ECOLOGY

6.3 Energy transfer in ecosystems

Objectives

- Explain the meaning of food chains and food webs .

- Describe how energy is transferred between trophic levels

- State that Energy released from carbon compounds by respiration is used in living organisms and converted to heat.

- Living organisms cannot convert heat to other forms of energy.

- Understand that heat is lost from ecosystems.

- Define trophic level as the position of an organism in a food chain, food web, pyramid of numbers or pyramid of biomass

- Explain why the transfer of energy from one trophic level to another is inefficient

- Explain why food chains usually have fewer than five trophic levels

Resources book pages 134,135,136

Food chains

Food chains show **the movement of energy from one organism to the next**. The direction of the energy flow is represented by an arrow. The position of the organism in the food chain is called the trophic level. The term "trophic" comes from a Greek origin which means "to feed". The trophic level of an organism depends on the type of food it feeds on:

- **Producers make their own food and they are the beginning of any food chain.**
- Primary consumers are herbivores that feed on producers.
- Secondary consumers are carnivores or omnivores that feed on herbivores.
- Tertiary consumers are carnivores or omnivores that feed on secondary consumers.

Producers, primary consumers, secondary consumers and tertiary consumers are examples of trophic levels.

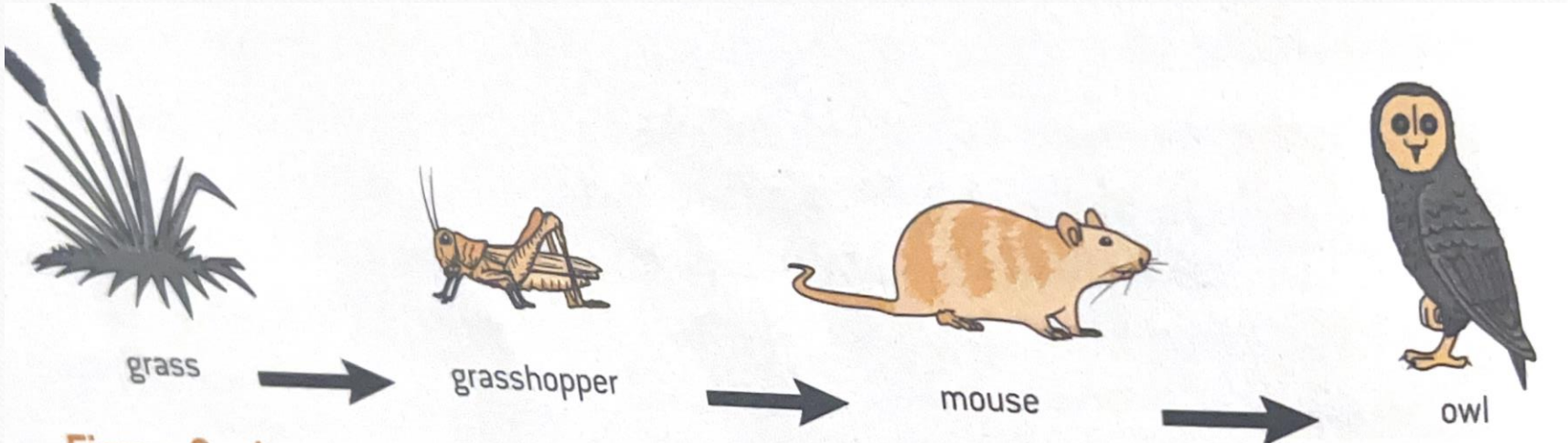


Figure 6. An example of a food chain

In this food chain, grass is the producer. It gets energy from the Sun and uses it to make its own food. The grasshopper is a primary consumer as it eats grass. The mouse is a secondary consumer because it eats the grasshopper. The owl is a tertiary consumer because it feeds on the mouse.

Food webs

Food webs :

In most communities, organisms eat more than one organism which results in several interacting food chains. A food web is a diagram that shows the relationships between organisms in a community. The arrows in the food web show the direction of the energy flow (figure 7).

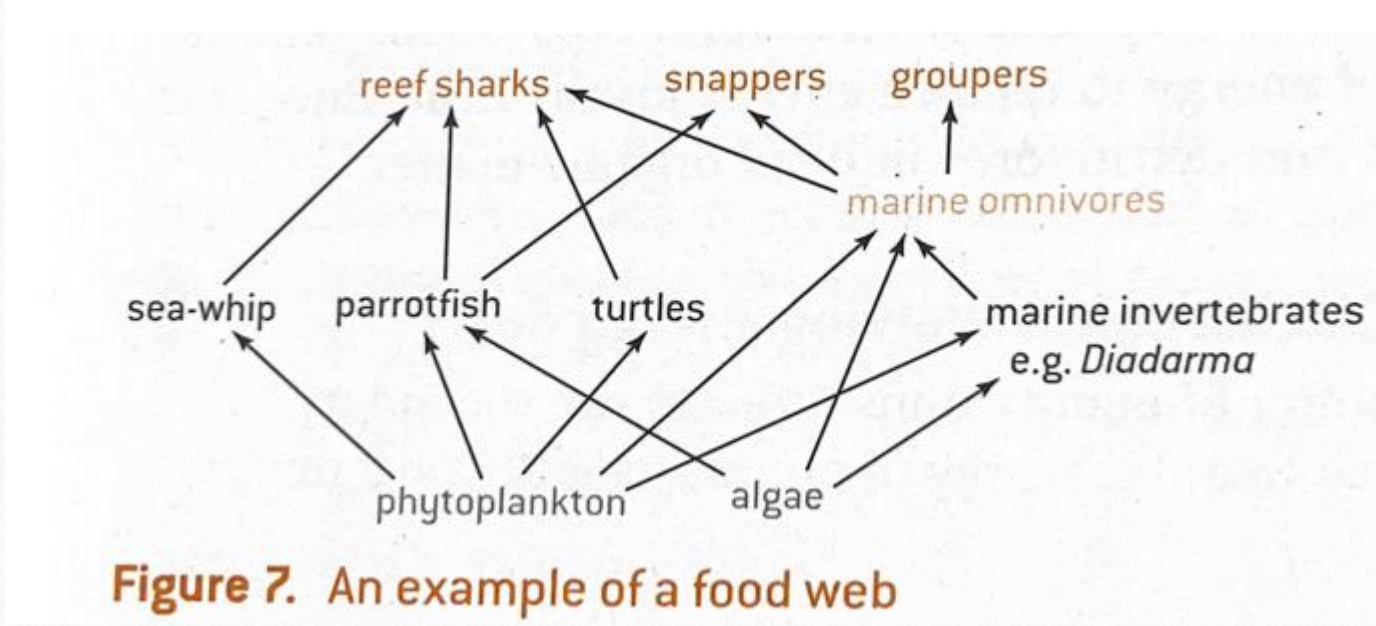


Figure 7. An example of a food web

Question

In the food web in figure 7, identify:

a) A producer : phytoplankton

b) A primary consumer : turtles

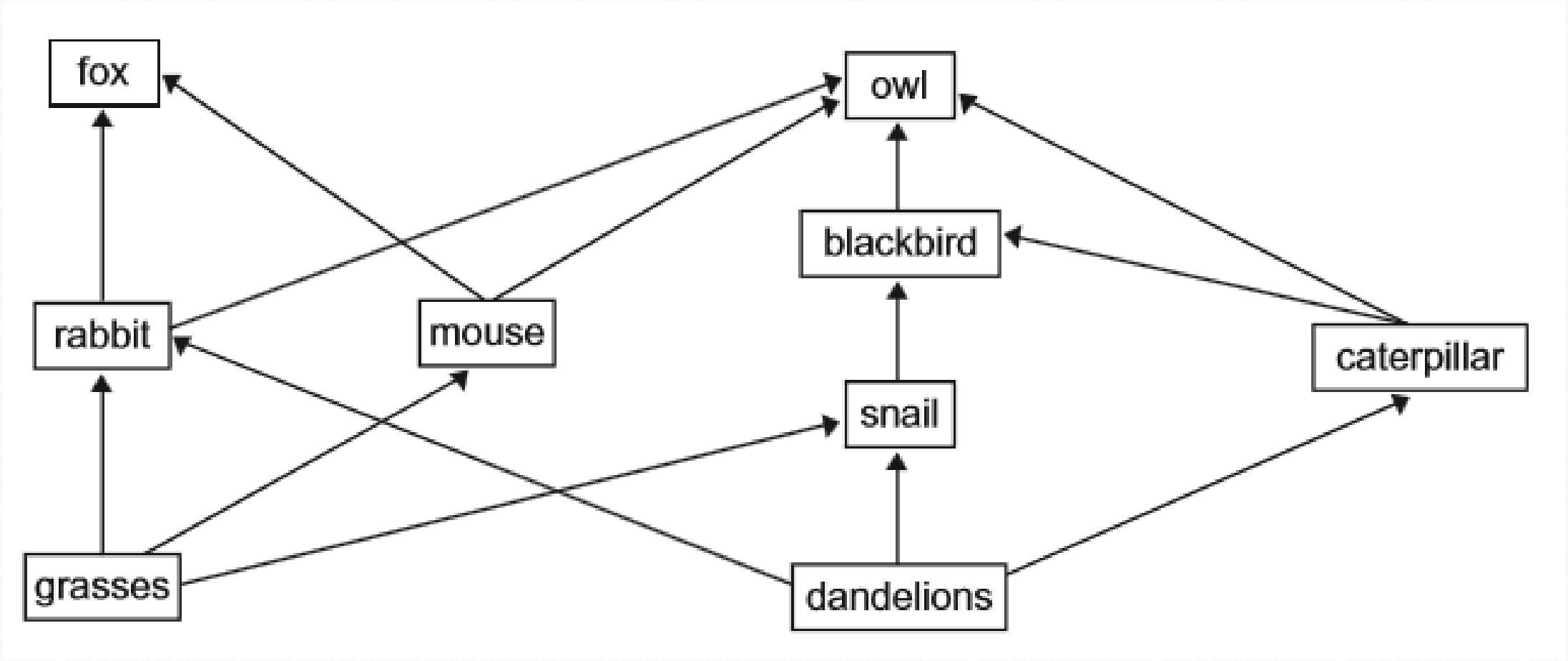
c) A secondary consumer : reef sharks

d) A tertiary consumer : snappers

e) An organism that can be both a secondary and a tertiary consumer : reef sharks .

Question :

The diagram shows a food web in areas of grassland.



a. Write three food chains from this food web.

Choose any three

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d. One year the snail population increased in the grassland area.

How could an increase in the number of snails cause the caterpillar population to change?

Caterpillar population will decrease because of limited food

Pyramid of energy

The amount of energy flow in a food chain is represented by a pyramid of energy. Each bar in the pyramid represents the amount of energy at each trophic level in the food chain. Producers form the base of any energy pyramid (figure 8).

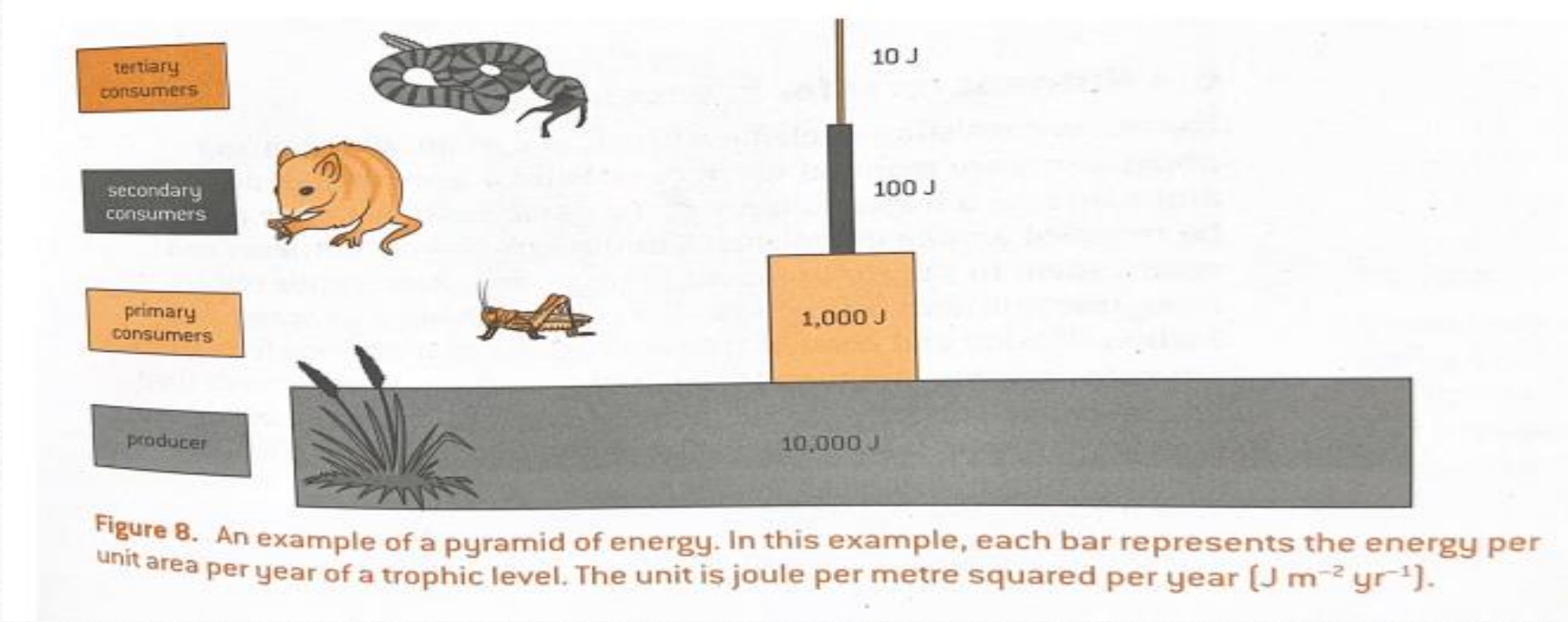


Figure 8. An example of a pyramid of energy. In this example, each bar represents the energy per unit area per year of a trophic level. The unit is joule per metre squared per year [J m^{-2} yr^{-1}].

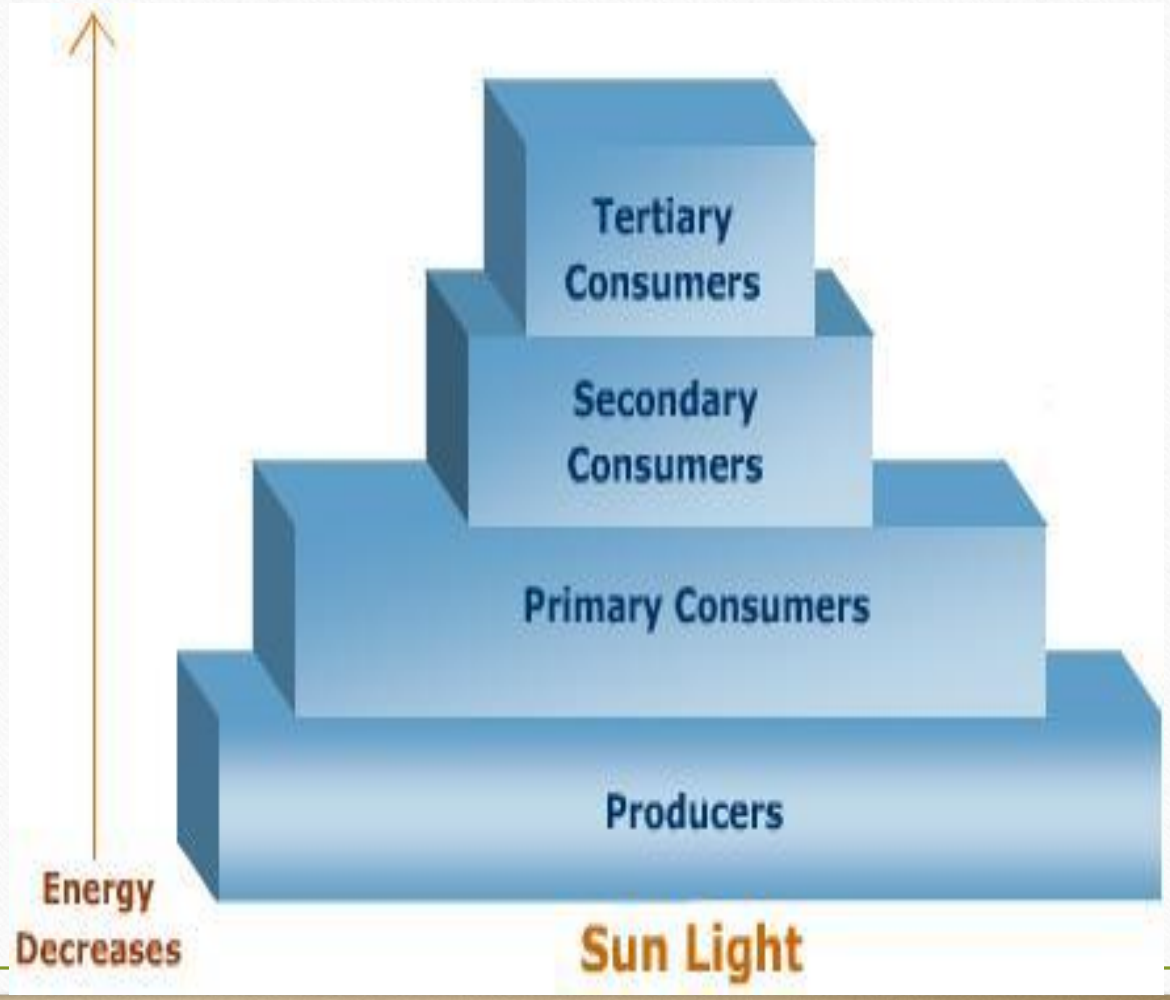
Energy pyramid / Pyramid of Biomass

https://www.youtube.com/watch?v=wGfOoRrICto

Energy pyramid not only shows how energy moves but also **represents the amount of energy available at each trophic level.**

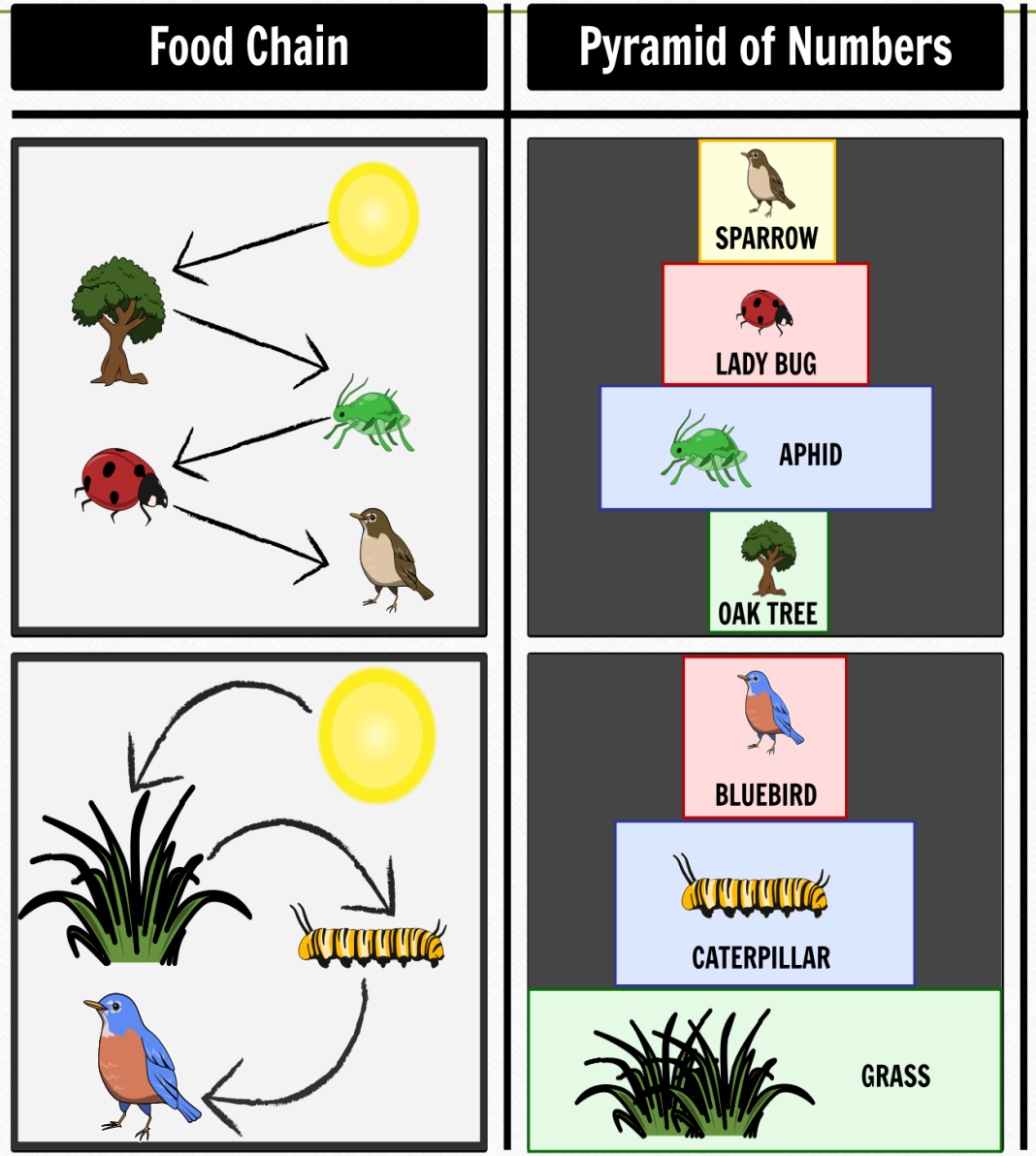
(Each step in a chain or energy pyramid is a trophic level).

The diagram shows the energy flows from sunlight to producers through each of the consumer levels



Pyramid of numbers

A **pyramid of numbers** shows the total **number** of individual organisms at each level in the food chain of an ecosystem. ... An inverted **pyramid of numbers** can be found in an ecosystem where the community contains a few producers with a very large biomass that support a larger **number** of smaller consumers.



Question :Use the pyramid of numbers to answer the following questions.

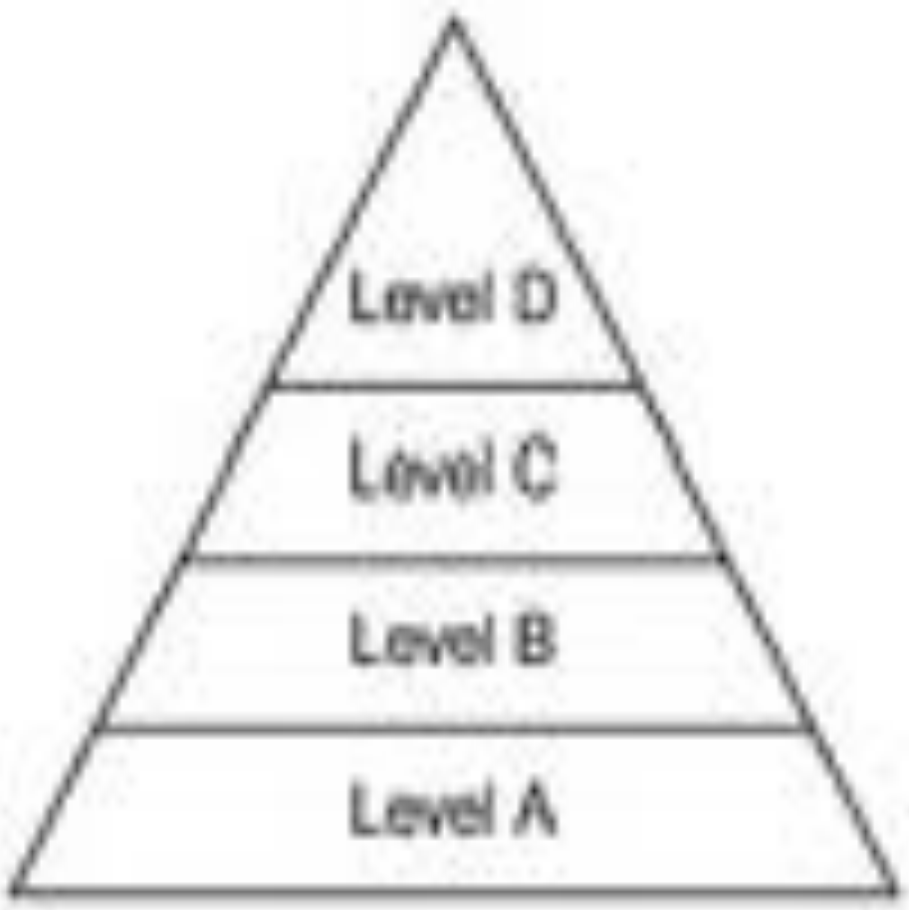
1. Which level contains the organisms with the highest amount of energy? A

2. Top predators are found in level …D……

3. Which level contains herbivores? …B……..

4. How does the amount of energy changes as you move from level A to level D?
……decrease …..

5. In a community of grass, rabbit, fox and eagle, which organism will fill level C?
…fox…..



Energy flow in a food chain

Sunlight is the source of energy on Earth. Energy enters a food chain from sunlight through producers ***which convert the light energy into chemical energy*** in organic compounds by photosynthesis.

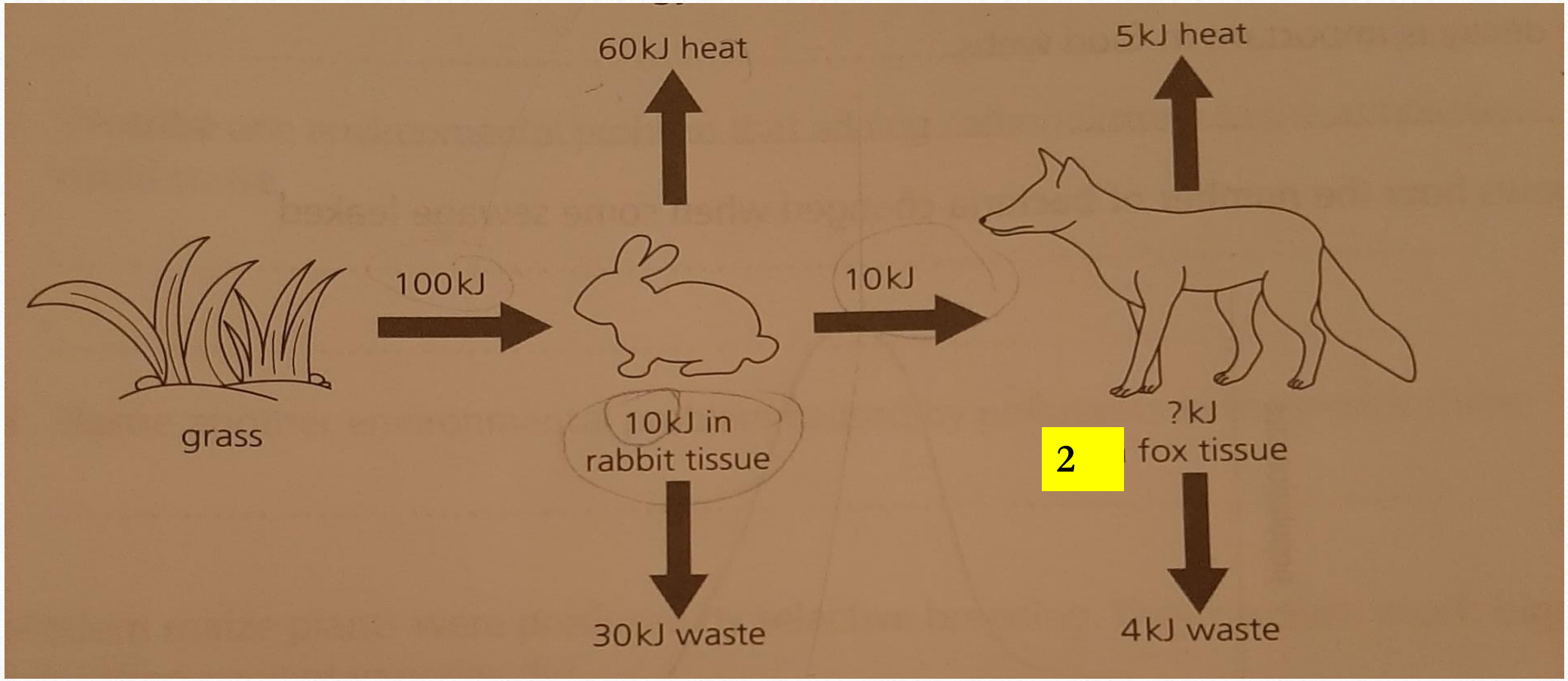
Chemical energy in carbon compounds flows through trophic levels by means of feeding. Energy transformations are never 100% efficient.

In the pyramid of energy in figure 8, notice the proportions of each bar drawn. Each bar is smaller than the one below. This is because only 10% of energy is transferred from one trophic level to the next and the remaining 90% is lost. Energy loss between trophic levels is mainly due to heat loss by cellular respiration. Therefore, ecosystems require a continuous supply of energy to replace energy lost as heat.

Energy is passed to saprotrophs and detritivores in dead organic matter.

Question :The diagram below shows the energy transfers in a food chain :

Calculate how much energy the fox uses to build new tissues .



Worked example: Calculations involving energy flow

Calculate the amount of energy transferred to the secondary consumer knowing that the energy of producers is 20000 J m- yr

Solution

Energy transferred to each trophic level = 10%.

Energy transferred from producers to primary consumer = 10% of

10

original =

100 × 20000

= 2,000 J m-2 yr-1

Energy transferred from primary consumer to secondary consumer

=

100 * 2000 = 200 J m2 yr'

Question

In the following food chain, calculate the amount of energy (in kJ) transferred to tuna fish knowing that the energy in phytoplankton is 150 000 J m-2 yr-1.

- **Phytoplankton -> Shrimp -> Tuna fish -› Sharks**

1500 J m-2 yr-1.

Energy Flow Through Food Chains

- Chemical energy, stored in **carbon compounds** in plant tissues, is **passed to the primary consumer** when the plant is **ingested**
  - The primary consumer **digests** the plant tissues and **absorbs** the carbon compounds containing **stored chemical energy**
  - These carbon compounds can either be used to fuel **respiration** or to build up animal tissue, meaning that the **stored chemical energy is transferred** to the tissues of the primary consumer

- When the primary consumer is ingested, the **carbon compounds in its tissues,** along with their **stored chemical energy**, pass to the **secondary consumer**, and so on up the food chain
- When an organism dies, the chemical energy stored in carbon compounds in its tissues passes to **detritivores** and **saprotrophs**
- In a food chain, the arrows represent the **transfer of energy**, in the form of stored chemical energy in carbon compounds, from one trophic level to the next, by the process of **feeding**

Food chains are limited in length

- Food chains rarely have more than around four or five trophic levels; this is because with energy losses at each trophic level, there is **less and less energy available to the consumer** as you go up the food chain
- When a food chain gets longer than four or five trophic levels it becomes too difficult for a predator to hunt enough prey to gain the energy to survive

Question

Which statement gives the best explanation for why most food chains have no more than five trophic levels?

A. Because 20% of the energy is transferred at each level and after 5 levels, all the energy is used up (5 × 20% = 100%).

B. The numbers of organisms are insufficient because the top predator has to have a count of 1 in a pyramid of numbers.

C. The biomass transferred from a consumer to the next-level consumer is too little.

D. There is a large amount of energy loss at each level so insufficient energy can be passed up to the sixth trophic level.