Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Period: \_\_\_\_\_

**Unit 10, Part 3 Notes – Community Ecology**

AP Biology

**What is a community?**

1. A group of species that occur together in a geographic area. A community differs from a population in that a community involves many different species, whereas a population involves organisms from a single species.

**How do we define a species’ “role” within a community?**

2. The sum total of a species’ use of and contribution to the **biotic** (living) and **abiotic** (nonliving) resources in its environment is called the species’ **ecological niche**. As a result of competition and other factors, a species’ **fundamental** **niche**, which is the niche potentially occupied by that species, may be different from its **realized niche** that is the niche the species actually occupies. For example, eating worms is part of our fundamental niche but (hopefully) not part of our realized niche.

**How is energy transferred within a community?**

3. **Food chains** show the transfer of energy from one group of organisms to another (i.e. as one group eats the other!). Each level of organisms to which energy is transferred is called a **trophic level**. When energy is transferred from just one group to the next, the result is a food chain. **Food webs**, in contrast, allow us to depict multiple food sources for each group of organisms and more accurately reflex the complex interactions within the community. A food chain and food web are shown below.

 

 4. Below are the trophic levels within a community. The word **trophic** comes from a greek word meaning nourishment. Therefore the term trophic level refers to the feeding interactions that are the basis for food chains and food webs.

A. **Producers**: Organisms that are able to make their own food either from the energy in sunlight (photosynthesis) or from simple organic compounds (chemosynthesis). Examples of producers include: Plants, algae, and some types of bacteria

*Note: A synonym for producer is* ***autotroph*** *(i.e. “self feeder”).*

B. **Primary Consumers**: Organisms that eat the producers (commonly called herbivores).

*Note: A synonym for consumer is* ***heterotroph*** *(i.e. “different feeder”)*

C. **Secondary Consumers**: Organisms that eat the primary consumers (commonly called carnivores).

D. **Tertiary Consumers**: Organisms that eat the secondary consumers (carnivores).

E. **Quaternary Consumers**: Organisms that eat the tertiary consumers (carnivores).

F. **Detritivores / decomposers**: Organisms that break down dead organic matter (aka detritus) and recycle the nutrients into the ecosystem (ex: soil bacteria that return nitrogen to the soil from decaying animals).

5. Some organisms can fill multiple trophic levels. For example, in the food web shown on the previous page, squid can be secondary consumers (if you follow this food chain within the food web: phytoplankton 🡪 copepods 🡪 squid) or tertiary consumers (if you follow this food chain within the food web: phytoplankton 🡪 copepods 🡪 carnivorous plankton 🡪 squid)

6. A community cannot have higher trophic levels beyond the quaternary level because the efficiency of energy transfer between the levels (aka **trophic efficiency**) is so low. Several reasons for this are given below.

-Plants convert light energy to chemical energy stored in the bonds of the molecule glucose. Only a portion of this chemical energy is stored in the tissues of the plants as glucose and other molecules (ex: starch, proteins, fats), however. Some of the glucose created using light energy is used in cellular respiration within plant cells and therefore its energy is “lost” to the environment.

*Note: Chemical energy stored in the tissues of any organism is known as biomass. It can be measured by taking the dry mass of the organism. Once all the water has been removed from an organism, all that is left are the molecules that make up the organism’s cells and tissues. Because chemical energy is stored in the bonds of these molecules, biomass is not only a measure of mass, but also a measure of stored energy.*

-For consumers, the chemical energy that they gain from digesting plants or animals is not all stored in the animal’s cells and tissues in the form of energy-rich molecules. Some of the energy is lost due to cellular respiration, and some is lost in the form of waste (ex: poop!)

-Additionally, not all parts of a consumer’s food can be digested (ex: humans cannot digest animal bones). This is another reason for the low rate of trophic efficiency.

7. A change in any one of the trophic levels can cause a **trophic cascade**. This occurs when a predator or its food source either increases or decreases drastically. Because of the multiple interactions of organisms what happens to a predator is felt not only by their prey, but also by the prey of their prey and by many other species connected to them.

8. Usually **only about 10% of energy from one level can be transferred up to the next trophic level** (i.e. stored as **biomass** in organisms at the next trophic level). Therefore, a large number of producers can only support a very small number of top consumers. We can depict this inefficiency of energy transfer using three types of diagrams:

A. **Pyramid of Production (aka Pyramid of Energy):** shows the amount of energy stored in the tissues of organisms on each trophic level, where energy is measured in Joules, kilojoules (aka calories), kilocalories, etc.



B. **Pyramid of Biomass**: each tier (level) represents the total dry weight (**biomass**) of all organisms in one trophic level. “Most biomass pyramids narrow sharply from primary producers at the base to top-level carnivores at the apex because energy transfers between trophic levels are so inefficient” (Campbell Biology).

****

“Certain aquatic ecosystems, however, have inverted biomass pyramids. Primary consumers outweigh the producers. Such inverted biomass pyramids occur because the producers—phytoplankton—grow, reproduce, and are consumed so quickly by the zooplankton that they never develop a large population size, or standing crop. Because the phytoplankton continually replace their biomass at such a rapid rate, they can support (from an energy standpoint) a biomass of zooplankton bigger than their own biomass” (Campbell Biology). An example of part of a biomass pyramid from an aquatic ecosystem where this is the case (the English Channel) is given below along with some examples of phytoplankton (tiny aquatic plant-like organisms) and zooplankton (tiny aquatic animal-like).



**Types of phytoplankton:**





C. **Pyramid of Numbers**: shows the actual number of organisms at each trophic level



**How much energy can photosynthetic producers harvest from sunlight?**

9. Energy enters communities through primary producers. The **primary production** is the amount of light energy converted to chemical energy by autotrophs in a particular area during a given period of time.

10. Solar energy is absorbed, scattered or reflected back by various surfaces or by the atmosphere. Bare ground and bodies of water absorb or reflect most of the incoming energy and make it useless for living organisms. Mostly the red and blue wavelength of the visible light range is used for photosynthesis but only 1 % of the visible light will really be converted to chemical energy stored in primary producer’s tissues.

11. **Gross primary production (GPP)**: the total primary production in an ecosystem which is the amount of light energy that is converted to chemical energy by photosynthesis per unit area per unit time. The units used are J/m2/yr or g/m2/yr.

12. **Net primary production (NPP)**: is the amount of chemical energy producers can actually store in their tissues as biomass. NPP is equal to the gross primary production minus the amount of energy used by producers for respiration **(NPP = GPP – energy used for respiration).** The units used are J/m2/yr or g/m2/yr.

*Note: If we know the dry mass (aka biomass) of the producers in grams, we can convert this value to joules, kilojoules (also called calories), or kilocalories (all direct units of energy).*

13. The net primary production can also be described as the amount of energy that will be available to the primary consumers in an ecosystem when they eat the producers.

14. **Secondary production (SP)**: the amount of chemical energy in primary consumers’ food that can be stored in their tissues as biomass. Most of their food (i.e. the producers they eat) cannot be converted to biomass because it is indigestible or its energy is used for waste or cellular respiration. **SP = NPP – energy used for respiration – energy lost as waste.**

15. Below I have included diagrams related to GPP, NPP, and SP.



16. Different ecosystems vary considerably in their net primary production and in their contribution to the total net primary production of the Earth. Terrestrial areas that are warm and wet tend to have a higher average net primary production measured in g/m2/year (figure “b” below). However, because oceans comprise the highest percentage of the Earth’s surface area (figure “a” below), they contribute the highest percentage of Earth’s net primary production (figure “c” below).



**What are some consequences of food web structure?**

17. “Because consumers must often consume many organisms from the trophic level below them to meet their energy requirements, biomagnification of toxic substances can occur.  **Biomagnification** is the increasing concentration of persistent, toxic substances in organisms at each trophic level, from the primary producers to the apex consumers. Many substances have been shown to bioaccumulate, including classical studies with the pesticide **d**ichloro**d**iphenyl**t**richloroethane (DDT), which was published in the 1960s bestseller, *Silent Spring*, by Rachel Carson. DDT was a commonly used pesticide before its dangers became known. In some aquatic ecosystems, organisms from each trophic level consumed many organisms of the lower level, which caused DDT to increase in birds (apex consumers) that ate fish. Thus, the birds accumulated sufficient amounts of DDT to cause fragility in their eggshells. This effect increased egg breakage during nesting and was shown to have adverse effects on these bird populations. The use of DDT was banned in the United States in the 1970s.

18. Other substances that biomagnify are polychlorinated biphenyls (PCBs), which were used in coolant liquids in the United States until their use was banned in 1979, and heavy metals, such as mercury, lead, and cadmium. These substances were best studied in aquatic ecosystems, where fish species at different trophic levels accumulate toxic substances brought through the ecosystem by the primary producers. As illustrated in a study performed by the National Oceanic and Atmospheric Administration (NOAA) in the Saginaw Bay of Lake Huron (see the graph given below), PCB concentrations increased from the ecosystem’s primary producers (phytoplankton) through the different trophic levels of fish species. The apex consumer (walleye) has more than four times the amount of PCBs compared to phytoplankton. Also, based on results from other studies, birds that eat these fish may have PCB levels at least one order of magnitude higher than those found in the lake fish. (See the figure on the next page)



*This chart shows the PCB concentrations found at the various trophic levels in the Saginaw Bay ecosystem of Lake Huron. Numbers on the x-axis reflect enrichment with heavy isotopes of nitrogen (15N), which is a marker for increasing trophic level. Notice that the fish in the higher trophic levels accumulate more PCBs than those in lower trophic levels. (credit: Patricia Van Hoof, NOAA, GLERL)*

19. Other concerns have been raised by the accumulation of heavy metals, such as mercury and cadmium, in certain types of seafood. The United States Environmental Protection Agency (EPA) recommends that pregnant women and young children should not consume any swordfish, shark, king mackerel, or tilefish because of their high mercury content. These individuals are advised to eat fish low in mercury: salmon, tilapia, shrimp, pollock, and catfish. Biomagnification is a good example of how ecosystem dynamics can affect our everyday lives, even influencing the food we eat” (Openstax Biology).

**How can we determine the stability of a community?**

20. A community that has a high **species diversity** (aka biodiversity) tends to be less vulnerable to ecosystem disturbances.

21. Species diversity is controlled by two factors… **species richness** – the total number of different species and **relative abundance** – the proportion of each species to the total number of individuals.

22. A higher species richness and a more “even” relative abundance (equal numbers of organisms of each species) contribute to a higher species diversity.

Note: For the diagram below, both communities (1 and 2) have the same species richness (four species each), but community 1 has a higher (more even) relative abundance. Therefore, community 1 has a higher species diversity than community 2.



Note: Species Richness tends to vary with latitude. It has been shown that species richness increases toward the equator. This is believed to be the case because over long time spans, climate conditions have been more stable in the tropics than in temperate regions. Further the warm, moist environment often promotes rapid growth of primary producers, which means that the NPP often increases towards the equator as well.

**How do different species interact within a community?**

23. **Symbiosis** is defined as any close relationship between members of different species. The types of symbiosis are given below:

A. **Mutualism** (+/+): A relationship where both species benefit (ex: plants and their insect pollinators)

B. **Commensalism** (+/0): A relationship where one species benefits and the other is neutral—neither helped nor harmed (ex: cattle and the birds that follow them and eat the insects they stir up in the dirt)

C. **Ammensalism** (-/0): A relationship where one species is harmed while the other is unaffected (ex: elephant walking through the grass where the grass is crushed and elephants are neither helped nor harmed)

D. **Parasitism** (+/-): A relationship where one species (the parasite) benefits and the other species (the host) is harmed (ex: a tapeworm living in human intestines). In this relationship, the host does not die because the parasite cannot survive for long without a host.

E. **Predation** (+/-): A relationship where one species benefits and the other is harmed. The first species (the predator) eats the second species (the prey). (ex: a lion killing a gazelle)

F. **Competition** (-/-): A relationship where both species are harmed because they use the same resources. There are two types of competition…

* **Intraspecific competition**: competition between members of the same species (ex: two foxes competing for the same rabbit)

*Note: IntrAspecific is between the sAme species (both have As)*

* **Interspecific competition**: competition between members of different species (ex: a pine tree and an elm tree competing for sunlight)

*Note: IntErspecific is between diffErent species (both have Es)*

* Strong competition can lead to the local elimination of one of the two competing species – **competitive exclusion principle**. Even slight advantage in using resources more efficiently can result in a reproductive advantage for one species and drive the other to extinction.
* At times two species that compete for resources will evolve differently from each other so they do not compete for the same resources anymore and they can coexist in the same community – **resource partitioning.**

***Competitive Exclusion Principle Resource Partitioning***

 

**Are some species more “important” than others within a community?**

24. **Dominant species** – the species that is so abundant that it has the highest biomass (total mass of all individuals in a population) of any species in the community. In terrestrial ecosystems, dominant species are always primary producers because consumer biomass is always less than producer biomass. Removing a dominant species can decrease the biodiversity within an ecosystem.

“For example, the American chestnut was a dominant tree in eastern North American forests in the early 1900s. By 1950, all American chestnut trees had been killed as a result of a fungus that had been accidentally introduced. Although no birds or mammals were affected by the loss of the chestnuts in the forests, seven species of insects that relied on the trees as a food source became extinct” (McGraw Hill Education).

25. **Keystone species** – They are not necessarily the most abundant species in a community but they exert strong control on community structure by their crucial ecological roles.

“One example of a keystone species is the sea otter. Sea otters are keystone predators in British Columbia’s coastal kelp forests. Sea otters eat sea urchins, which feed on kelp. During the 20th century, sea otter populations were greatly reduced as otters were trapped for their fur. As their numbers declined, the number of sea urchins increased. More sea urchins began eating the kelp, so the kelp biomass decreased. When this happened, the fish that depend on kelp forests as a habitat also declined in number. When sea otters were re-introduced, the kelp forests recovered. Sea otters are a keystone species because they keep the number of sea urchins in check, allowing the kelp to survive

Another example of a keystone species is the prairie dog. Prairie dogs build burrows in huge colonies, known as “dog towns.” As European settlement spread across the western grasslands of North America, prairie dogs were once thought of as pests, especially because they consumed crops and interfered with ranching. Through poison, trapping, and guns, prairie dog populations were drastically reduced in Canada and the United States. The wild prairie ecosystems suffered when populations of this keystone species were reduced. In places where the prairie dog has persisted, ecologists have discovered that dog towns are important for increasing plant diversity, turning over soil, increasing the nitrogen content of the soil, and allowing deeper water penetration of the soil. Another feature of dog towns that make prairie dogs a keystone species is that many species use the burrow system they establish. Black-footed ferrets are predators that use these burrows, and they eat prairie dogs. As the dog towns disappeared, so did the ferret. The last black-footed ferret in Canada was seen in 1937. The species survived longer in the United States, but it was thought to be completely extinct by 1979. However, in the early 1980s, a small American population was found.” (McGraw Hill Education).

*\*\*\*Thank you to the AP Biology teachers at Aurora High School, Campbell Biology, Openstax Biology, and McGraw Hill Education for some of the content included in these notes!\*\*\**

**Notes Questions**

1. When slug species A and slug species B live in the same community, Species A eats leaves and species B eats moss. When species B is removed from the community, Species A eats both leaves and moss. What can you infer about the fundamental and realized niches of species A in this community?

2. For the situation described above, what can you infer about the realized niche of species B? Can you infer anything about the fundamental niche of species B? Why or why not?

3. Which of the following diagrams best represents the energy transfer relationships within a community—a food chain or a food web? Explain your choice.



4. Identify one organism at each of the following trophic levels in the food web shown to the right—producer, primary consumer, secondary consumer, tertiary consumer.

5. Where might you put a quaternary consumer on the food web to the right? In other words, what is one organism that it might eat?

6. Where might you put a detritivore/decomposer on the food web to the right? In other words, which organisms would it eat?

7. Identify one organism that is both a secondary and tertiary consumer in the food web to the right. Explain your choice.

8. Explain how the extinction of crabs would affect the size of the bladderwrack, flat winkle, and herring gull populations in the food web on the previous page.

9. What is the value for trophic efficiency? Why is it so low?

10. If there are 34 KJ of energy stored in organisms at the quaternary consumer level, how many KJ of energy are stored at the primary consumer level within this community?

11. Which of the following diagrams is a pyramid of biomass and which is a pyramid of numbers? How do you know?

**

12. Would you expect a pyramid of energy for this population to look more like Diagram 1 or Diagram 2? Explain your answer.

13. Why do oceans have the highest percentage contribution to Earth’s net primary production despite having a relatively low average net primary production (in g/m2/yr)?

14. Why are humans more affected by ocean mercury levels than organisms like small fish?

14. Based on the information in the chart below, which community has a higher species diversity? Explain your answer using the terms “relative abundance” and “species richness”

|  |  |  |
| --- | --- | --- |
| **Species** | **Community 1** | **Community 2** |
| A | 25% | 20% |
| B | 25% | 20% |
| C | 25% | 20% |
| D | 25% | 20% |
| E | N/A (Species E does not exist for this community) | 20% |

15. Based on the information in the chart below, which community has a higher species diversity? Explain your answer using the terms “relative abundance” and “species richness”

|  |  |  |
| --- | --- | --- |
| **Species** | **Community 1** | **Community 2** |
| A | 1% | 25% |
| B | 26% | 15% |
| C | 2% | 20% |
| D | 70% | 18% |
| E | 1% | 22% |

16. Identify the type of symbiotic relationship described in each scenario given in the chart below.



17. Explain the difference between the following two terms: intraspecific competition and interspecific competition.

18. Describe how the terms “competitive exclusion principle” and “resource partitioning” are related to one another.

19. Explain the difference between the following two terms: dominant species and keystone species.