved trees shed their leaves during the winter months? Why do the leaves change from green to different colors, such as red?

46. What animals live in the leaf litter? What do they eat?

47. Describe the salamander. Why are they rarely seen?

48. Describe the shrew. What is unusual about the shrew?

49. How do salamanders protect themselves against predatory shrew?

50. What is hibernation? What changes occur in the body of the small mammals such as chipmunks that hibernate during the winter months?

51. Describe the behavior of the black bear during the winter months.

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ADDITIONAL INFO. This is called **winter sleep** instead of hibernation, because their metabolic rate does not significantly decrease. They rely upon fat supplies for energy.

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52. When spring finally comes to the forest, why do the ground plants flower so quickly?

53. Where does the wood duck nest?

54. What spring conditions cause the fungi to produce their fruiting bodies (mushrooms)? What is produced by the fruiting bodies?

Locator: Forests of Florida and Georgia

55. How are the climatic conditions of this forest different?

56. What is unusual about the oak?

57. What other type of evergreen tree is found in these southern forests? What conditions favor the growth of pines in these forests?

58. What is the effect of fire on the oaks? on pines? What protects the terminal buds of young pines? [Note: terminal buds are the growing buds at the end of each branch.]

59. What are the two causes of fires in these forests?

60. Why do dry pine needles catch fire so quickly?

61. How do many of the forest inhabitants avoid the fire?

62. Why do beetles seek areas that have been stricken by fire? How do they locate these areas? Where do they lay their eggs?

63. Why is the forest rejuvenated by fire?

64. What is different about areas that have regular fires? How does this promote swampy areas and open marshes?

65. Describe the red-cockaded woodpecker. Why does it build its nest in living trees? Does one woodpecker build the nest?

66. How is the nest of the red-cockaded woodpecker protected from predators such as the rat snake?

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ADDITIONAL INFO. The tree produces resin for itself, not for the bird. The conifer produces resin to seal its wounds and protect itself from invading fungi and insects. The woodpecker takes advantage of the resin for its own protection.
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67. Describe the giant sequoia. How old is the tree shown in the video? What is unusual about the General Sherman tree?

68. How did the sequoias get trapped in the Sierra Nevada mountains?

CONCEPTS FOR EPISODE 4: THE JUNGLE

TROPICAL FORESTS

Tropical rain forest, often called the **jungle**, is the most productive and diverse terrestrial ecosystem. Most of the tropical rain forests are located around the equator (between 10 degrees latitude north and south). The tropical rain forests are found in regions that are warm year round and receive large amounts of rain, often on a daily basis. Average rainfall varies between different rain forests but is generally around 200-250 cm per year (80-90 in/yr).

Even though Attenborough does not mention them in the video, there are other types of tropical forests. These include **seasonal forests** (with distinct wet and dry seasons), **mountain forests** (found at higher elevations), **cloud forests** (wrapped in fog and mists at even higher elevations), **gallery forests** (which line riverbeds of tropical grasslands) and **dry forests** (with dry seasons of eight months).

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Author's Note: Don't be mislead by the use of the word "tropical". According to Webster's dictionary, the tropics are between 23½ degrees N and S. Tropical rain forest is only one type of community found within the "tropics".
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CHARACTERISTICS OF TROPICAL RAIN FORESTS

As mentioned above, there are no seasons in tropical rain forests. There is little **annual** change in temperature and rainfall. There is abundant rain, which falls daily.

Another feature is the stratification of vegetation. In tropical rain forests, the upper layers are particularly thick. Most of the visible plant and animal life are located in these upper levels. If you saw the movie *Medicine Man*, you may remember the view from the top of the trees. The typical tropical rain forest layers are:

- **emergent layer** of trees that are very tall. These trees are often 50-80 meters high and are widely spaced from one another. The crown of leaves receives direct sunlight and the leaves are exposed to wind. Watch for the kapok tree.

- the **canopy,** made up of the crowns of trees less than 50 meters in height. This is a very thick layer, between 6 and 15 meters deep. This usually contains numerous trees, very tightly packed together. Their leaves form a dense continuous blanket (or canopy) of green, as the leaves compete for light. This layer is very productive due to high photosynthesis and animals are found here in great abundance. The climatic conditions of the canopy are very different from the emergent layer. There is much less light within and under the canopy due to the thick layer of leaves. This layer is very warm and humid. There is no wind. The canopy is shown clearly on the video.

- **understory** of young trees, shrubs, ferns, taller herbaceous (non-woody) plants. Dangling vines pass through this layer, linking the forest floor with the canopy. There are few plants in this layer and they are often widely spaced. Since there are fewer leaves, there is less food and animal life is scarce. The young trees, or **saplings,** cannot grow without abundant light. Watch the video for lianas and the changes that occur when light becomes available.

- **forest floor** (ground layer) of seedlings, small herbs and small ferns. This layer has very little light. The floor collects dead leaves, branches, logs and other debris. Roots spread out and form thick mats, since most nutrients are found in the upper few inches of soil. There are numerous small organisms in the leaf litter, such as ants, termites, fungi, bacteria, worms and insects. Watch the tape for: *Rafflesia*, termites, spiders, whip scorpions, planaria, *Peripatus*, beetles, blind legless burrowing lizard, phasmid, tenrec and elephant shrew.

The typical rain forest soil is another important feature. The soil is poor because many of the nutrients are washed out by the daily rains. Fortunately, the organisms in the leaf litter quickly break down debris. A leaf, for example, is totally decomposed in about 6 weeks. This rapid cycling is the main source of nutrients in the soil. As a result, nutrients are available only in the top layer of soil (about the first foot or so). Also, nutrients have to be rapidly absorbed by the plants or they might be washed out. As a result, the roots of the trees are shallow and concentrated in the first foot of soil.

This, by the way, is a potential problem for a tree. Think about it. You have a tree that is 50 meters tall (about 150 feet). Yet, most of its roots are anchored in 1 foot of soil. The trees get around this by having **buttresses,** outgrowths that act as props. Look for these in the video.

Another noticeable feature is the presence of abundant plant life among the trees. Tropical rain forests have abundant **epiphytes** with aerial roots, such as the orchids and bromeliads shown on the tape. (An epiphyte is a plant that is attached to the outside of another plant but is not a parasite.) Vines known as **climbers,** or lianas, stretch from the tree tops to the ground. Climbers use the tree trunks for support but do not harm the tree. Other vines called **stranglers,** such as strangler figs, surround host trees in order to gain light.

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ADDITIONAL INFO: The following tidbit about strangler figs is taken from the April 1997 *National Geographic*. Recent studies indicate that strangler fig seeds actually sprout high in the canopy and then grow their roots to the ground. They "strangle" the host tree so tightly that the tree may die because it cannot transport water and nutrients to its own tissue.

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NITROGEN CYCLE

In the "Concepts for Episode 3", we spoke about decomposers returning nutrients to the soil. Nutrients include carbon, oxygen, hydrogen, phosphorus, nitrogen, sulfur and other elements that are used as building blocks of living tissue. [So what does that mean? Lipids, proteins, carbohydrates and nucleic acids are made of these nutrients.]

The growth of plants is often restricted by the levels of nitrogen and/or phosphorus. In woody plants, like trees, these nutrients are bound up for years in the body of the plant. When a tree dies, decomposers release the nutrients into the soil. Other plants can then use these newly available nutrients to grow.

We are going to discuss the nitrogen cycle in greater detail as an example of how nutrients flow through an ecosystem. Keep in mind that there are several different nutrient cycles. Any decent ecology textbook will contain the cycles for water, carbon, nitrogen, phosphorus and sulfur.

Most of the nitrogen on our planet is in the form of atmospheric nitrogen, N_2, which is the most common gas in our atmosphere (about 79%). Unfortunately, plants cannot use atmospheric nitrogen until it is converted into ammonia (NH_3), nitrite (NO_2) or nitrate (NO_3).

The process of converting atmospheric nitrogen into forms that plants can use is a multi-step process that depends upon many kinds of bacteria. Each kind of bacterium carries out a specific step in the process.

Step 1 - Nitrogen fixation. Atmospheric nitrogen is converted (**fixed**) into ammonia by cyanobacteria (blue green algae) in water, free-living bacteria in the soil (such as *Azotobacter*) and symbiotic bacteria (such as *Rhizobium*) in the root nodules of plants in the bean and pea family (legumes). These are the only organisms that can fix nitrogen. All life on this planet depends on these organisms for usable nitrogen, either directly or indirectly. (That means that you can thank them for the nitrogen in your proteins and nucleic acids.)

Now, for the sake of being technically correct, some nitrogen is fixed by lightning or volcanic activity. This accounts for a **very** small percentage of usable nitrogen, not nearly enough to support life.

Step 2 - Nitrification. This is a two-step process. First, ammonia is converted into nitrite (NO_2) by a specific group of bacteria (such as *Nitrosomonas*). Then, nitrite is converted into nitrate (NO_3) by a different group of bacteria (such as *Nitrobacter*).

Step 3 - Assimilation. Most terrestrial plants use nitrates because it is available. The roots of the plant take up nitrate from the soil. Plant cells then convert nitrate back to ammonia and use it to make proteins and nucleic acids (DNA).

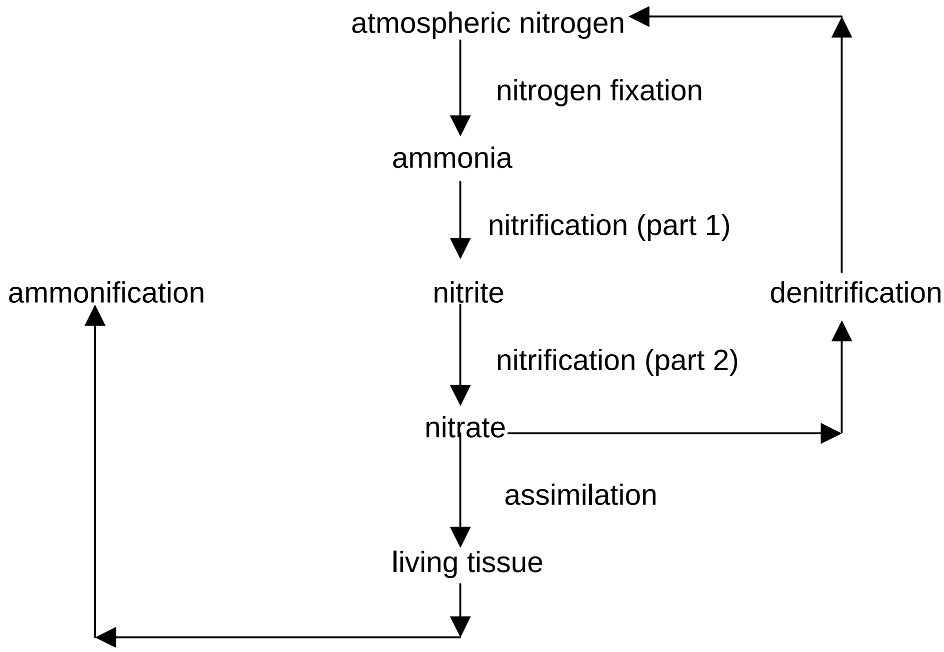
After assimilation by the plants, the nitrogen can move up the food chain as primary consumers eat plant parts and as secondary consumers eat primary consumers and so forth. At this point, the nitrogen is somewhere in the body of a living organism.

So what happens next? Well, there are several options. You can get eaten, in which case your nitrogen becomes part of the next guy. You can give off wastes (such as urine and feces), in which case the nitrogen goes to the decomposers (see step 4 below). You can die and decay, in which case the nitrogen goes to the decomposers. If you are a plant, your leaves can fall off, in which case the nitrogen in the leaves goes to the decomposers. Get the picture?

Step 4 - Ammonification. The nitrogen in proteins and nucleic acids is converted back to ammonia by the decomposers (bacteria **and** fungi). Now, ammonia goes back to step 2 and starts the process all over again.

Now, this seems simple. By now, you should be suspecting that anything this simple is too good to be true. And, you would be right. In actuality, there are two possible pathways for nitrate. We have just described the most common cycle where the nitrates are used by plants to form living tissue. There is an alternate pathway. Nitrates can be converted back into atmospheric nitrogen by a different group of bacteria. This process is called **denitrification** and the bacteria are called **denitrifiers.** This takes the nitrogen back to the beginning of the cycle.

Here's a simple diagram of the nitrogen cycle.



References:

Smith, Robert Leo. 1992. *Elements of Ecology,* 3rd edition. HarperCollins New York.

Ricklefs, Robert E. 1990. *Ecology,* 3rd edition. W.H. Freeman, New York.

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CONCEPT CHECK: Many of our students have struggled to understand the nitrogen cycle. To check your understanding, answer the questions below and then check our answers on the next page.

Q1. What is denitrification? What organisms are responsible?
Q2. What is nitrification? What organisms are responsible?
Q3. What is nitrogen fixation? What organisms are responsible?
Q4. What is assimilation? What organisms are responsible?
Q5. What is ammonification? What organisms are responsible?
Q6. What is the difference between the nitrogen cycle and nitrogen fixation?
Q7. What is the difference between the nitrogen cycle and any of the steps of the cycle (nitrification, ammonification, etc.)?

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ANSWERS TO THE CONCEPT QUESTIONS:

Q1. **Denitrification** refers to the conversion of nitrates back into atmospheric nitrogen. Bacteria are responsible for this step. (Specifically, these bacteria are called **denitrifying bacteria.**)

Q2. **Nitrification** is a two-step conversion of (1) ammonia into nitrites, and (2) nitrites into nitrates. Both steps require bacteria; these bacteria are called **nitrifying bacteria.**

Q3. **Nitrogen fixation** is the conversion of atmospheric nitrogen into ammonia. Biologically, the conversion is done by cyanobacteria in water, bacteria such as <u>Azotobacter</u> in the soil and symbiotic bacteria such as <u>Rhizobium</u> in the roots of legumes. These bacteria are grouped together as **nitrogen-fixing bacteria.**

Q4. **Assimilation** is the conversion of nitrates into proteins and nucleic acids. **Plants** are responsible for this conversion.

Q5. **Ammonification** is the release of ammonia due to the breakdown of proteins and nucleic acids. Bacteria and fungi are responsible for this step; these organisms are known as the **decomposers.**

Q6 and Q7. What is the difference between the nitrogen cycle and nitrogen fixation? [or any of the steps of the cycle]

The **nitrogen cycle** is the entire process and includes every step in which nitrogen is converted from one form into another. (Look at the diagram to see the entire process or cycle.)

Nitrogen fixation, on the other hand, is a **single step** in the cycle. Nitrogen fixation is **LIMITED ONLY** to the conversion of atmospheric nitrogen into ammonia.

So, a cycle is made up on many individual steps. The cycle is not any one step but is the cumulative total of all steps.

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BIODIVERSITY

A hot topic today is biodiversity. **Biodiversity** refers to the **number** of different <u>types</u> of organisms and the **relative abundance** of each. What is relative abundance? It is the percentage of one species relative to all species in the community.

Let's look at these two examples. Each community has 100 members and 5 species.

Community A	**Community B**
50 spruce trees	20 live oak trees
25 aspen trees	20 post oak trees
15 blueberry bushes	20 ashe juniper trees
9 wintergreen herbs	20 hackberry trees
1 ladyslipper orchids	20 cedar elms

So, what's the **relative abundance** of spruce trees in Community A? 50% Aspen trees? 25% Blueberry bushes? 15%. You figure out the rest.

Now, let's go back and look at **diversity.** In Community A, spruce trees are clearly the most common plant. It is the **dominant** plant in the community, since it appears far more frequently than any other. What about Community B? Is there a dominant plant?

If you said "no", you are correct. Each plant occurs at the same frequency (20%) and no one species is dominant. A community is considered to be **more diverse** when there is no dominant species. It is **less diverse** if one or two species are clearly dominant.

Now, let's compare different forests, (plant biodiversity ONLY):

Tropical rain forest - as many as 200-300 species of trees
- no one species is dominant
- high biodiversity

Temperate deciduous forest - perhaps 20-25 species of trees
- 1-2 species are dominant
- medium biodiversity

Northern coniferous forests - perhaps 6-8 species of trees
- 1 dominant species
- low biodiversity

Keep in mind that biodiversity applies to all ecosystems. You can talk about animal biodiversity, plant biodiversity, insect biodiversity, total biodiversity or anything you care to actually go out and count.

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ADDITIONAL INFO: The Earth Almanac section of the May 1997 issue of *National Geographic* describes the biodiversity of a 129-acre plot in a national park in Malaysia. 1175 tree species were found; this means that there are 9.1 **different** species of trees **per acre** in this forest, making it "one of the most diverse forests in the world".

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Why is biodiversity a hot topic? First, humans do not surround themselves with diversity. We convert naturally diverse communities into urban areas or agricultural areas. Look around Austin. Do you think this is a diverse habitat? Look at your neighborhood. What's there? We'll bet on St. Augustine grass and maybe 4-5 species of trees. What about a wheat field? Do you think a farmer is going to be thrilled about mixing his wheat crop with a bunch of "weeds"?

Secondly, the loss of habitat means that species disappear and some become extinct. When species begin to disappear, the ecosystem changes and no longer functions properly. Humans, just like all other animals, rely upon ecosystems for food, oxygen, and other necessities. At some point, as more and more ecosystems stop properly functioning, the planetary ecosystem may be disrupted to the point that our life on earth is threatened. Some people think this is a "radical, wild-eyed" theory but how willing are you to chance it?

The February 1999 issue of *National Geographic* is devoted to the topic of biodiversity. While there are several concepts discussed in this issue of the magazine, we have chosen to give you some highlights from "The Sixth Extinction" written by Virginia Morell. According to her article, about 50% of the world's plants and animals may be extinct within the next 100 years. Please note that this is a **worldwide** problem, not just limited to tropical rain forests. Other grim news: 11% of all bird species are on the verge of extinction; 12.5% of all plant species are at risk. (Are you getting nervous yet? We are!)

GLIDING AS A MEANS OF TRANSPORTATION

In the videotape, Attenborough discusses the flying squirrel, which is able to move from tree to tree by gliding. This allows the animal to move around in the canopy without descending from one tree trunk, crossing the ground, and ascending the next tree trunk. It is also a less energy-demanding means of moving than flying. On the other hand, animals who fly have more control.

Gliding is not limited to squirrels and snakes. Borneo also has a species of flying lizard. On either side of its body, it has a flap of skin which is stiffened by bony processes from the ribs. While gliding, the ribs are pulled forward, which extends the flaps. Flying frogs have very long toes, which are webbed. As the frog glides, the webbed toes act as tiny "parachutes". (This information and a picture of the flying lizard can be found in Attenborough's book, pages 98-99.)

Website for flying lizard: http://www.wildasia.net/main.cfm?page=article&articleID=324

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ADDITIONAL INFO: There is a superb article on strangler fig trees in the April 1997 issue of *National Geographic* (pages 38-55). In addition to the role of strangler fig trees in the jungle, the article discusses

1) the symbiotic relationship between fig trees and fig wasps,
2) competition for space to lay eggs among different species of wasps, and
3) the role of ants in dispersing the seeds of strangler figs.

One important tidbit from the article: The food supply from figs is almost always available in the jungle. The members of one species of fig tree all bear fruit at the same time. However, there are several different species of fig trees; each species bears fruit at a different time from the others. Hence, there is almost a continual supply of figs somewhere in the jungle. Many animals rely almost exclusively on figs for food. As a result, fig trees are considered to be **keystone species** in the jungle ecosystem.

What is a **keystone species?** This means that the organism plays a central role in the functioning of the ecosystem. If the keystone species dies out, this causes a domino effect. Every animal that depends on the keystone species dies out. Their predators then die out and the effect spreads through the food web. The net result: the ecosystem collapses.

The environmental problem: do you trust our ability to determine which species are keystone species **before** we wipe them out?

Websites for Strangler Fig Trees:

http://www.blueplanetbiomes.org/strangler_figs.htm
http://www.mongabay.com/04strangler_fig.htm
http://waynesword.palomar.edu/ploct99.htm

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CONCEPTS STUDY QUESTIONS FOR EPISODE 4:

1. Describe the general location of tropical rain forests and the climatic conditions that exist where these forests are found.

2. Describe the stratification seen in a typical tropical rain forest and the types of plants found in each layer.

3. Compare light, wind, and moisture conditions in the layers of a tropical rain forest.

4. Explain why the soil in tropical rain forests is low in nutrients.

5. Explain why organisms need nitrogen.

6. Describe each step in the nitrogen cycle. Be able to draw a diagram showing the relationship between these steps or processes, the various forms of nitrogen (nitrate, nitrite, ammonia, atmospheric nitrogen), and living tissue.

7. Explain the ecological significance of these organisms: cyanobacteria, *Azotobacter*, *Rhizobium*.

8. Describe the two meanings of biodiversity.

9. Calculate relative abundance for each species in this community:

	relative abundance:
20 oak trees	
25 sugar maple trees	
40 chestnut trees	
9 black walnut trees	
8 shagbark hickory trees	
6 grape vines	

10. Based on what you learned about chestnut trees in Concepts for Episode 3, is the community described in #9 likely to be a currently existing plant community in the United States? Explain your answer.

11. Explain how dominance and diversity are related.

12. Explain what is meant by the term “keystone species”.

VIDEO STUDY QUESTIONS FOR EPISODE 4:

Locator: Jungle

species mentioned in this section: harpy, crowned eagle, hawk eagle, squirrel monkey

1. Which terrestrial ecosystem has the greatest number and greatest diversity of animals? Why?

2. Where are the jungles located?

3. Describe the kapok tree.

4. How are climatic conditions different for the kapok tree?

5. What is a disadvantage of wind to the kapok tree? an advantage?

6. Which birds live in the kapok tree? What other similar birds are found in other giant trees of other jungles? What do they eat?

7. How are conditions different in the canopy?

8. What adaptation is found in the leaves of canopy trees?

9. Describe the weaver ants.

10. What other animals are found in the jungle canopies?

11. Describe the flowering cycle of the jungle plants. How is this different from the other forests?

12. How do the plants distribute pollen?

13. How are seeds dispersed?

14. What do the fruit bats eat? What do most of the other bats eat?

15. Describe the pygmy marmosets. What are sap wells?

16. How are the spores of mosses and ferns transported?

17. Describe the orchids and bromeliads. How do they collect moisture?

18. Describe the breeding cycle of the arrow poison frog.

19. What are the lianas? How are they used by the jungle inhabitants?

20. How do snakes climb the tall trees of the forest?

21. How does the paradise tree snake move from tree to tree?

Locator: Borneo

species mentioned in this section: golden lion marmoset

22. Describe the flying squirrels.

23. How do other animals move through the canopy?

24. Where do termites nest? How do other animals use termite nests?

25. Describe the macaw and its nesting behavior.

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CORRECTION FOR THE VIDEO: Birds do not chew food. They swallow food in chunks, which is then broken up by a muscular gizzard.

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26. What other animals nest in holes in the trees?

27. Why do jungle trees have buttresses?

28. Describe the forest floor. What provides sustenance on the floor?

29. What two factors promote rapid decomposition of the jungle leaf litter?

30. Name the two main groups of organisms that are responsible for the decay of the leaves in the leaf litter.

Locator: Sumatra

species mentioned in this section: planarian worm, Peripatus

31. Describe the parasitic plant, *Rafflesia*. How does its flower attract pollinators?

32. How are the seeds of the *Rafflesia* plant spread?

33. What provides food for the termites on the forest floor? Why are termites important to this ecosystem?

34. How do the termites protect themselves?

35. What other animals inhabit the leaf litter?

Locator: Madagascar

36. Describe the tenrec. Where does it live? What does it eat?

37. Describe the elephant shrew of Africa. How does it locate food in the leaf litter?

Locator: Ecuador

species mentioned in this section: howler monkey, gibbon

38. Describe the life style of the South American Indians (Waorani).

39. How do they harvest their favorite fruit, the chunta?

40. Why do the Waorani plant cecropia trees?

41. What physical adaptation has occurred in the Waorani? What is the advantage of this adaptation?

42. Why do many jungle animals use sound to communicate?

43. What other methods are used by animals to communicate?

Location: Borneo

44. Describe the mating dance of the argus pheasant of Southeast Asia.

Location: South America

45. Describe the mating displays of the cock-of-the-rock.

46. Describe the climatic conditions of the jungles.

47. How old are the jungles? What has been the effect of the great age of the jungles on the jungle inhabitants?

48. Describe the various ways that insects have developed to look like other objects (mimicry).

49. **Thinking Question:** What is one advantage of mimicry?

50. What problems are created by the drenching torrents of rain? What effect does this have on the soil?

51. Describe the jaguar. Where is it usually found? What does it eat?

52. How do white tent-making bats use the leaf of the heliconia?

53. Describe the changes that occur when a tree dies.

54. How long does it take before the canopy is complete again?