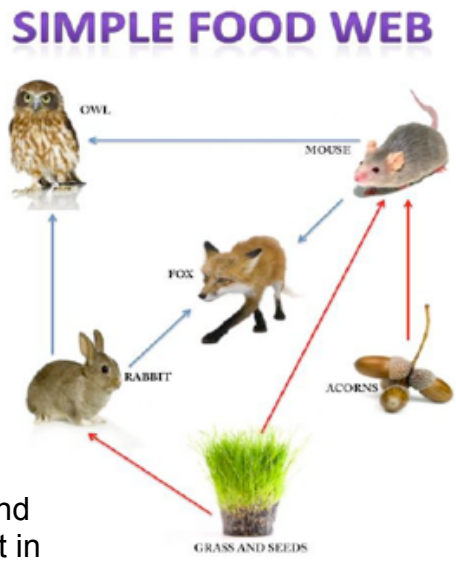
Reading Science

Name: _____ Date: _____ Group: _____

Energy Flow through an Ecosystem

1 All energy necessary to sustain life comes from the sun. Plants harvest this energy directly and are called producers. Animals eat either plants or other animals to get energy. They are called consumers. Each organism occupies a specific feeding level within the ecosystem. This is known as a trophic level. Energy has to come continuously from the sun. Energy is not recycled. We'll look at the details of energy flow through the Kansas tall grass prairie ecosystem, using the simple food chain at right. Big bluestem grass is eaten by eastern cottontail rabbits, which are in turn eaten by coyotes and foxes.



2 Prairies used to be the most common ecosystem in the central part of the North American continent. Today, farmland has replaced most of the prairies. Protected remnants exist in the Flint Hills of Kansas and Oklahoma. In tall grass prairies, grasses can be more than two meters tall. Every ecosystem needs producers. In addition to grasses, flowering plants as well as lichens and liverworts are the producers of the prairie. Interestingly, about three-quarters of plant material is below ground in large root systems that anchor plants and provide water and nutrients. Large grazing animals such as buffalo used to be the most abundant primary consumers. Currently, white-tailed deer consume plants, as well as many smaller animals such as rabbits, voles, and mice. Secondary (2nd level) and tertiary (3rd level) consumers include both mammals and birds. Coyotes, bobcats, foxes, kestrels, and harriers are most abundant. Decomposers and other detritivores include dung beetles and worms. These organisms remove the remaining bit of energy from dead plants and animals and return molecules back into the appropriate nutrient cycle.

3 All organisms need energy to survive. Organisms use energy for staying alive as well as for producing more tissue. So, for example, cottontail rabbits use about 98% of the energy they get from grasses to maintain their body temperature, hop around, and eat. Only 2% is available to make more tissue. This 2% is known as net production efficiency. Either each adult rabbit can grow bigger, or rabbits can reproduce, making more little cottontail rabbits. Invertebrates (animals with no skeleton) use less energy to keep themselves alive, so their net production efficiency is about 20%. Plants have a net production efficiency of between 30% and 85%. Why do scientists and farmers care about net production efficiency? Only net production efficiency can be passed onto the next higher trophic level. In other words, when a fox eats a rabbit, it gets only the energy stored in the tissue of the rabbit, not the energy the rabbit used to stay warm or hop around.

4 As stated earlier, energy enters the ecosystem through photosynthesis. Initially energy from sunlight is captured during photosynthesis and stored in the chemical bonds of sugars and starches. The sun delivers much more energy to the earth than is captured. In the tall grass prairie, all producers put together only capture a fraction of one percent of the sun's energy. Interestingly, scientists discovered that grazed prairies capture slightly more energy than un-grazed prairies. One explanation may be that grasses grow relatively fewer roots and more leaves when grazing animals are present. Another explanation may be that grazing animals eat more of the less efficient grasses, leaving plants with larger leaves behind.

5 Energy flows through the ecosystem through chemical bonds. Both sugars and starches are held together by chemical bonds. When any organism needs energy, it breaks the chemical bonds in its food and releases the stored energy. Even plants have to grow and stay alive. They use up some of the sugars and starches they make to keep themselves alive. Each time chemical bonds are broken, some of the released energy is used and some is converted to heat. Overall energy has to be conserved. While overall energy is neither created nor destroyed, small amounts of heat energy are not usually captured and therefore energy becomes progressively unavailable to the ecosystem. As long as the sun continues to shine and producers capture the energy, new energy is available for ecosystems to use.

6 One useful rule of thumb for ecosystems is the 10% rule. It states that on average, 10% of the energy contained in one trophic level is available for the next higher trophic level. Energy can be measured in Joules. Let's assume that one area of prairie contains only plants, rabbits, and foxes. If the plants contain 1,000 Joules, only 100 Joules are available to the cottontail rabbit. Ten joules are then available to the foxes. When drawing the energy in each trophic level, a pyramid is often used to indicate this relationship. Producers are shown on the bottom, and consumers occupy each higher and smaller level. Relatively little energy flows into the higher trophic levels. Therefore, most ecosystems contain only three or four trophic levels.

7 Populations in most ecosystems also follow a pyramid. There are far more grasses and other plants than primary consumers, and fewer secondary consumers still. The population of tertiary consumers is even smaller. At higher trophic levels there is simply not enough energy to sustain a population large enough to reproduce. If you visit a tall grass prairie, grasses and rabbits will be far more abundant than foxes. This also means that animals occupying higher trophic levels are, in general, more vulnerable to extinction.

8 Energy flow through ecosystems also affects humans. Humans are omnivores, eating both plants and animals. When humans consume plants directly, more energy is available than when they consume primary consumers, such as beef or chicken. Moving toward a more plant-based diet therefore increases the amount of energy available to human populations. Different primary consumers have different net production efficiencies. For example, chicken and turkey have higher net production efficiency than beef. Herbivorous fish such as catfish and tilapia are even more efficient. This difference is also partly reflected in prices; beef is becoming more expensive. As the human population continues to grow, agricultural practices are shifting.

1 Which of the following organisms would you expect to be most abundant in the tall grass prairie ecosystem?

A Grasses and flowering plants

B White tailed deer and cottontail rabbits

C Bobcats and coyotes

D Harriers and kestrels

---

2 Which statement correctly defines net production efficiency? The amount of energy —

A captured from sunlight.

B available to decomposers.

C stored in roots.

D available to make new tissue.

3 Invertebrates have a higher net production efficiency than mammals. Which statement most likely explains this observation?

A Invertebrates are more abundant than mammals in an ecosystem.

B Mammals maintain their body temperature, invertebrates don't.

C Most mammals are secondary consumers. Most invertebrates are primary consumers.

D Invertebrates have smaller bodies than mammals.

---

4 What factor most limits the energy available to producers in the tall grass prairie ecosystem? The amount of energy —

A delivered by sunlight.

B used by producers to grow.

C captured during photosynthesis.

D consumed by primary consumers.

5 The plants in a given area of tall grass prairie contain 10,000 Joules of energy. How much energy is available to the coyotes?

A 10,000 Joules

B 1,000 Joules

C 100 Joules

D 10 Joules

---

6 Scientists count the number of organisms in the tall grass prairie. Which trophic level would you expect to contain the smallest number of organisms?

A Producers

B Primary consumers

C Secondary consumers

D Tertiary consumers