Department of Civil Engineering
College of Engineering
King Saud University

GE 302 – Industry and the Environment
Topic 1

Introduction to the Environment and Ecosystems

Course Description

- This course introduces the impact of engineering and industrial activities on the environment.
- The lectures cover basics of ecosystems, environmental balance, types of pollution, and types, sources, and limits of pollutants; in addition to fundamentals of Environmental Impact Assessment (EIA).
- Pollution control technologies and examples of pollution from various engineering and industrial sectors are also covered.
- The course also includes a group term project.

Course Learning Objectives (CLOs)

Students completing this course successfully will be able to:

1. Understand the basics of the global ecosystem and the natural cycles of its major components.
2. Understand the types of environmental pollution caused by engineering and industrial activities.
3. Realize the importance of sustainable development and maintaining environmental balance.
4. Understand the different types of pollutants, their sources, limits and the various technologies for pollution control.
5. Recognize the importance of EIA prior the development of the projects.
6. Improve their communication skills, including reading, writing, and oral presentations.

Course Description

Textbook:

- Mackenzie Davis, Susan Masten, ***Principles of Environmental Engineering & Science***, 3rd ed., McGraw-Hill Education.
- Gilbert M. Master, Wendell P. Ela, **Introduction to Environmental Engineering and Science**, 3rd edition, Pearson
- G. Tyler Miller, Scott Spoolman, ***Living in the Environment***, 17th ed., Cengage Learning.

Grade Distribution:

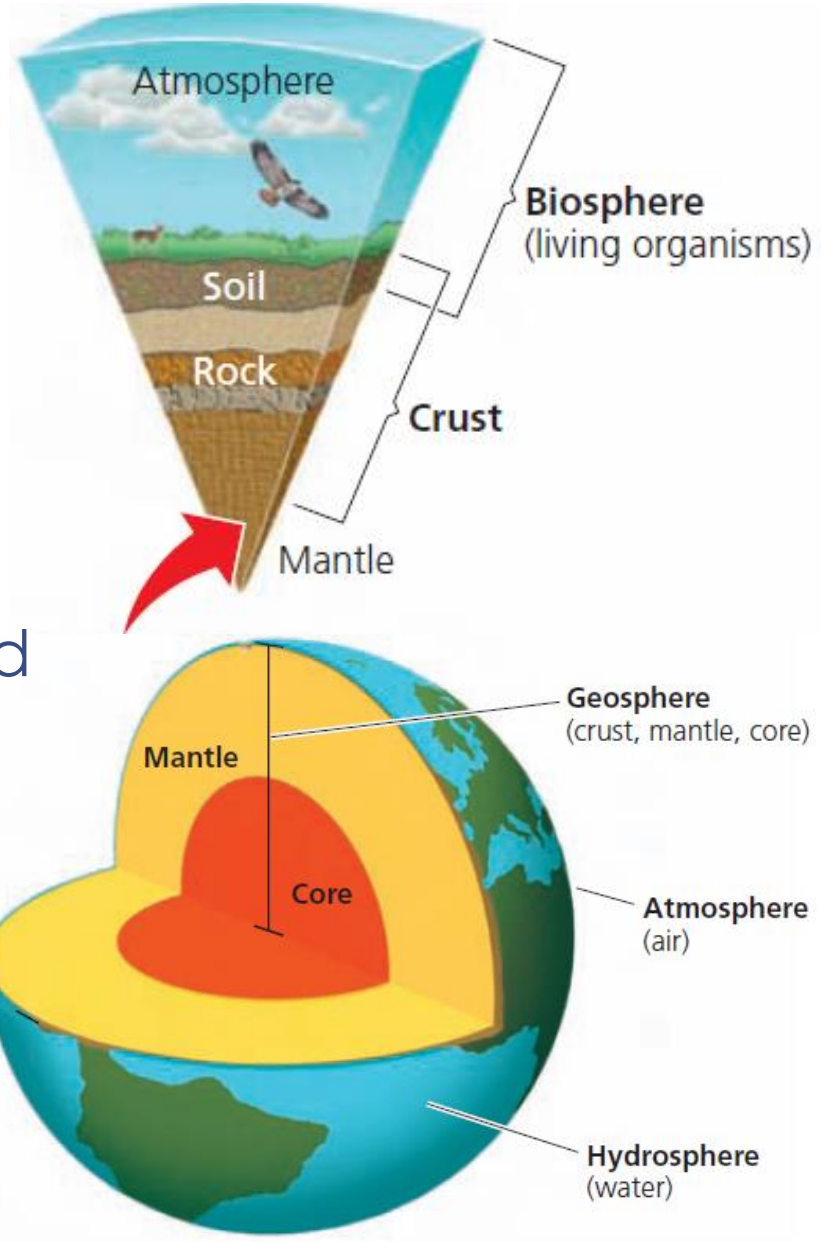
Two Mid-term Exams:	40%
Activities (field visit, quizzes, etc.):	10%
Project:	10%
Final Exam:	40%

Examinations:

1st midterm on:	(6:00 - 7:30 pm)
2nd midterm on:	(6:00 - 7:30 pm)

Environmental components of earth

- The **earth's life-support system** consists of four main spherical systems that interact with one another
  - The atmosphere (air)
  - the hydrosphere (water)
  - the geosphere (rock, soil, and sediment)
  - the biosphere (living things)



(a) Land, air, water, and plants in Siberia

(c) Endangered Siberian tiger

(b) Monarch butterfly and flower

(d) Coral reef in Hawaii

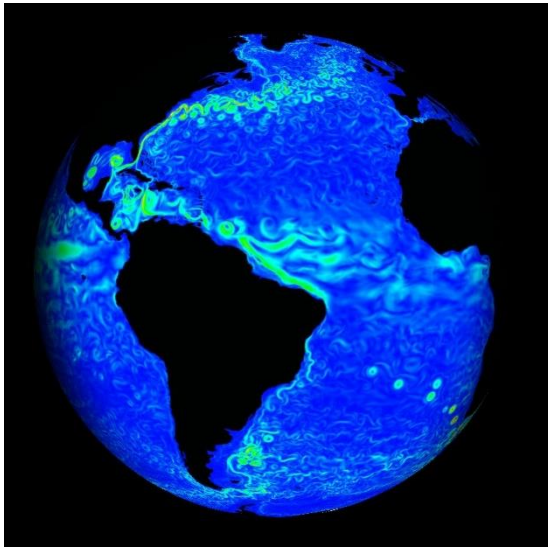
Land, air, water, and a variety of plants and animals sustain the earth's diversity of life and human economies.

The atmosphere

- Is a thin spherical envelope of gases surrounding the earth's surface.
- Its inner layer, the **troposphere**, contains air that we breathe, which consists of:
  - nitrogen (78% of the total volume)
  - oxygen (21%).
  - The remaining 1% of the air includes water vapor, carbon dioxide, methane, etc. all of which are called **greenhouse gases**
- The next layer is called the **stratosphere**, Its lower portion holds enough ozone (O_3) gas to filter out about 95% of the sun's harmful *ultraviolet (UV) radiation*

The hydrosphere

- consists of all of the water on or near the earth's surface.
- It is found as *water vapor* in the atmosphere, *liquid water* on the surface and underground, and *ice*.
- The oceans, which cover about 71% of the globe, contain about 97% of the earth's water.



The geosphere

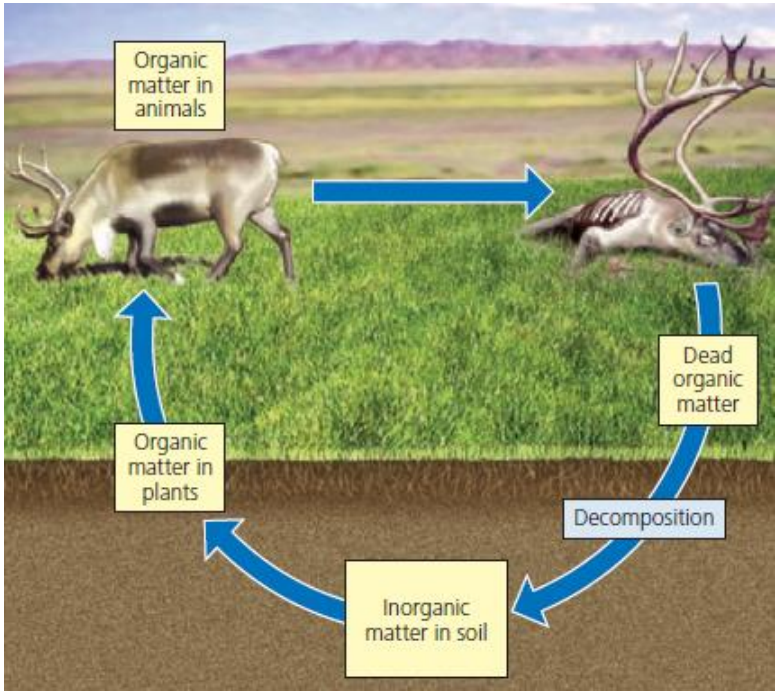
- consists of the earth's intensely hot *core*, a thick *mantle* composed mostly of rock, and a thin outer *crust*.
- Its upper portion contains nonrenewable fossil fuels and minerals that we use, as well as renewable soil chemicals (nutrients) that organisms need in order to live, grow, and reproduce.

The biosphere

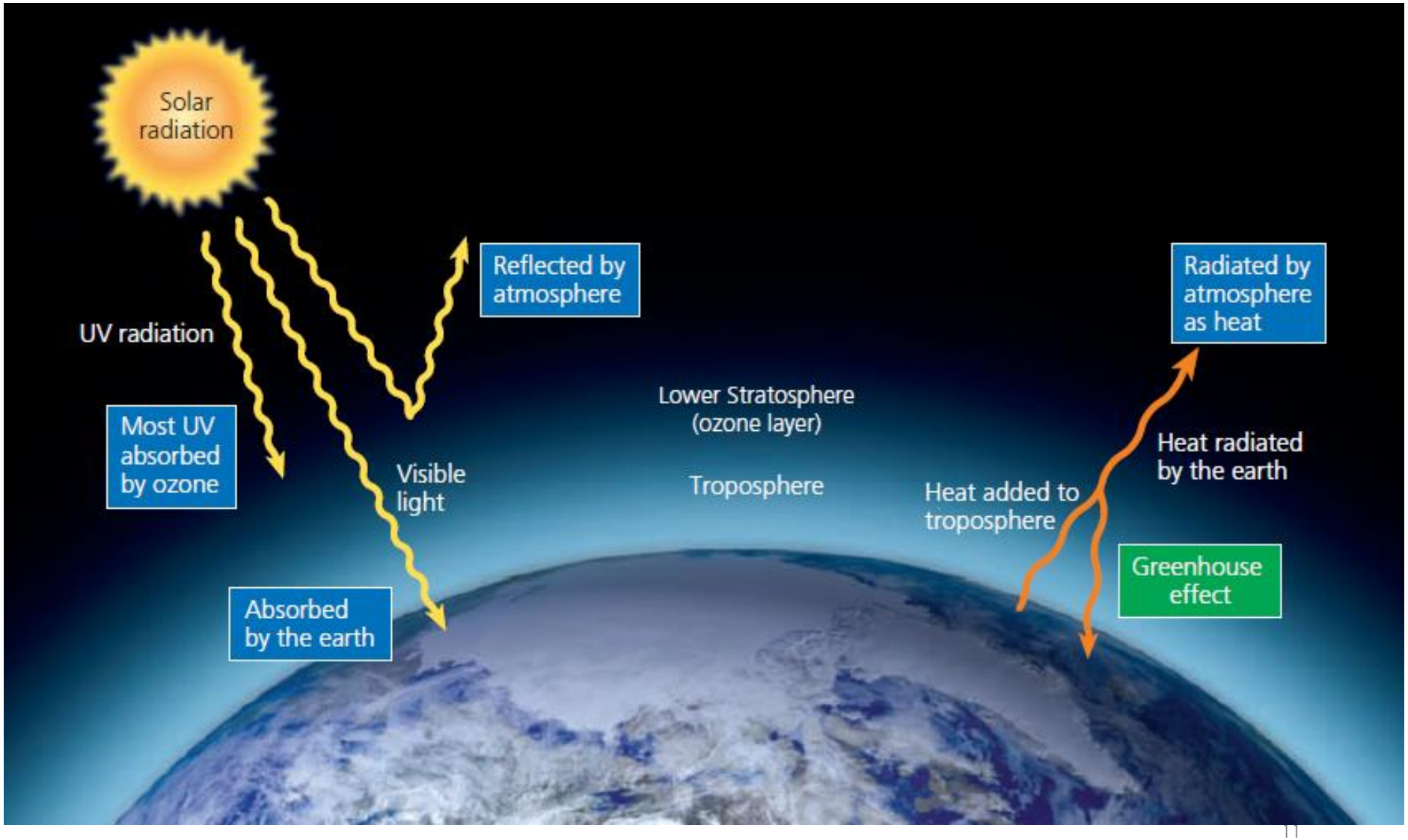
- consists of the parts of the atmosphere, hydrosphere, and geosphere where life is found.

Factors Sustain the Earth's Life

1. The **one-way flow of high-quality energy** from the sun, through living things in their feeding interactions.
2. The **cycling of nutrients** (the atoms, ions, and molecules needed for survival by living organisms) through parts of the biosphere.
3. **Gravity**, which allows the planet to hold onto its atmosphere and helps to enable the movement and cycling of chemicals through air, water, soil, and organisms.



Interaction of solar energy with the atmosphere and earth's surface



Energy flow from sun to earth and within the earth's systems

- Sun releases tremendous amounts of energy into the space, only a very small amount of this energy reaches the earth.
- This energy reaches the earth in the form of electromagnetic waves, composed mostly of visible light, ultraviolet (UV) radiation, and heat (infrared radiation).
- Much of this energy is absorbed or reflected back into space by the earth's atmosphere and surface.
- The solar energy that reaches the atmosphere lights the earth during daytime, warms the air, evaporates and cycles water through the biosphere, and generate winds.
- Also, green plant and algae use solar energy to produce the nutrient they need through the photosynthesis process, and in turn, to feed the animal.

Energy flow from sun to earth and within the earth's systems

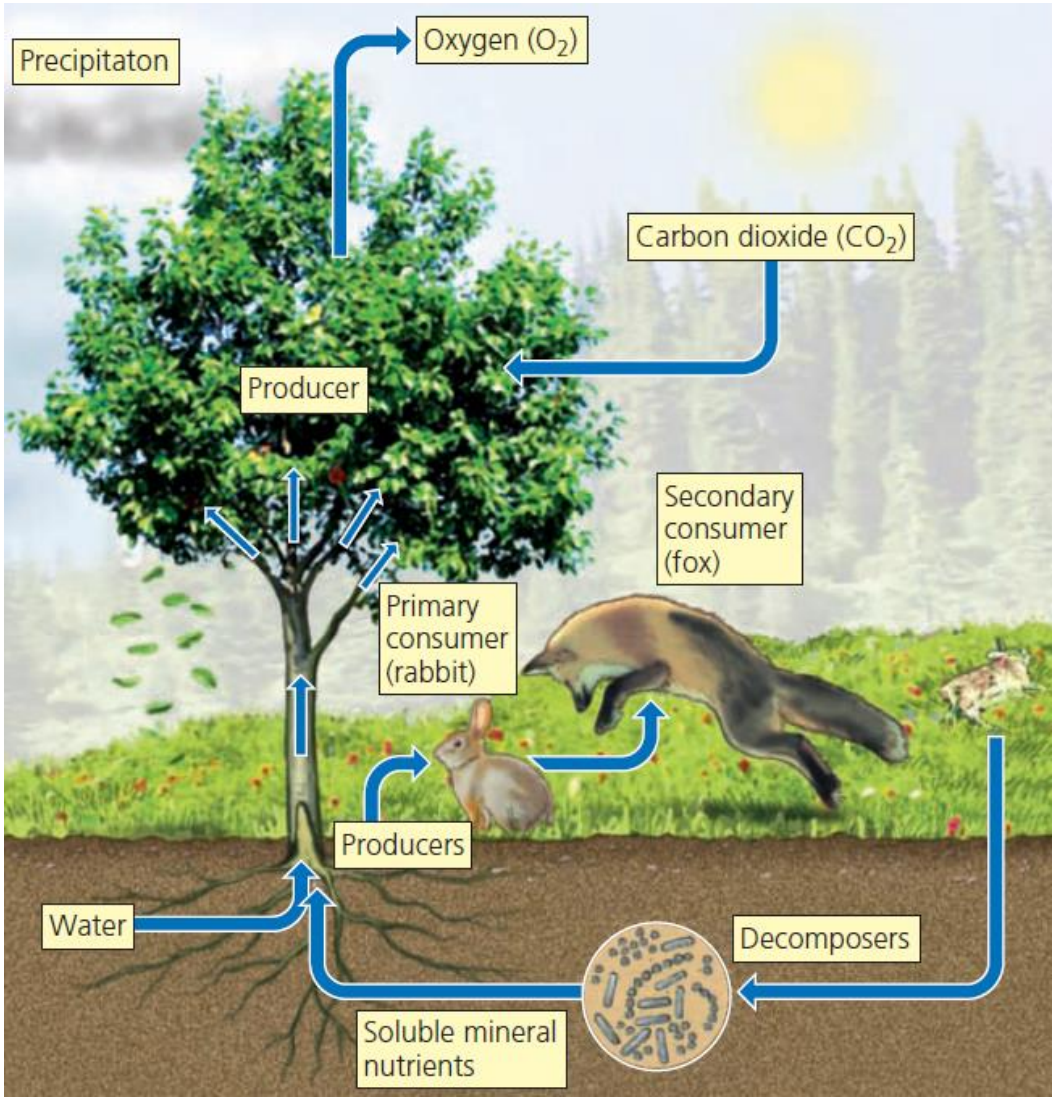
- The solar radiation reached the planet's surface, interacts with the earth's land, water, and life and is degraded to lower-quality infrared radiation.
- Some of the **infrared radiation** is reflected back to the lower atmosphere, where it will interact with greenhouse gases (water vapor, carbon dioxide, methane, etc.) and Some of it flows back into space as heat.
- When radiated heat from earth's surface interact with greenhouses gases it warm the lower atmosphere and the earth's surfaces, which is know as **greenhouse effect**.
- Without this **natural greenhouse effect**, the earth would be too cold to support the forms of life we find here today.

Ecology is the science that focuses on how organisms interact with one another and with their nonliving environment of matter and energy.

Biosphere	Parts of the earth's air, water, and soil where life is found
Ecosystem	A community of different species interacting with one another and with their nonliving environment of matter and energy
Community	Populations of different species living in a particular place, and potentially interacting with each other
Population	A group of individuals of the same species living in a particular place
Organism	An individual living being

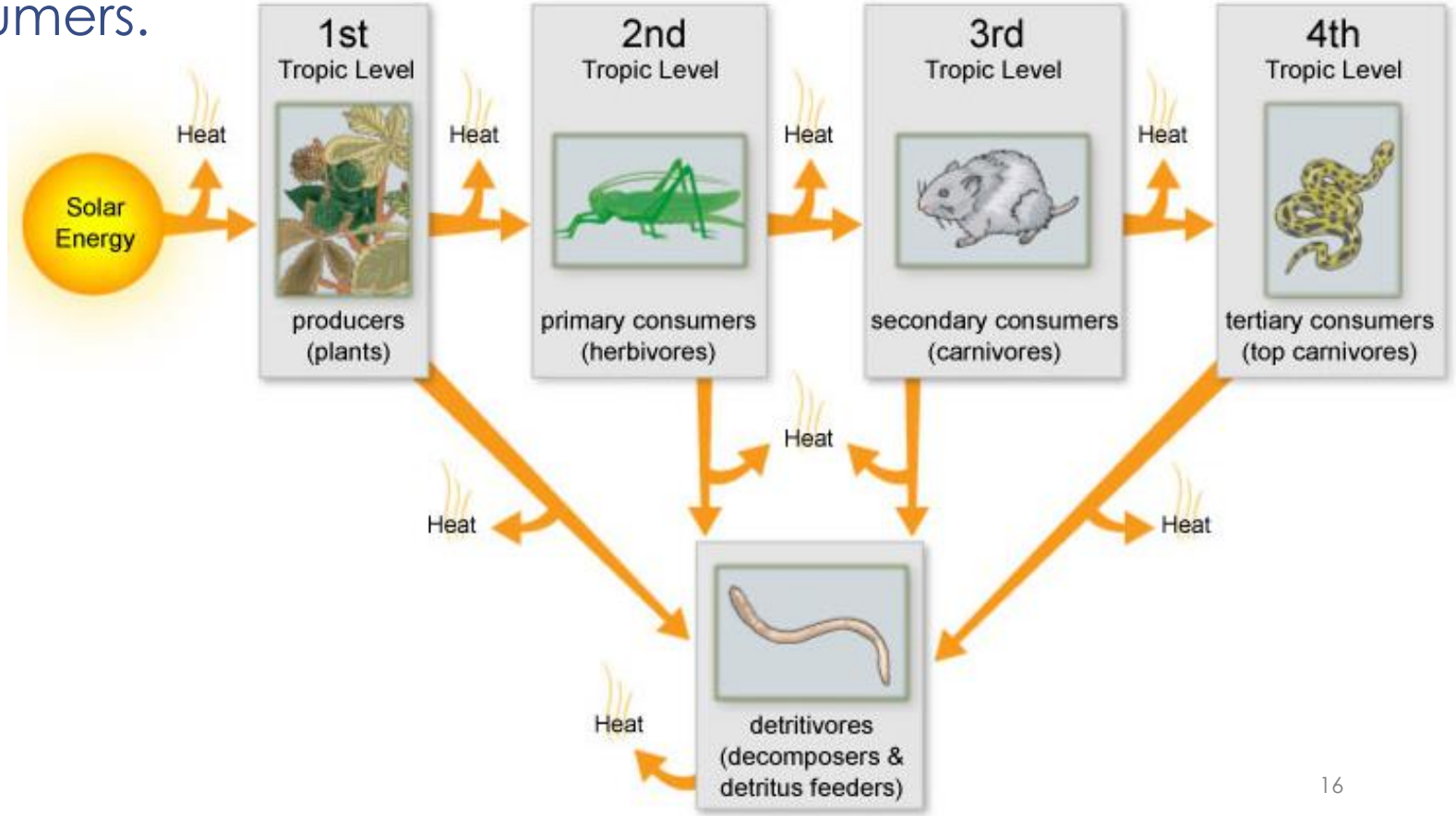
Ecosystems Have Living and Nonliving Components

- The ecosystems are made up of living (**biotic**) and nonliving (**abiotic**) components.
- nonliving components are water, air, nutrients, rocks, heat, and solar energy.
- Living components include plants, animals, microbes, and all other organisms.



Trophic level

- Depending on its source of food or nutrients, organism in an ecosystem is assigned to a *feeding level*, or **trophic level**
- living organisms transfer energy and nutrients from one trophic level to another within an ecosystem
- We can broadly classify the organisms as producers and consumers.



- **Producers**, sometimes called **autotrophs** (self-feeders), make the nutrients they need from compounds and energy obtained from their environment.
- In a process called **photosynthesis**, plants typically capture solar energy that falls on their leaves and use it in combination with carbon dioxide and water to form organic molecules.

carbon dioxide + water + solar energy → glucose + oxygen

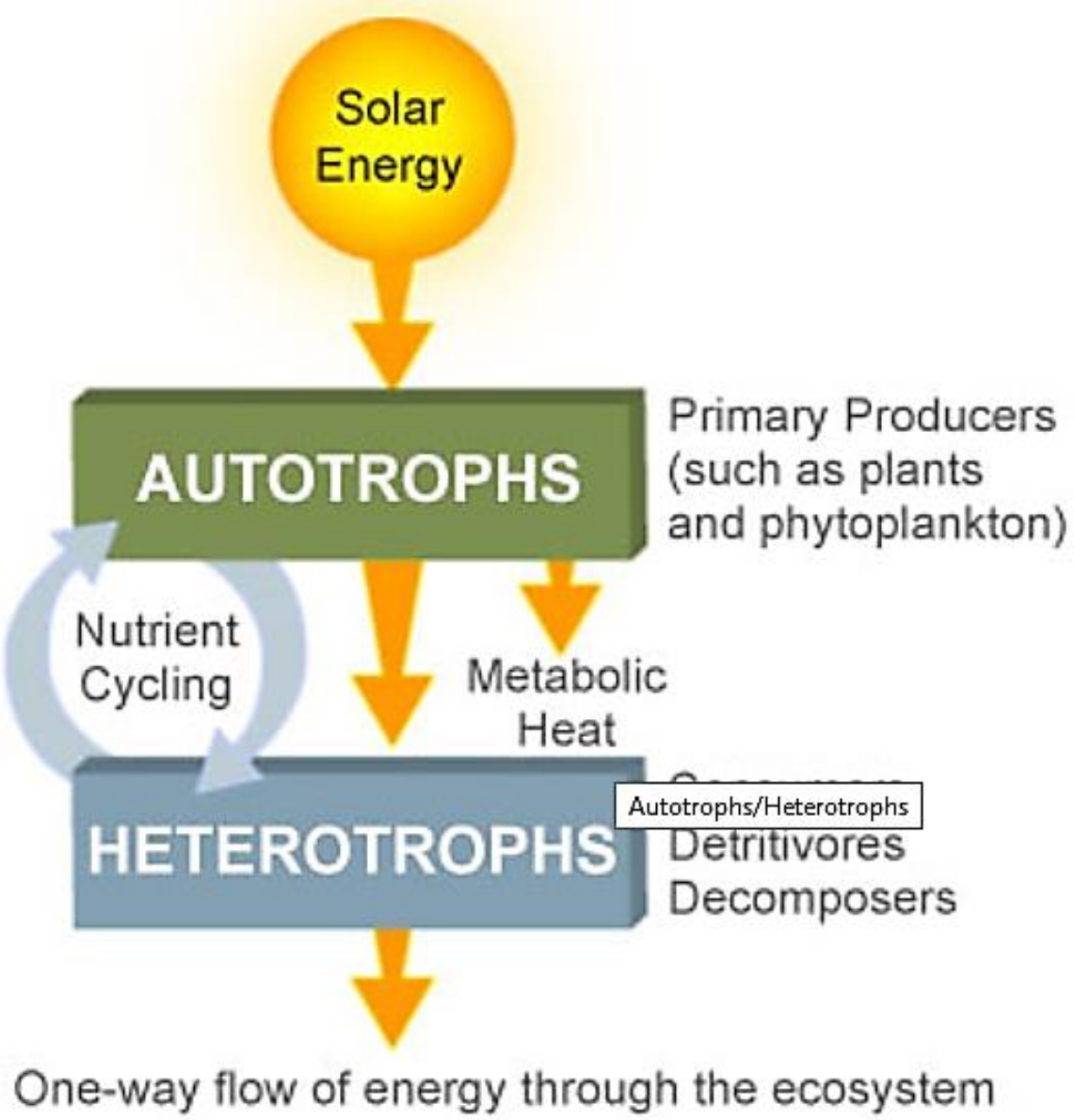
$6\ CO_2 + 6\ H_2O + \text{solar energy} \rightarrow C_6H_{12}O_6 + 6\ O_2$

green plants

algae and aquatic plants

- **Consumers**, or **heterotrophs**, cannot produce the nutrients they need through photosynthesis or other processes.
- Consumers obtain their energy and nutrients by feeding on other organisms (producers or other consumers).
- Types of consumers:
  - **Herbivores**, or **Primary consumers,** (plant eater), are animals that eat mostly green plants.
  - **Carnivores** (meat eaters) are animals that feed on the flesh of other animals.
    - **secondary consumers** that feed on the flesh of herbivores
    - **tertiary consumers** that feed on the flesh of other carnivores
  - **Omnivores** eat plants and other animals.
  - **Decomposers** release nutrients from the wastes or remains of plants and animals and then return those nutrients to the soil, water, and air for reuse by producers (bacteria and fungi).

- In natural ecosystems the wastes and dead bodies of organisms serve as resources for other organisms, as the nutrients that make life possible are continuously recycled
- Without decomposer, the planet would be overwhelmed with plant litter, animal wastes, dead animal bodies, and garbage.



Giraffe feeding on the leaves of a tree is an herbivore

lion feeding on the dead body of a giraffe is carnivores

fungus feeding on a dead tree is a decomposer

Aerobic & anaerobic respiration

- Consumers, and decomposers use the chemical energy stored in glucose and other organic compounds to fuel their life processes.
- This energy is released by:
  - **Aerobic respiration** which uses oxygen to convert glucose (or other organic nutrient molecules) back into carbon dioxide and water.

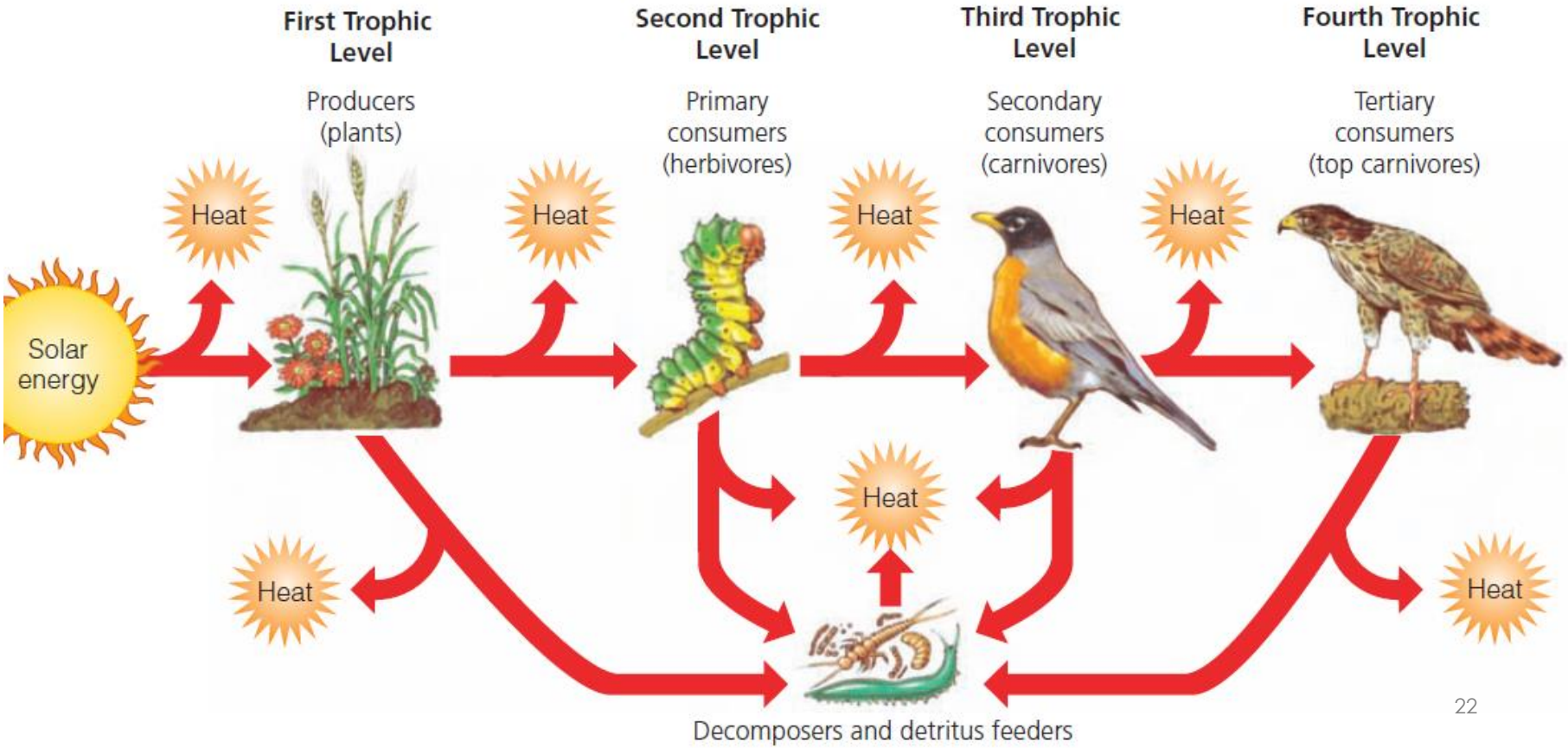
glucose + oxygen → carbon dioxide + water + energy

$C_6H_{12}O_6 + 6\,O_2 \rightarrow 6\,CO_2 + 6\,H_2O$ + energy

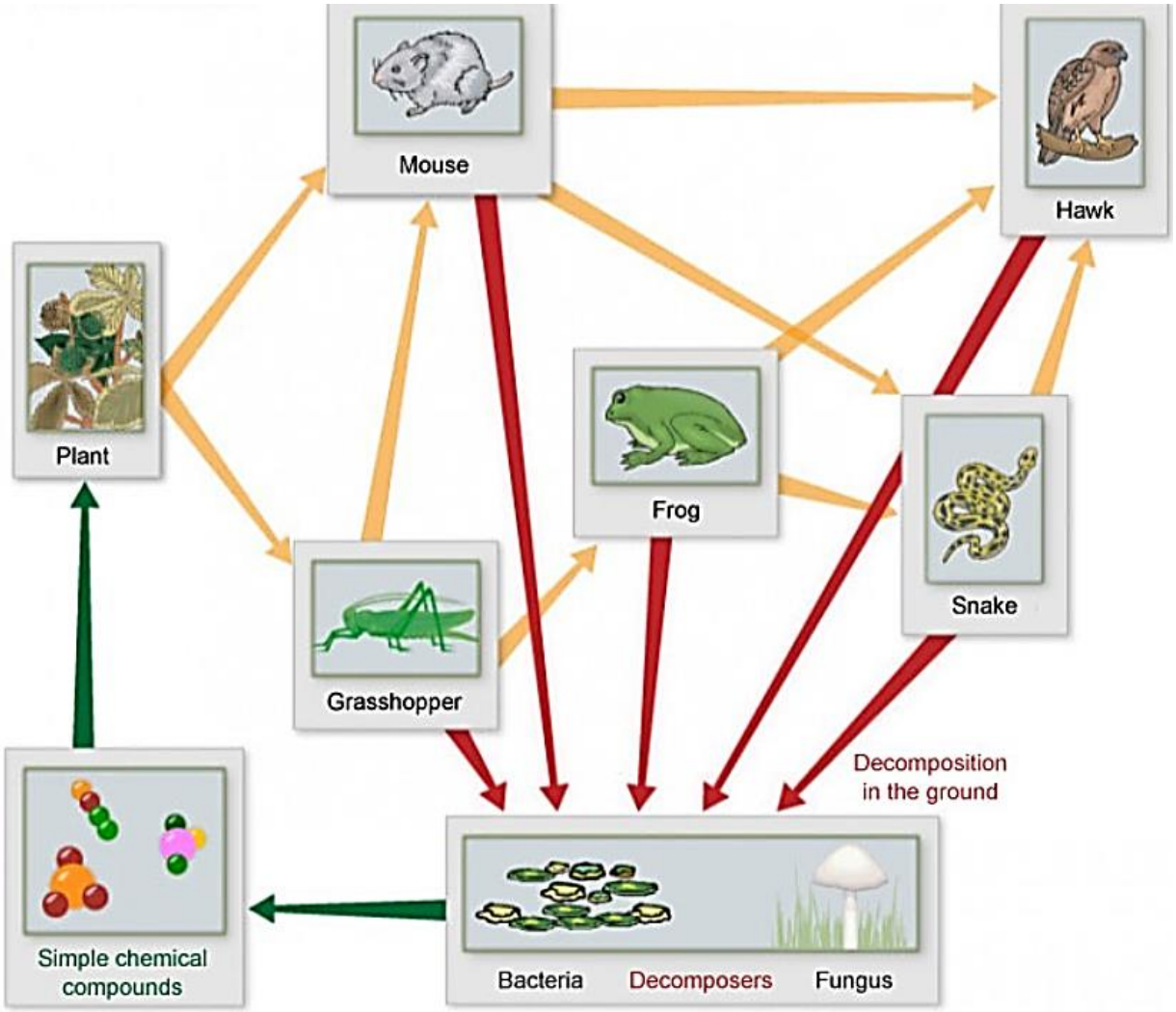
  - **Anaerobic respiration,** or **fermentation,** which breaks down organic compounds in the absence of oxygen. The end products of this process are compounds such as methane gas (CH_4), hydrogen sulfide (H_2S), etc.

Energy Flows through Ecosystems in Food Chains and Food Webs

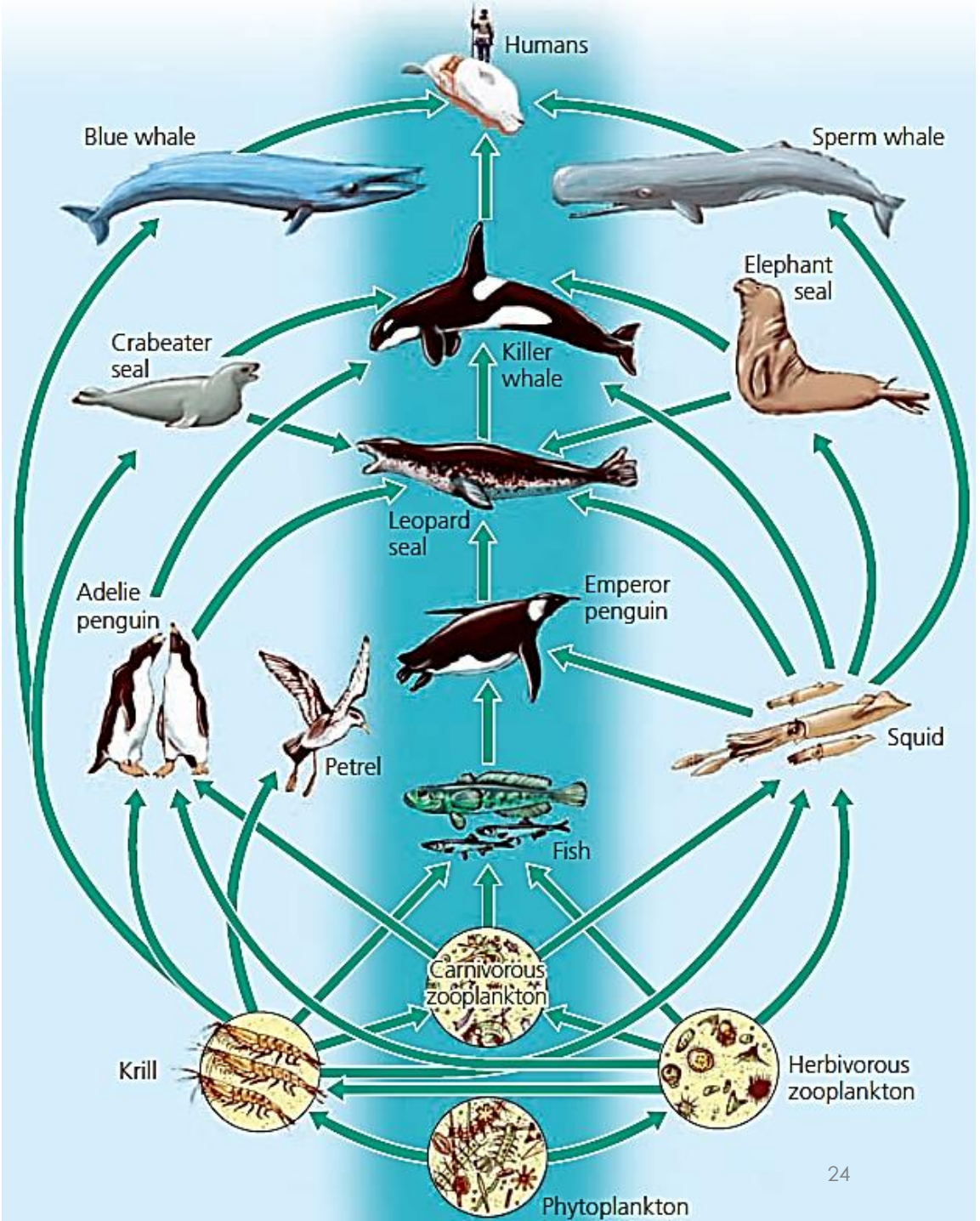
- The chemical energy stored as nutrients in the bodies and wastes of organisms flows through ecosystems from one trophic (feeding) level to another.
- **Food chain** is a sequence of organisms, each of which serves as a source of food or energy for the next.

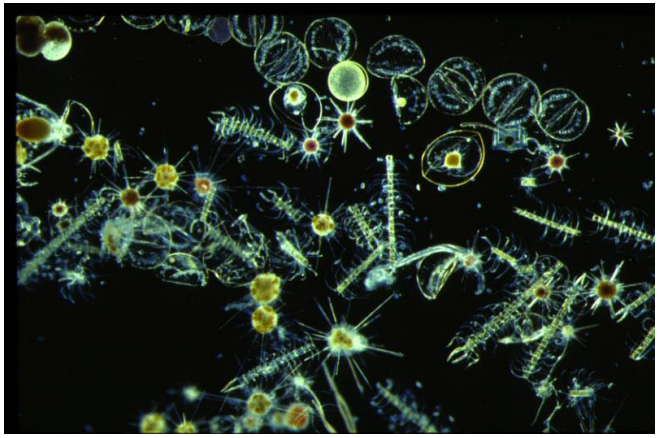


- In natural ecosystems, most consumers feed on more than one type of organism, and most organisms are eaten or decomposed by more than one type of consumer.
- Organisms in most ecosystems form a complex network of interconnected food chains called a **food web**.

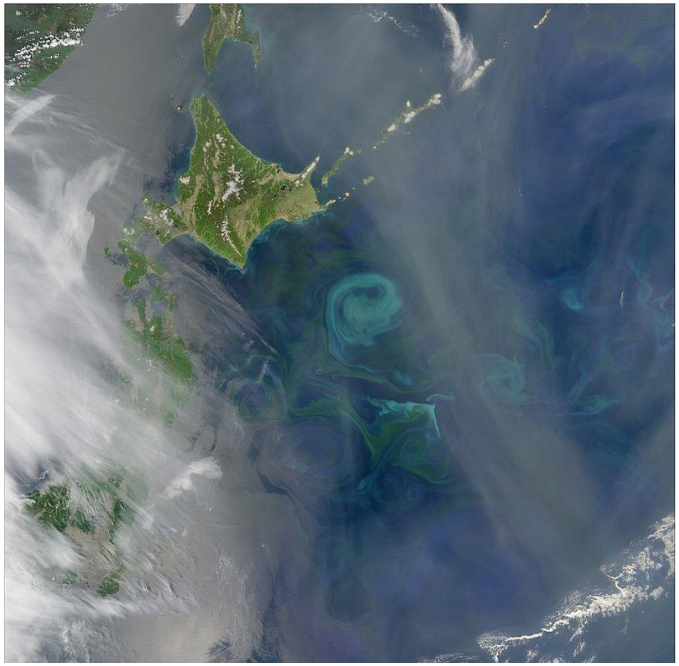


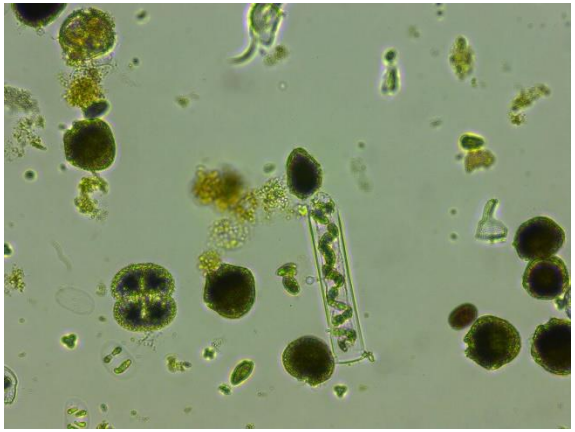
This diagram illustrates a greatly simplified food web in the southern hemisphere. The shaded middle area shows a simple food chain. Its participants interact in feeding relationships to form the more complex food web shown here.





Marine Phytoplankton

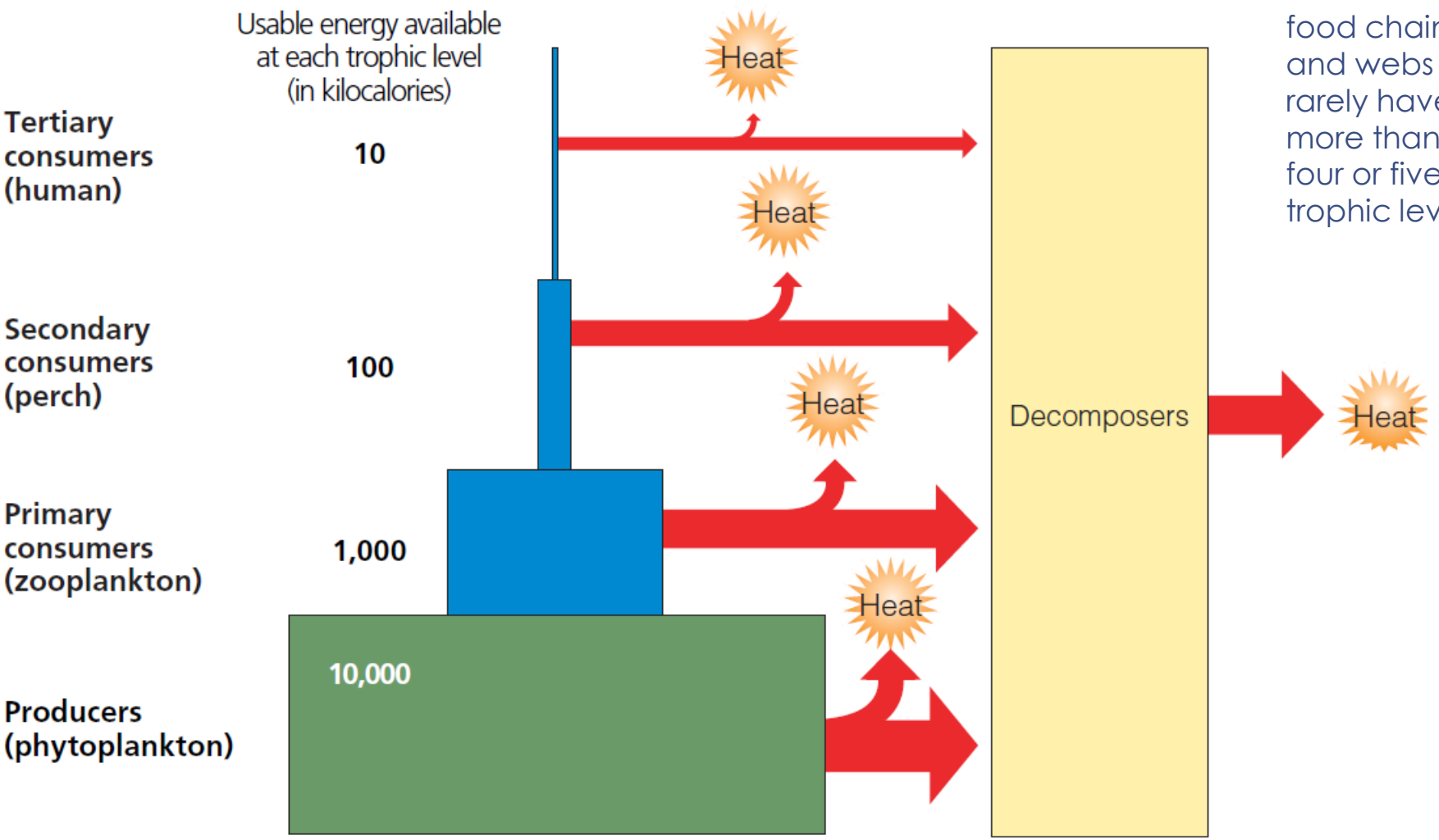




freshwater phytoplankton

Usable Energy Decreases with Each Link in a Food Chain or Web

- Each trophic level in a food chain or web contains a certain amount of **biomass** (the dry weight of all organic matter contained in its organisms).
- In a food chain or web, chemical energy stored in biomass is transferred from one trophic level to another.
- As energy flows through ecosystems in food chains and webs, there is a decrease in the amount of high-quality chemical energy available to organisms at each succeeding feeding level
- With each transfer, some usable chemical energy is degraded and lost to the environment as low-quality heat.



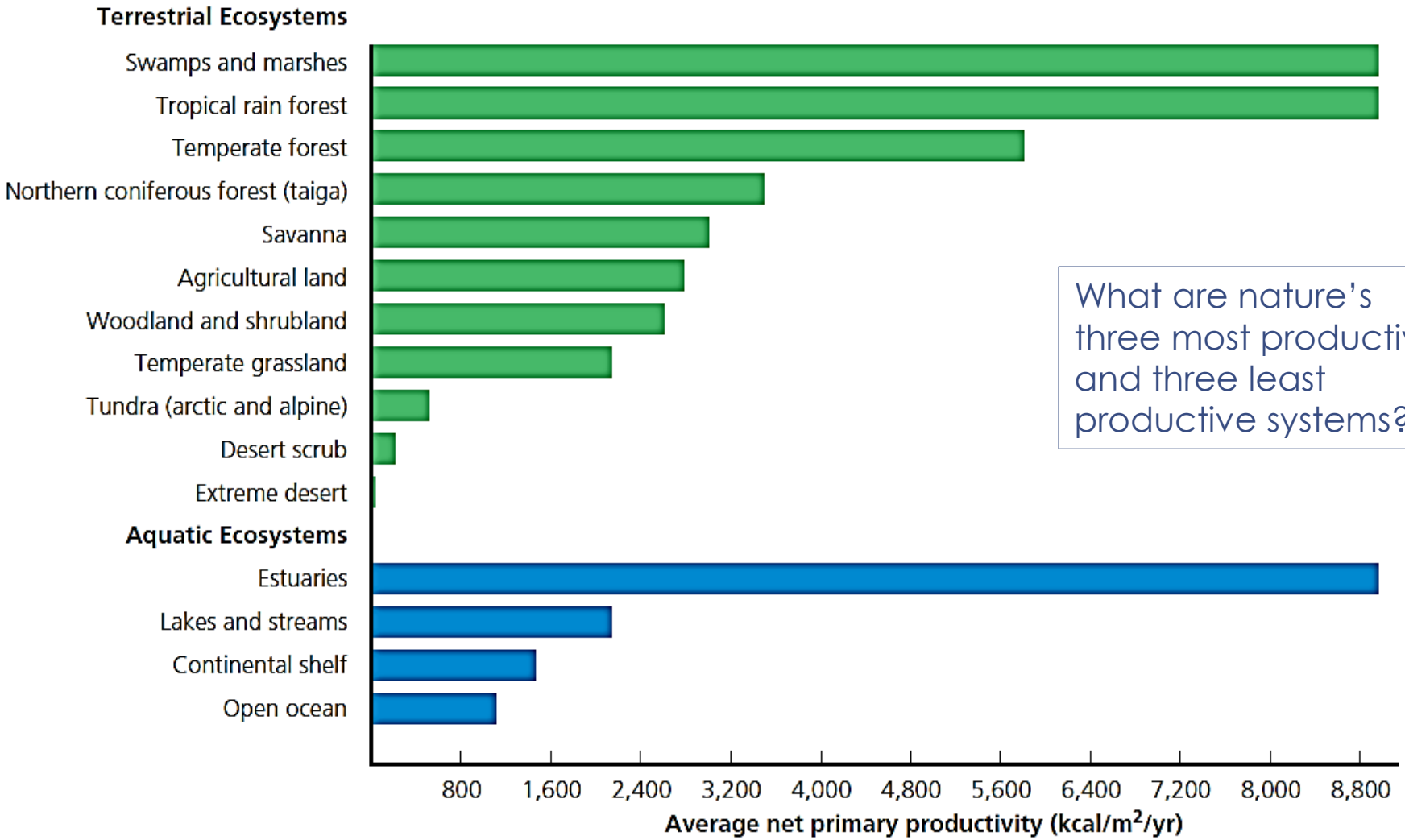
food chains and webs rarely have more than four or five trophic levels

This model is a generalized **pyramid of energy** flow that shows the decrease in usable chemical energy available at each succeeding trophic level in a food chain or web.

Why there are fewer tigers in tropical rain forests than there are insects?

Some Ecosystems Produce Plant Matter Faster Than Others Do

- The amount of living organic material (biomass) that a particular ecosystem can support is determined by
  - how much solar energy its producers can capture and store as chemical energy.
  - how rapidly they can do so.
- **Primary productivity** is the rate at which an ecosystem's producers convert solar energy into chemical energy in the form of biomass found in their tissues.
- It is usually measured in ($kcal/m^2/yr$)
- To stay alive, grow, and reproduce; producers must use some of the chemical energy stored in the biomass they make for their own respiration.
- **Net primary productivity (NPP)** is the *rate* at which producers use photosynthesis to produce and store chemical energy minus the rate at which they use some of this stored chemical energy through aerobic respiration.



What are nature's three most productive and three least productive systems?

- Only the biomass represented by NPP is available as nutrients for consumers, and they use only a portion of this amount.
- Thus, the planet's NPP ultimately limits the number of consumers (including humans) that can survive on the earth. This is an important lesson from nature.

Glossary

Environment All external conditions, factors, matter, and energy, living and nonliving, that affect any living organism or other specified system.

Ecology Biological science that studies the relationships between living organisms and their environment; study of the structure and functions of nature.

Ecosystem One or more communities of different species interacting with one another and with the chemical and physical factors making up their nonliving environment.