Republic of Iraq
Ministry of Higher Education
& Scientific Research

University: Baghdad
College: Engineering
Dept.: Environmental
Stage: 2nd year students
Lecturer: Dr. Hussein Jabar.

<table>
<tr><td>Title</td><td colspan="4">Ecology</td></tr>
<tr><td>Course Instructor</td><td colspan="4">Dr. Hussein Jabar.</td></tr>
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<tr><td>Course Objective</td><td colspan="4">The main aim of this course are
• Introduce to student the basic concept of Ecology
• Describe the general principal involve of Environmental ecology</td></tr>
<tr><td>Course Description</td><td colspan="4">This course introduces the description of the environmental ecology. Topic covered: Principles of general ecology, Biochemical pathways, Kinetics ecosystem structure and function, Nutrient cycling, Development and application of mass balance for lake eutrophication, Preliminary design of waste ponds and constructed wetlands, Transfer of toxic chemicals in food webs</td></tr>
<tr><td>Reference Books</td><td colspan="4">• Fundamental of Ecology by P. Odum and W. Barrett
• Introduction to Environmental Engineering and Science by G. Masters and W. Ela
• Environmental Engineering by G. Kiely</td></tr>
<tr><td rowspan="2">Grading System</td><td>Mid exam</td><td>Quizzes</td><td>Homework& Project</td><td>Final Exam</td></tr>
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Course Weekly Outline

Week	Topes Covered
1	Principles of general ecology
2	Principles of general ecology
3	Biochemical pathways
4	Kinetics ecosystem structure and function
5	Kinetics ecosystem structure and function
6	Nutrient cycling
7	Nutrient cycling
8	Development and application of mass balance for lake eutrophication
9	Development and application of mass balance for lake eutrophication
10	Preliminary design of waste ponds and constructed wetlands
11	Preliminary design of waste ponds and constructed wetlands
12	Transfer of toxic chemicals in food webs
13	Review- Mid exam

Principles of general ecology

Biology is the science of life. **Ecology** is basically a branch of biology. It deals with study of interactions among organisms and their biophysical environment.
This biophysical environment includes both living (biotic), as well as, non-living (abiotic).
The Biophysical environment in which all interactive mechanisms happen is called as an ecosystem.

The study of Ecology deals with
1. Spatial distribution of an abundance of organisms,
2. Temporal changes in the existence, abundance and activities of organisms,
3. Interrelations between organisms, communities and populations,
4. Structural adaptation and functional adjustments of organisms to the change in environment,
5. Behavior of organisms under natural environment,
6. Productivity of organisms and energy to mankind
7. Development of interactive models for predictive purposes.

The term **'Environment',** is a composite term for the conditions in which organisms live and, thus, consists of air, water, food and sunlight which are the basic needs of all living beings and plant life, to carry on their life functions.
Ecology is also called 'environmental biology'
The word **'environment'** comes from a French word *'environ'* meaning 'around', 'to surround, 'to encompass'. It is used to describe everything that surrounds on organism. Thus, environment is a complex of so many things (light, temperature, soil, water etc.,) which surrounds an organism.
Environment is a very wide concept.

The inter-dependence and interrelationship of living organisms - plants, animals and microbes with each other and with their physical environment may be expressed in a suitable manner in the diagram, as indicated, below.

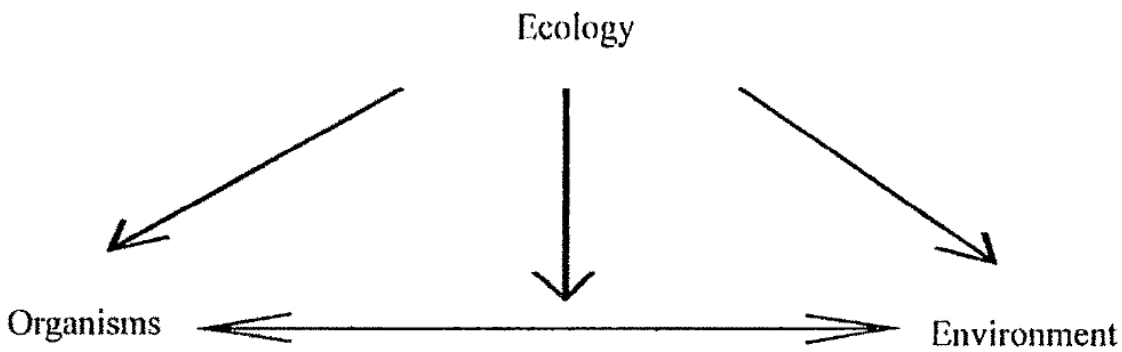


Figure 1: Ecology is the study of animals and plants in their relations to each other and to their physical environment.

The sum of all these living and non-living factors makes the environment of an organism. The place, where an organism lives -habitat, indeed, presents a particular set of environmental conditions

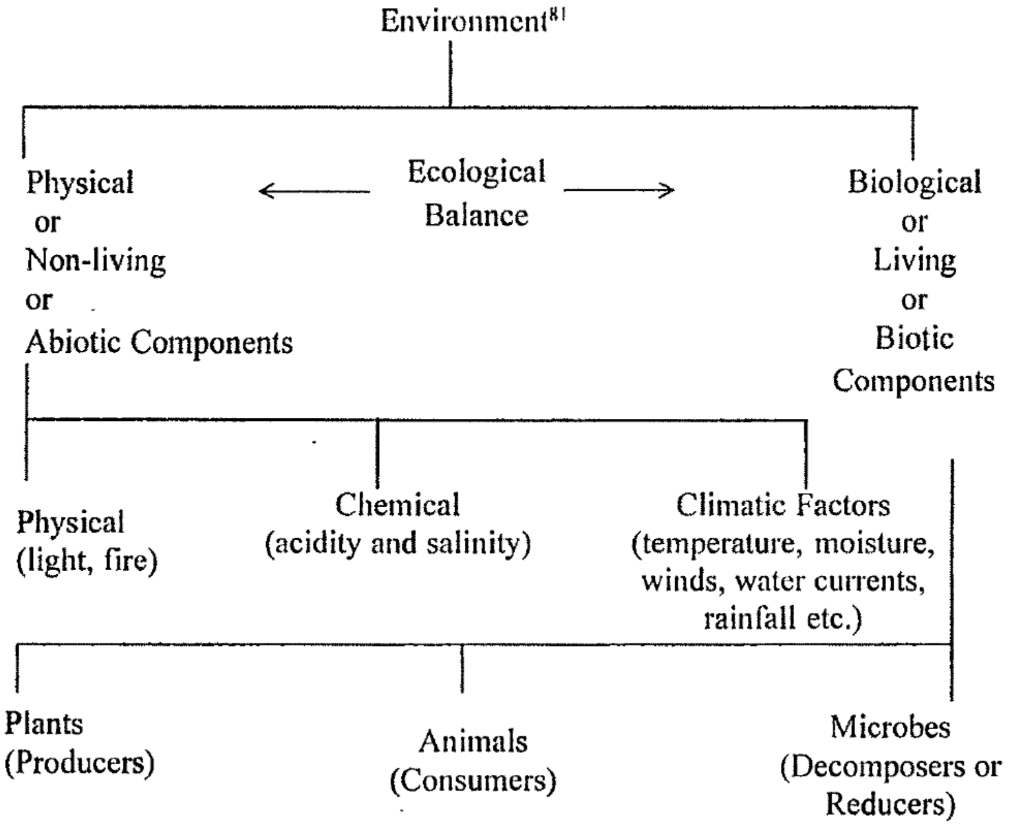


Figure 2: Environment refers to the external conditions in which an organism lives

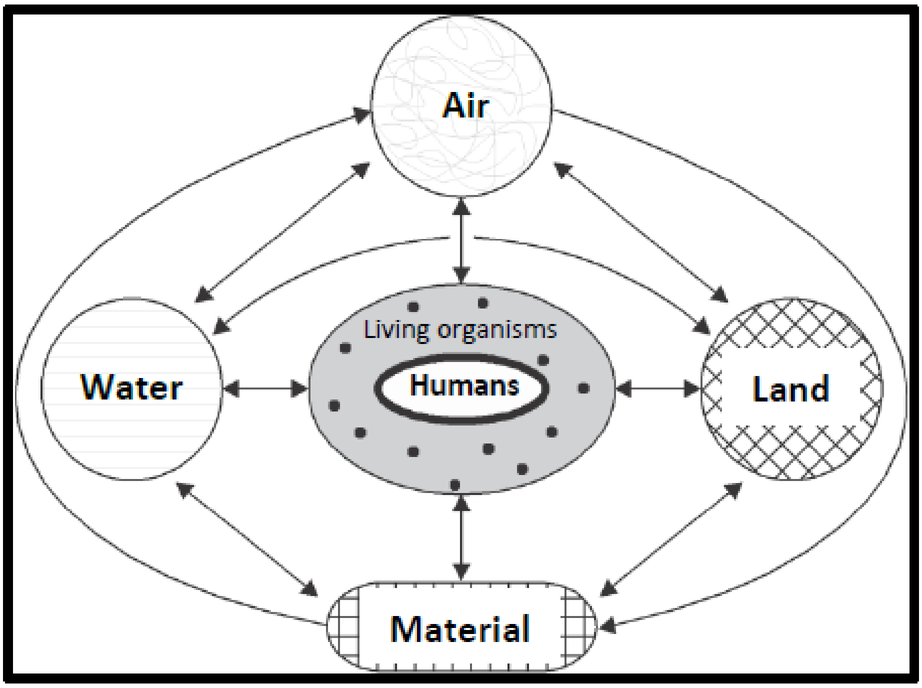


Figure 3**:** Concept of Environment: air, water, land, living organisms and materials surrounding us and their interactions together constitute environment.

The best way to delimit modern ecology is to consider the concept of levels of organization, visualized as an ecological spectrum (Fig.4) and as an extended ecological hierarchy (Fig. 5). Hierarchy means "an arrangement into a graded series interaction with the physical environment (energy and matter) at each level produces characteristic functional systems.

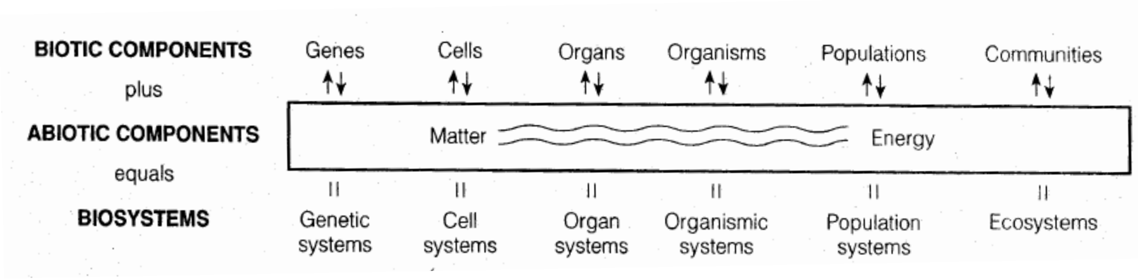


Figure 4: Ecological levels-of-organization spectrum emphasizing the interaction of living and nonliving components

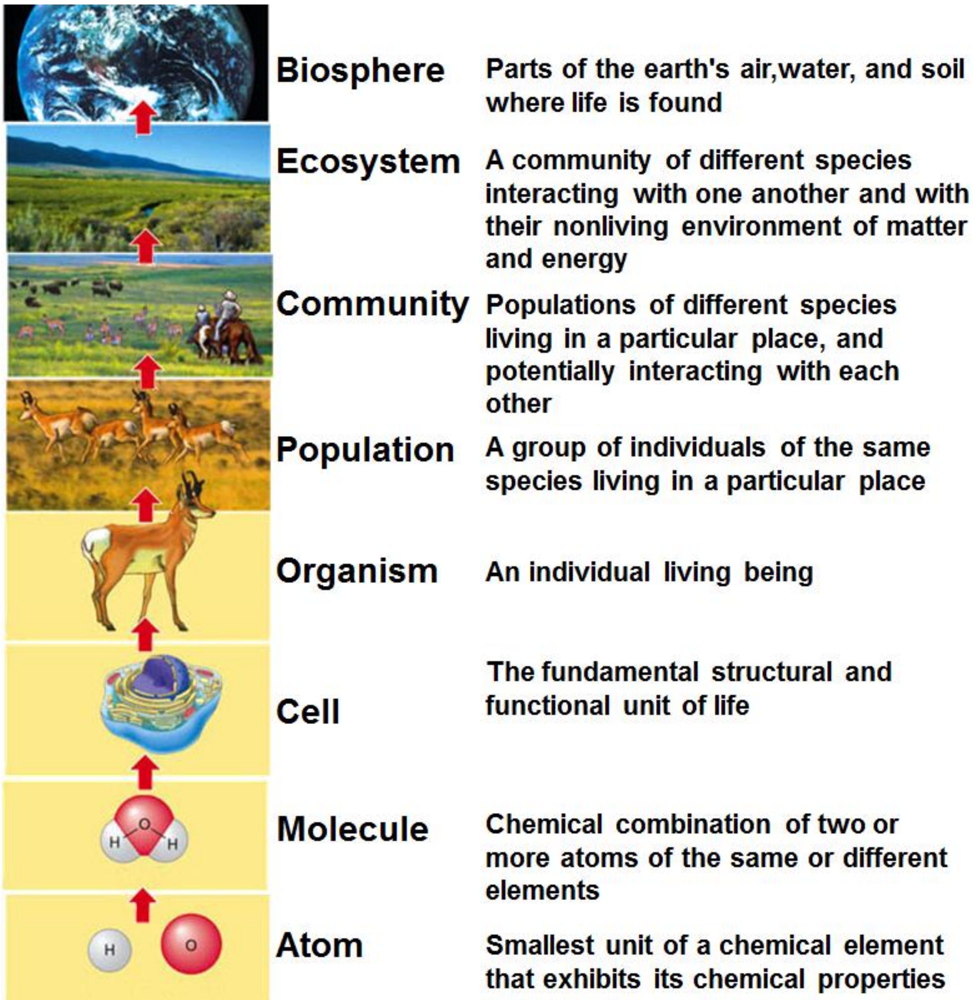


Figure 5: Some levels of Hierarchy organization of matter in nature.

Ecology focuses on five of these levels of matter, Organisms, Populations, Communities, Ecosystems and Biosphere

Organism

Characteristics of the Physical Environment that Affect Organism Distribution

- Metabolic requirements
  - nutrients and limiting nutrients
  - oxygen as a requirement for metabolism
  - anaerobic and aerobic organisms
  - eutrophication and algal bloom
- Metabolic wastes
  - carbon dioxide is a common byproduct of metabolism

Population

Changes in Population Size

- Can occur through:
  - reproduction
  - death
  - Emigration

Population Growth

Many ways a population can increase in size, depending on the carrying capacity of the environment

- exponential/logarithmic growth
- logistic growth

Exponential Population Growth

When resources are unlimited, a population can experience exponential growth, where its size increases at a greater and greater rate. This accelerating pattern of increasing population size is called exponential growth.

The best example of exponential growth is seen in bacteria. Bacteria are prokaryotes that reproduce by fission. This division takes about an hour for many bacterial species. If 1000 bacteria are placed in a large flask with an unlimited supply of nutrients, after the third hour, there should be 8000 bacteria in the flask; and so on. After 1 day and 24 of these cycles, the population would have increased to more than 16 billion. When the population size, N, is plotted over time, a J-shaped growth curve is produced.

Logistic growth

Exponential growth is possible only when infinite natural resources are available; this is not the case in the real world. To model the reality of limited resources, population ecologists developed the logistic growth model.

When the number of individuals becomes large enough, resources will be depleted, slowing the growth rate. Eventually, the growth rate will plateau or level off. This population size, which represents the maximum population size that a particular environment can support, is called the carrying capacity

A graph of this equation yields an S-shaped curve; it is a more-realistic model of population growth than exponential growth.

There are three different sections to an S-shaped curve. Initially, growth is exponential because there are few individuals and ample resources available. Then, as resources begin to become limited, the growth rate decreases. Finally, growth levels off at the carrying capacity of the environment, with little change in population size over time.

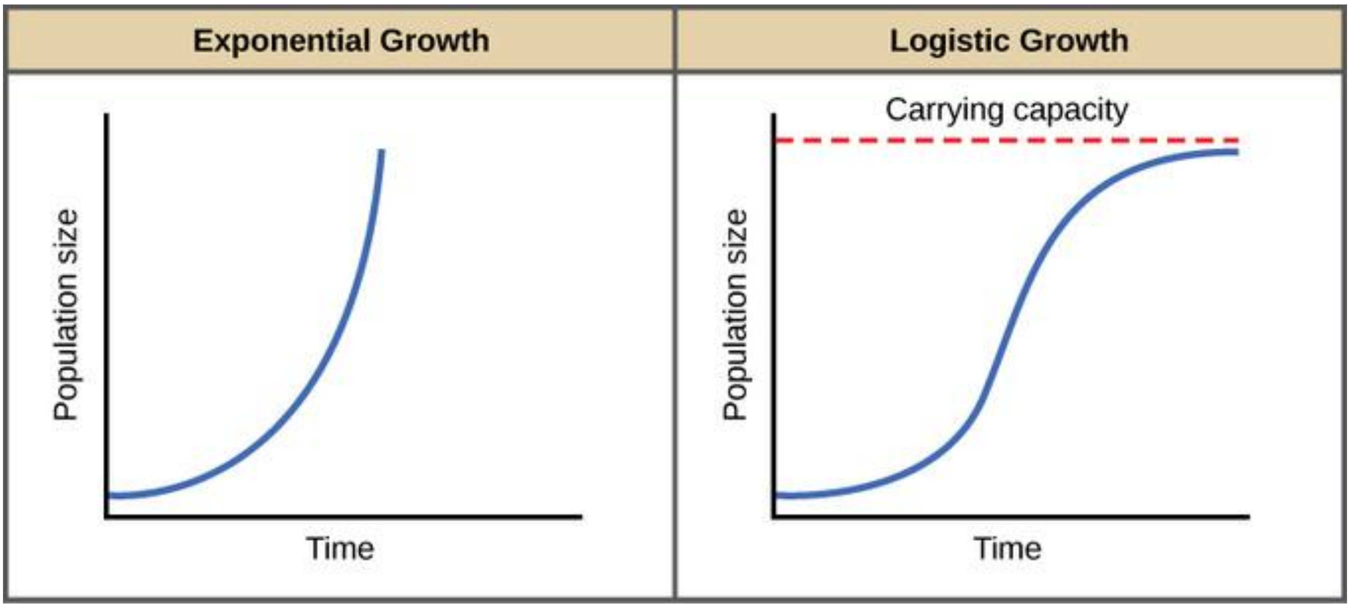


Figure 6: Exponential and logistical population growth

Communities

- Composed of populations of different species that live in one habitat at the same time

Symbiosis: living together

- mutualism – both organisms benefit
- commensalism – one organism benefits, the other is nether harmed nor benefited
- parasitism – one organism benefits, the other is harmed

Ecosystems

As energy flows through ecosystems in food chains and food webs, the amount of chemical energy available to organisms at each succeeding feeding level decreases.

- Food chain
  - Sequence of organisms, each of which serves as a source of food for the next
- Food web
  - Network of interconnected food chains
  - More complex than a food chain

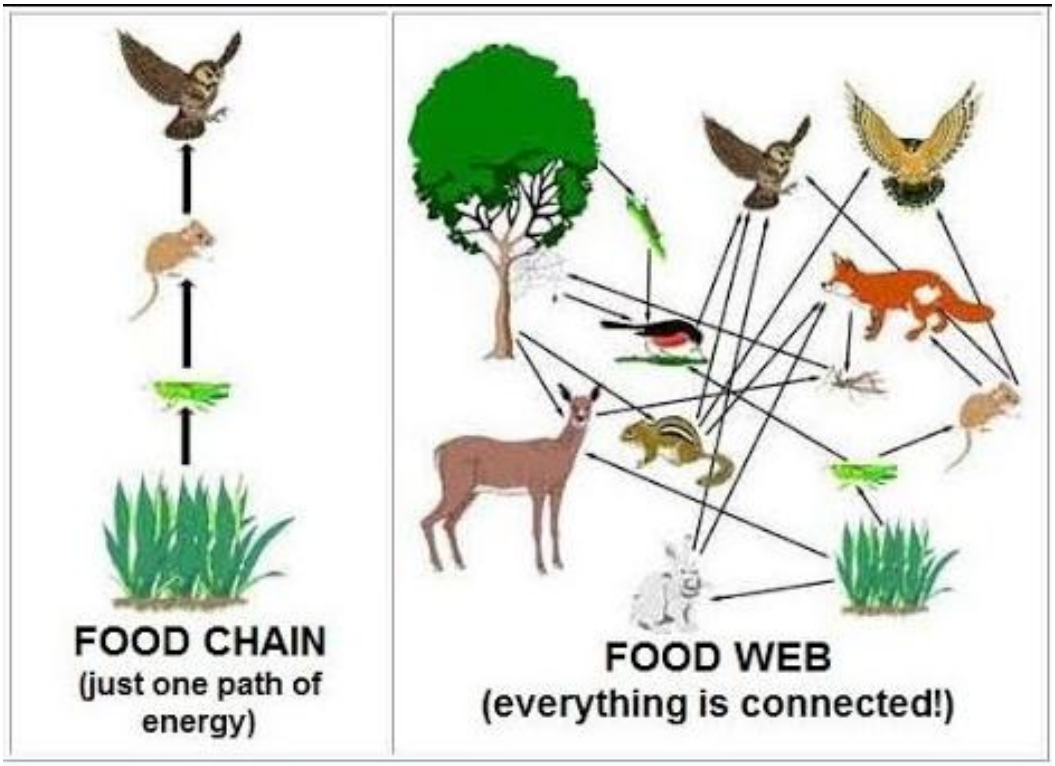


Figure 7: A food chain

Trophic levels

- Biomass decreases with increasing trophic level
- Number of levels is limited because only a fraction of the energy at one level passes to the next level
- Ecological efficiency
  - ten percent rule
- Trophic pyramids
  - as energy passed on decreases, so does the number of organisms that can be supported

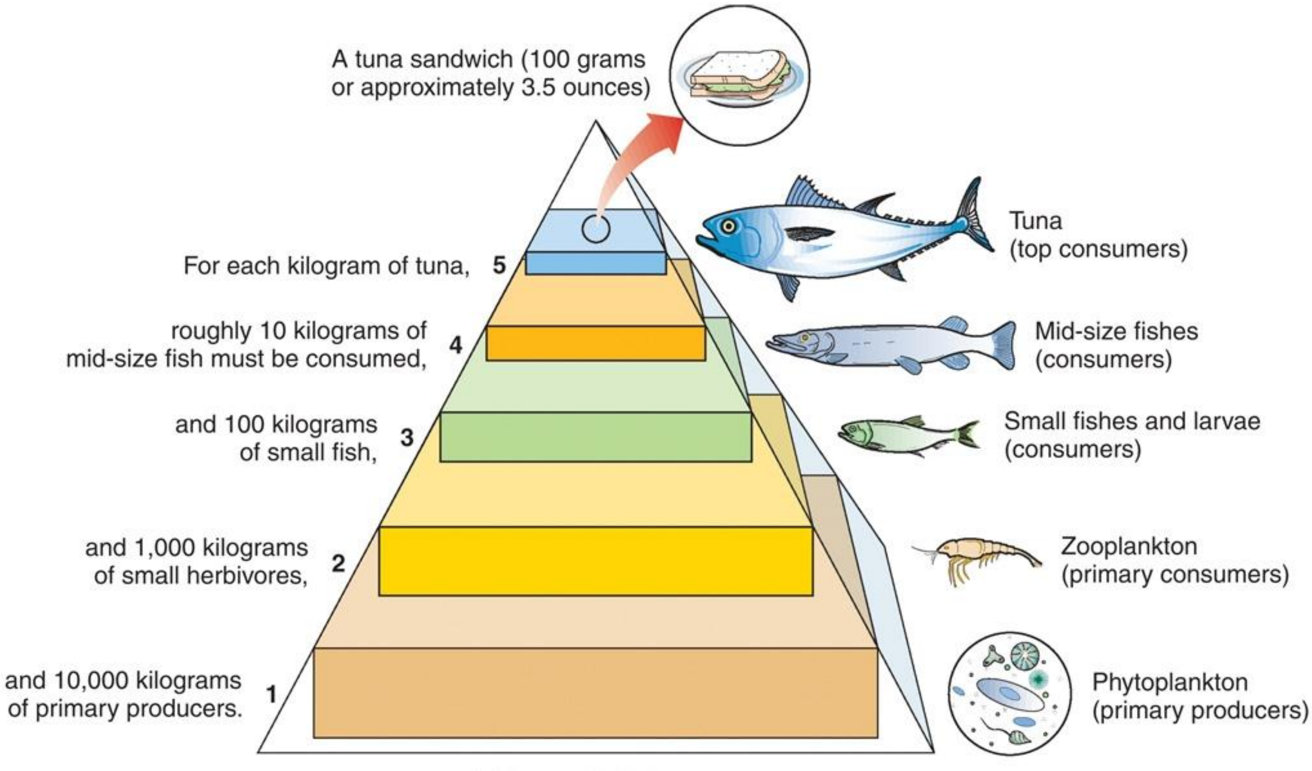
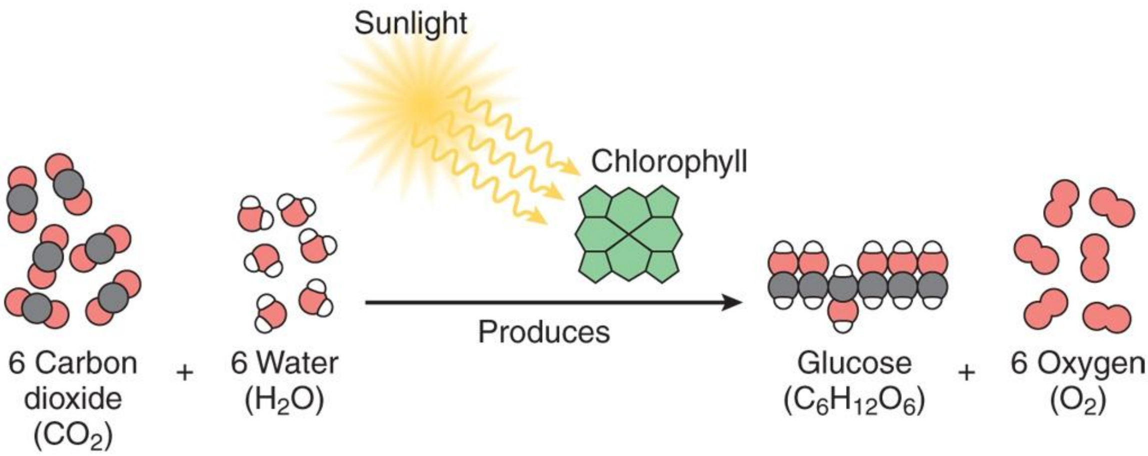


Figure 8: The trophic pyramids

Components of ecosystem

- Producers = Autotrophs
  (auto = self, troph = feed)
  - photosynthetic producers
  - chemosynthetic producers



- Consumers = Heterotrophs

(hetero = other, troph = feed)
  - first-order consumers (herbivores)
  - second- and third-order consumers (carnivores)
  - Omnivores

- Decomposers
  - Release nutrients from the dead bodies of plants and animals- Fungi and bacteria

Energy Flow and Nutrient

Ecosystems sustained through:

- One-way energy flow from the sun
- Nutrient recycling

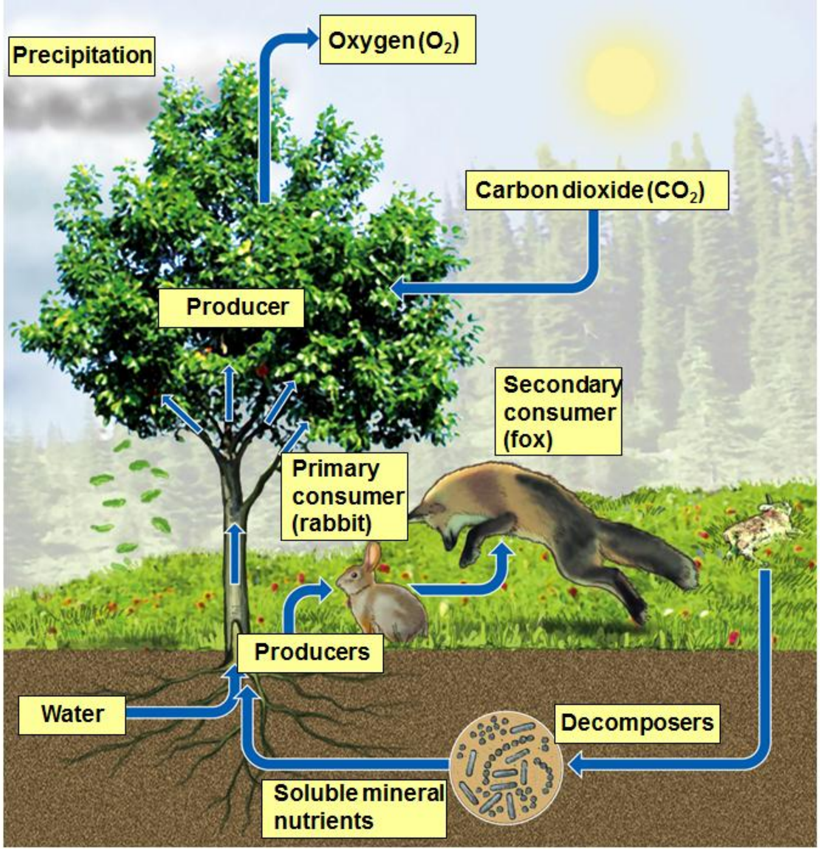


Figure 9: Major living and nonliving components of an ecosystem in a field

- The arrows (Fig. 10) show how chemical energy in nutrients flows through various trophic levels in energy transfers; most of the energy is degraded to heat.

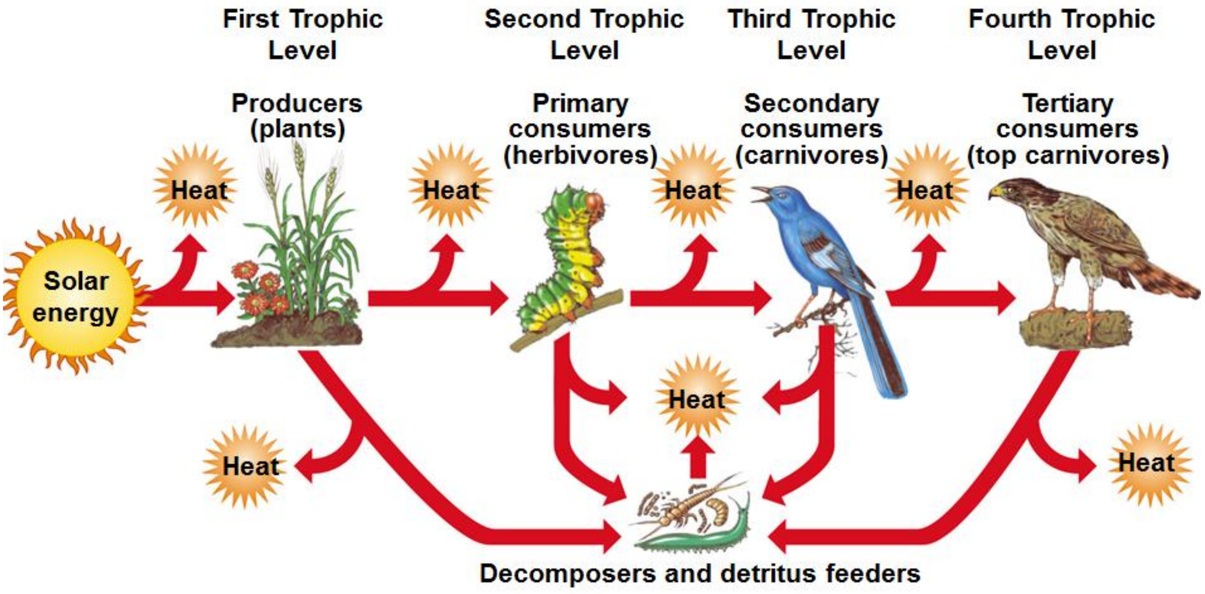


Figure 10: The energy flow through food chain.

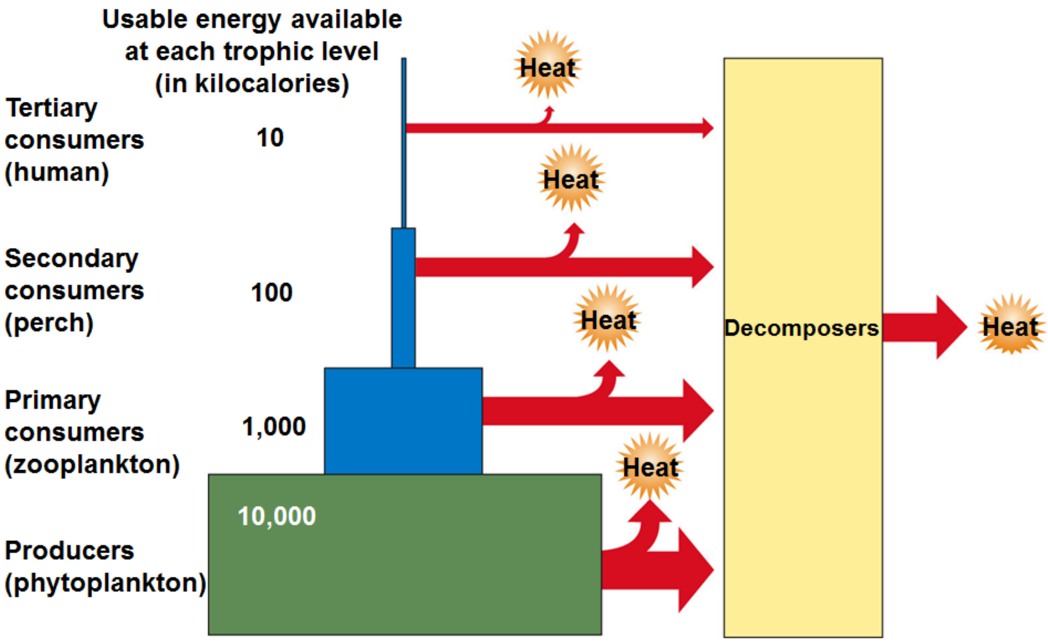


Figure 11: Generalized pyramid of energy flow showing the decrease in usable chemical energy available at each succeeding trophic level in a food chain or web. This model assumes that with each transfer from one trophic level to another there is a 90% loss in usable energy to the environment in the form of low-quality heat.

Energy in Ecological Systems

Energy is defined as the ability to do work. The behavior of energy is described by the following laws: The first law of thermodynamics or the law of conservation of energy, states that energy may be transformed from one form into another but is neither created nor destroyed.

The second law of thermodynamics, or the law of entropy, may be stated in several ways, including the following: No process involving an energy transformation will spontaneously occur unless there is a degradation of energy from a concentrated form into a dispersed form. The second law of thermodynamics may also be stated as follows: Because some energy is always dispersed into unavailable heat energy, no spontaneous transformation of energy (sunlight, for example) into potential energy is 100 percent efficient.

The transfer of energy through the food chain of an ecosystem is termed the energy flow because, in accordance with the law of entropy, energy transformations are "one way," in contrast to the cyclic behavior of matter. The total energy flow that passes through the living components of the ecosystem will be analyzed.

The basic units of energy quantity are presented in Table I. There are two classes of basic units: potential (stored) energy units, independent of time (Class A), and power, with time built into the definition (Class B). Inter conversions of power units must take account of the time unit used; thus, 1 watt = 860 cal/h.

Units of energy and power and some useful ecological approximations

(A) Units of potential energy

Unit (abbreviation)	***Definition***
calorie or gram-calorie (cal or gcal)	the heat energy required to raise the temperature of 1 cubic centimeter of water by 1 degree Centigrade (at 15° C)
kilocalorie or kilogram-calorie (kcal)	the heat energy needed to raise the temperature of 1 liter of water by 1 degree Centigrade (at 15° C) = 1000 calories
British thermal unit (BTU)	the heat energy needed to raise the temperature of 1 pound of water by 1 degree Fahrenheit
joule (J)	the work energy required to raise 1 kilogram to a height of 10 centimeters (or 1 pound to approximately 9 inches) = 0.1 kilogram-meters
foot-pound	the work energy required to raise 1 pound to a height of 1 foot
kilowatt-hour (KWh)	the amount of electric energy delivered in 1 hour by a constant power of 1,000 watts = 3.6×10^6 joules

(B) Units of power (energy-time units)

Unit (abbreviation)	***Definition***
watt (W)	the standard international unit of power = 1 joule per second = 0.239 cal per second; also the amount of electrical power delivered by a current of 1 ampere across a potential difference of 1 volt
horsepower (hp)	550 foot-pounds per second = 745.7 watts

In organism the biological work require energy include processes such as

- Growing
- Moving
- Reproducing
- Repairing and Maintenance

Nutrient cycles

Matter, in the form of nutrients, cycles within and among ecosystems and in the biosphere, and human activities are altering these chemical cycles.

Hydrologic Cycle

- Water cycle is powered by the sun
- Water vapor in the atmosphere comes from the oceans – 84%
- Over land, ~90% of water reaching the atmosphere comes from transpiration
- water is lost through evaporation returned through precipitation and runoff

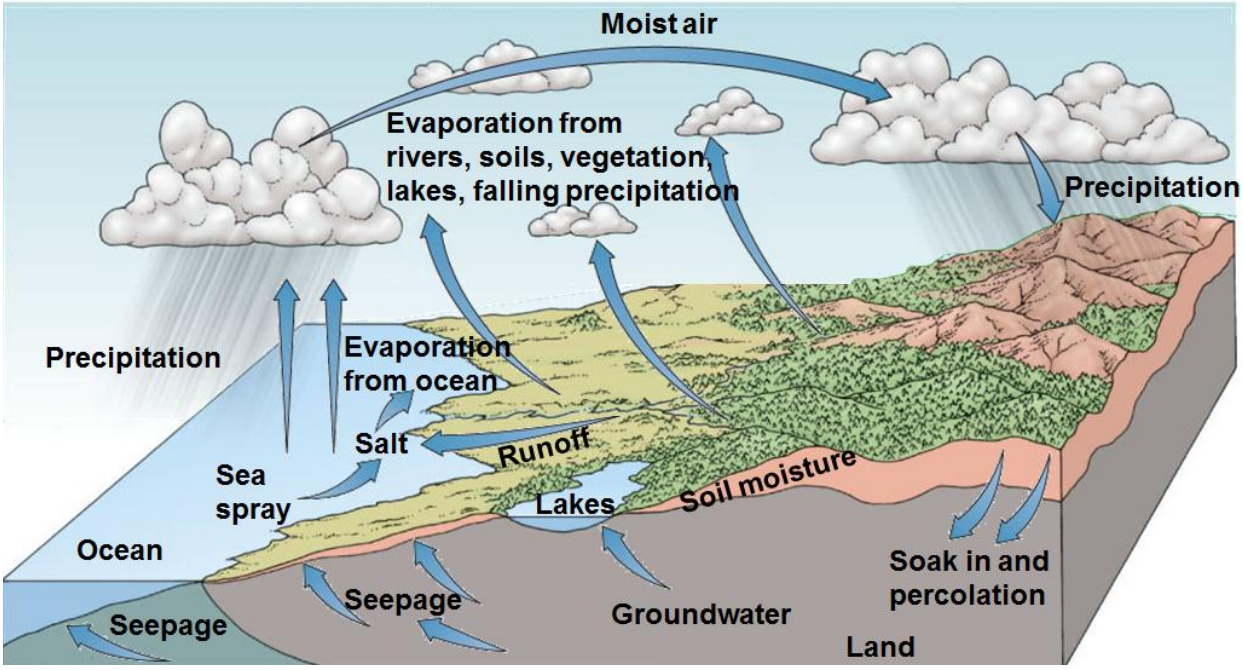


Figure 12: The hydrologic cycle

Carbon cycle

- carbon released from organisms through respiration and decomposition
- recycled by photosynthetic producers
- carbon is used in shells, corals and skeletons as part of calcium carbonate
- fossil fuels when burned release CO_2 back into atmosphere and contribute to global warming

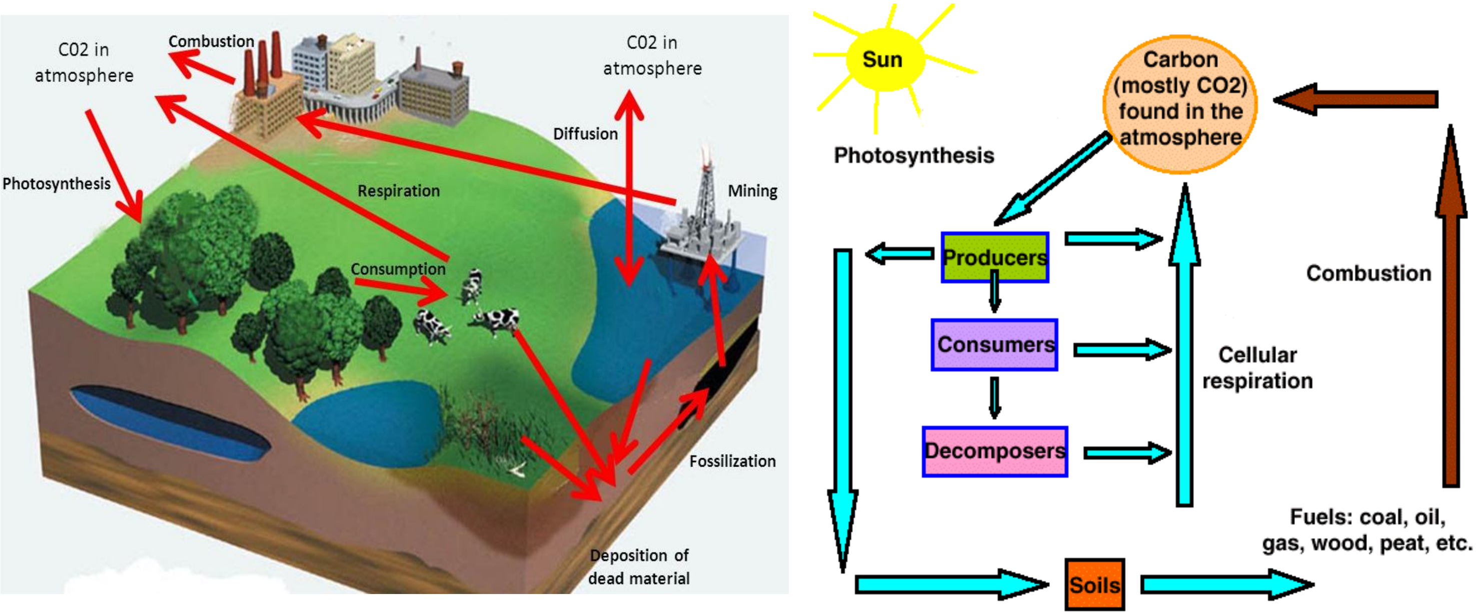


Figure 13: The carbon cycle

Nitrogen cycle

- producers use nitrogen to synthesize protein forming amino acids
- bacteria recycle nitrogen from wastes and decomposing, dead organisms
- fixation of atmospheric nitrogen by microorganisms

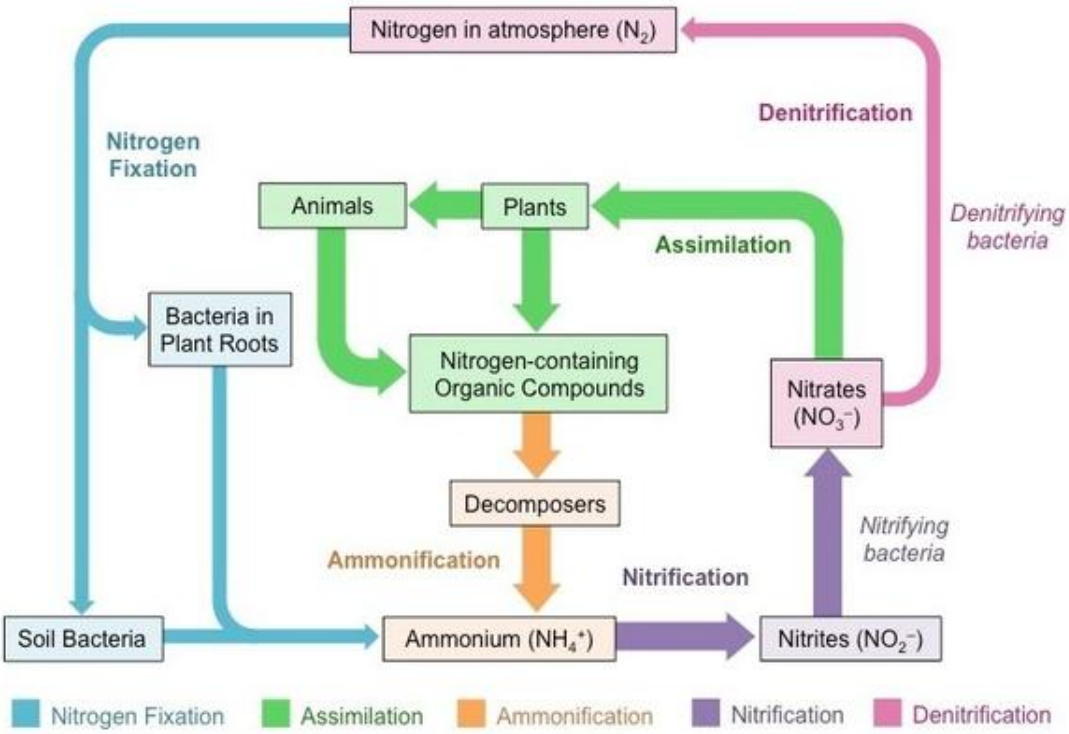


Figure 14: The nitrogen cycle.