ESE 2021

UPSC ENGINEERING SERVICES EXAMINATION

Preliminary Examination

General Studies and Engineering Aptitude

Basics of Energy and Environment

Comprehensive Theory *with* Practice Questions
and ESE Solved Questions

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ESE 2021 Preliminary Examination : Basics of Energy and Environment

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Preface

B. Singh (Ex. IES)

The compilation of this book **Basics of Energy and Environment** was motivated by the desire to provide a concise book which can benefit students to understand the concepts of this specific topic of General Studies and Engineering Aptitude section.

This textbook provides all the requirements of the students, i.e. comprehensive coverage of theory, fundamental concepts and objective type questions articulated in a lucid language. The concise presentation will help the readers grasp the theory of this subject with clarity and apply them with ease to solve objective questions quickly. This book not only covers the syllabus of ESE in a holistic manner but is also useful for many other competitive examinations. All the topics are given the emphasis they deserve so that mere reading of the book clarifies all the concepts.

We have put in our sincere efforts to present detailed theory and MCQs without compromising the accuracy of answers. For the interest of the readers, some notes, do you know and interesting facts are given in the comprehensive manner. At the end of each chapter, sets of practice question are given with their keys and detailed explanations, that will allow the readers to evaluate their understanding of the topics and sharpen their question solving skills.

Our team has made their best efforts to remove all possible errors of any kind. Nonetheless, we would highly appreciate and acknowledge if you find and share with us any printing and conceptual errors.

It is impossible to thank all the individuals who helped us, but we would like to sincerely thank all the authors, editors and reviewers for putting in their efforts to publish this book.

With Best Wishes

B. Singh

CMD, MADE EASY Group

Basics of Energy and Environment

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Chapter 6

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2 Basics of Environment, Ecology & Ecosystem

2.1 Introduction

- The word 'environment' has been derived from French word "*Environner*" which means "*to encircle" or "to surround*", whereas "Nature" word is derived from Latin word "*Natura*" which refers to characteristics of plants, animals and other creatures.
- All organisms (from virus to man) are obligatorily dependent on the environment for food, energy, water, oxygen, shelter and for other needs.
- Environment is total sum of all conditions which affect evolution and development of life on Earth's surface where organisms live including abiotic components (soil, water, air, etc.) and biotic components (plants, animals, microorganisms, etc.).
- The environment varies from place to place due to variation in climate, soil type and topography. The activities of an organism influence the hydrosphere, the lower atmosphere and the near-surface part of the lithosphere through exchanges of matter and energy.

Table 2.1: Components of Environment

Components of Environment	
Abiotic	**Biotic**
• Energy • Radiation • Temperature and heat flow • Water • Atmospheric gases and wind • Fire • Gravity • Topography • Soil • Geological substratum	• Green plants • Non-green plants • Decomposers • Parasites • Symbionts • Animals • Man

- The short term properties of the atmosphere (such as cloud cover and wind), at a given place and time are called weather.
- Average weather of an area, including atmospheric conditions, seasonal variations and weather extremes averaged over a long period is called a climate.

2.2 Nature of Relationship between Man & Environment

- The environment influences the life of human beings and also human beings modify their environment as a result of their growth, dispersal, activities, death and decay, etc.
- All living beings including man and their environment are mutually affecting each other in a number of ways and a dynamic equilibrium is possible in between the two, i.e. human beings (society) and environment are inter-dependent.
- The stages of interaction between human being and nature have been progressive and as follows:

Stage-I: Period of hunting and gathering (2.5 million–1 million year ago) [Paleolithic Age]

Stage-II: Period of plant domestication and pastoralism (1 million–10,000 B.C.) [Mesolithic Age]

Stage-III: Agriculture Revolution (10,000 B.C.) [Neolithic Age]

Stage-IV: Industrial Revolution (1750–1850 A.D.)

Stage-V: Medical Revolution (1930–1950 A.D.)
Stage-VI: Information Technology Revolution (1970–1990 A.D.)
Stage-VII: Biotech Revolution (1990 –1st decade of 21st Century)
Stage-VIII: Technological Revolution (Present)
Stage-IX (Expected): Green Technology Revolution (Future)

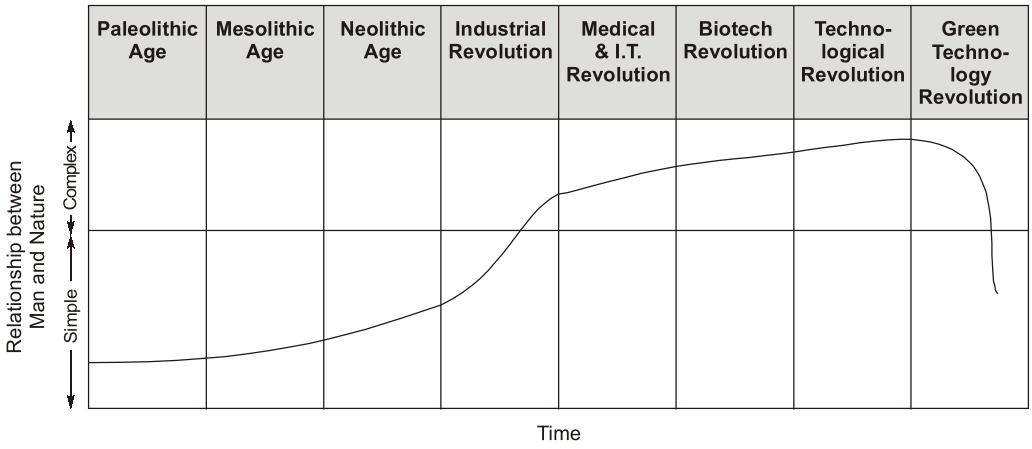


Fig: 2.1 Nature of Relationship Between Man & Environment

2.3 Biosphere

Biosphere is the part of the earth's crust, hydrosphere, and atmosphere that supports life. It is formed through the interaction of atmosphere, lithosphere and hydrosphere. The area of contact and interaction between these three components are the basic requirement for the biosphere to exist.

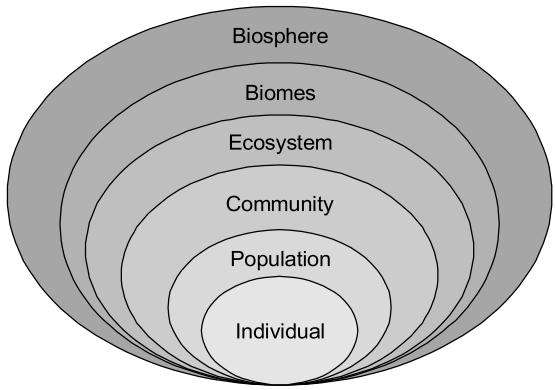


Fig: 2.2 Biosphere

2.3.1 Atmosphere

- The atmosphere is the body of air which surrounds earth. Most of the atmosphere is located close to the earth's surface where it is most dense.

Air Composition

- Nitrogen and oxygen are the most abundant gases in the Troposphere, constituting about 78% and 20.9% of total gaseous volume respectively. The remaining 1% consists of argon, water vapour, CO_2 and ozone. These gases occur in minute quantities in the atmosphere, but are essential for maintaining life on the earth.
- Carbon dioxide, water vapour and ozone play an important role in maintaining the heat balance of the earth.

Table 2.2 Normal Composition of Gases in Air

Constituents	Chemical Symbol	Mole Percent
1. Nitrogen	N_2	78.084%
2. Oxygen	O_2	20.947%
3. Argon	Ar	0.934%
4. Carbon dioxide	CO_2	0.038%
5. Neon	Ne	0.001818%
6. Helium	He	0.000524%
7. Methane	CH_4	0.00017%
8. Krypton	Kr	0.000114%

Some of the major gases in atmosphere are:

Nitrogen

Nitrogen is required by organisms for the synthesis of proteins, nucleic acids, and other nitrogenous compounds. In nature, atmospheric nitrogen is fixed by specialized organisms. Besides, there are industrial processes to convert atmospheric nitrogen into fertilizers.

Oxygen

Oxygen is necessary for the survival of ecosystem. Oxygen enters the living world through respiration which is a familiar process in both plants and animals. Through this process, glucose molecules are converted into energy which is needed for various activities.

Carbon dioxide

- Carbon dioxide along with water is used by all plants in their photosynthetic process to produce organic substances such as glucose (a vital molecule in living things) and Oxygen. Similarly in respiration, the food (glucose) is broken to give carbon dioxide to the environment.
- Carbon dioxide of the atmosphere is replenished not only through the process of respiration or biological oxidation but also through combustion of fuels and volcanic eruptions.

2.3.2 Structure of Atmosphere

- The atmosphere is divided into a series of concentric shells of sphere due to the variations in temperature and pressure at various altitude.

Troposphere

- It is the lower portion of the atmosphere extending upto about 12 km height and contains 90% of gases in the atmosphere.
- In this layer, generally temperature decreases with increasing height up to tropopause. The temperature averages 15°C near the soil surface and it lower down to –57°C at the tropopause.

Stratosphere

- It extends up to 50 km in height.
- A thin layer of ozone is present in the Stratosphere at the height of 15 to 30 km.
- There is little mixing of gases between the Troposphere and Stratosphere.
- Stratopause is the transition layer between Stratosphere and the Mesosphere.

Mesosphere

It is situated above the Stratosphere and extends up to an attitude of 80 km and shows a decrease of temperature with increase in height.

Thermosphere

It is situated directly above the Mesosphere and below the Exosphere. It extends upto about 700 km.

Exosphere

The layer beyond the Thermosphere is known as Exosphere.

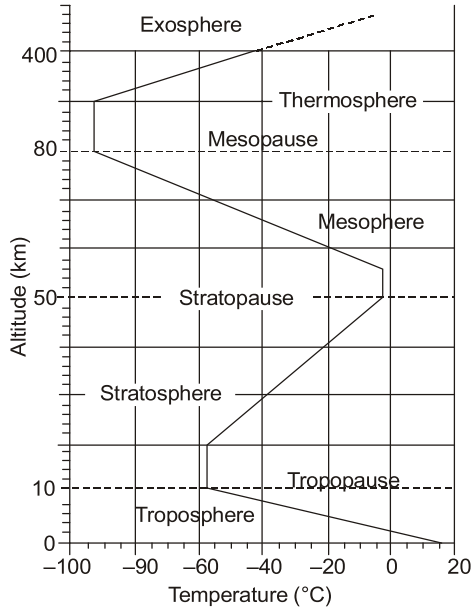


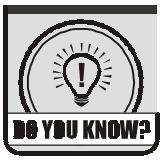
Fig: 2.3 Layers of Atmosphere

2.3.3 Lithosphere

- The Lithosphere is the solid, rocky crust covering entire earth. This crust is inorganic and is composed of minerals.
- Geologically, Lithosphere refers to the combination of earth's crust and outer mantle. It provides the platform and habitat to the biotic elements of the ecosystem. It covers the entire surface of the earth from the top of Mount Everest to the bottom of the Mariana Trench.
- Lithosphere has two main functions with reference to the biosphere:
  (a) It provides platforms for terrestrial, transitionary and aquatic plants
  (b) It is the source of nutrients and minerals vital for the growth and survival of ecosystem.

2.3.4 Hydrosphere

- The Hydrosphere is composed of all of the water on or near the surface of earth. This includes the oceans, rivers, lakes, and even the moisture in the air. Water is considered to be the most important constituent of biotic elements.
- 97% of the earth's water is in the oceans, and remaining 3% is fresh water. The three-quarters of the fresh water is solid and exists in ice sheets.
- On a large scale, water is cycled through evaporation to cloud formation to precipitation to run off; whereas, water when consumed by biotic elements is partially used for metabolic activities and is partially excreted as waste in the environment in various forms.



Biosphere has also been divided in different Bio-geographical realms at sub-global levels. Bio-geographic realms are large spatial regions within which ecosystems share a broadly similar biological evolutionary history.

2.4 Ecosystem

- An ecosystem is a complex set of relationship among the living resources, habitats, and residents of an area. It includes plants, trees, animals, fishes, birds, micro-organisms, water, soil, people, etc. Everything that lives in an ecosystem is dependent on the other species and elements that are also part of ecological community.
- Ecosystems include living organisms, the dead organic matter produced by them, the abiotic environment within which the organisms live and exchange elements (soils, water, atmosphere), and the interactions between these components.
- When an ecosystem is healthy (i.e., sustainable) it means that all the elements live in balance and are capable of reproducing themselves.
- The term 'ecosystem' was first coined by A.G. Tansley in 1935.
- The concept of ecosystem was initially given by E.P. Odum who is widely considered as "Father of ecosystem/ ecology".

Do you know? Biomes are regional ecosystems, and the biosphere is the largest of all possible ecosystems.

2.4.1 Structure of Ecosystem

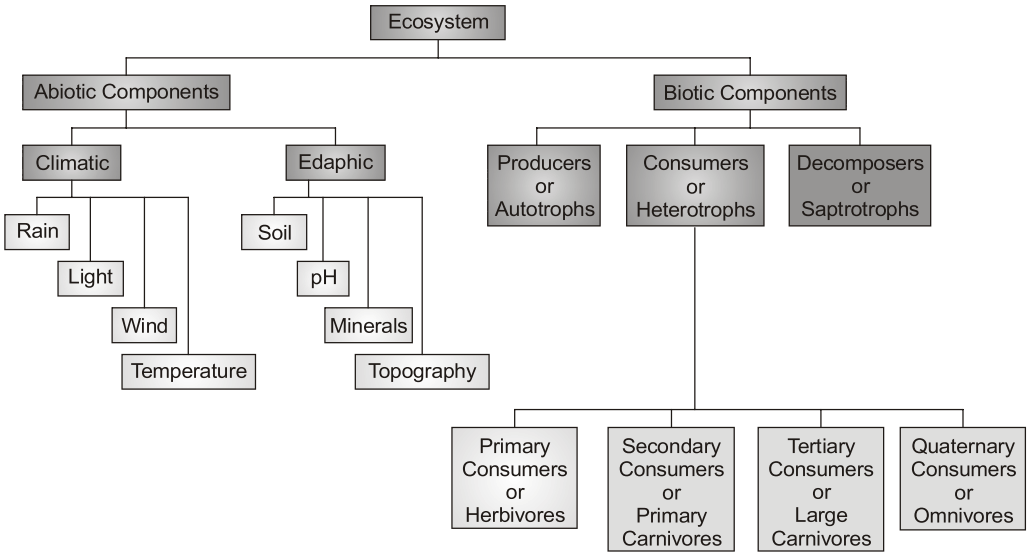


Fig: 2.4 Schematic Representation of the Structure of an Ecosystem

Ecosystem is a subset of Biosphere, wherein various species, their populations and communities interact with each other along with non-living things like land, sunlight, wind, humidity, etc., called as abiotic elements, whereas, the living things are called as biotic elements.

Abiotic Components

- Abiotic components are the inorganic and non-living parts of an ecosystem. These consist of soil, water, air, light energy, etc. They also involve a large number of gases like oxygen, nitrogen, etc. and physical processes including volcanoes, earthquakes, floods, forest fires, climate and weather conditions.
- Abiotic factors are the most important determinants of where and how well an organism exists in its environment.

Some of the important abiotic factors are:

(i) **Energy (Sunlight)**

Sunlight is the primary source of energy in nearly all ecosystems. It is the energy that is used by green plants (which contain chlorophyll) during the process of photosynthesis; a process during which plants manufacture organic substances by combining inorganic substances.

(ii) **Water**

Water is essential for all living beings. It helps to regulate body temperature. Further, water bodies form the habitat for many aquatic plants and animals.

(iii) **Temperature**

Temperature is a critical factor of the environment which greatly influences survival of organisms. Organisms can tolerate only a certain range of temperature and humidity.

(iv) **Atmospheric gases**

Atmospheric gases like oxygen, nitrogen and carbon dioxide are imperative for the survival of flora and fauna of this planet. In addition to keeping the planet warm by greenhouse gas effect, they are vital as:

(a) all organisms require oxygen for respiration.
(b) Carbon dioxide is used by green plants to make food by the process of photosynthesis.
(c) Nitrogen is necessary for all plants and atmospheric nitrogen is fixed by nitrogen fixing bacteria through the action of lightening.

(v) **Soil (Edaphic factors)**

These factors include soil texture, soil temperature, soil water, soil solution and pH, together with soil organisms and decaying matter.

(vi) **Climate**

Climate of a region includes the average rainfall, temperature and the patterns of winds that occur. Climate is one of the most important abiotic factors of an ecosystem.

Do you know? Heliophytes and Sctophytes are the plants which grow well in bright sunlight and shady conditions respectively.

Biotic Components

Biotic components include living organisms comprising plants, animals and microbes. These are classified according to their functional attributes into producers and consumers.

(i) **Producers**

- Producers are also known as autotrophs, or self-feeders. Producers manufacture the organic compounds that they use as sources of energy and nutrients. Most producers are green plants or algae that make organic compounds through photosynthesis.

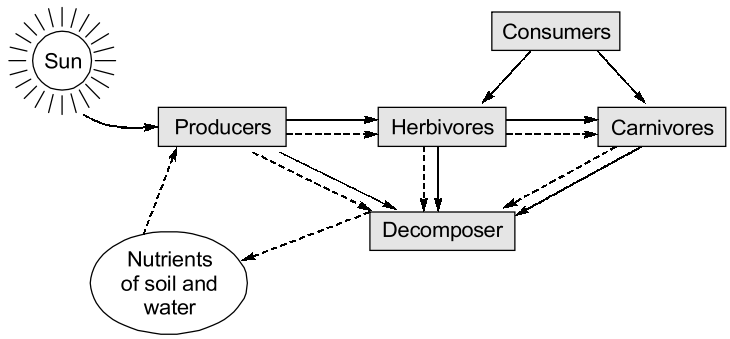


Fig: 2.5 Relationship Between Producers and Consumers

- A few producers, including specialized bacteria, can extract inorganic compounds from the environment and convert them to organic nutrients in the absence of sunlight. This process is called chemosynthesis.

(ii) Consumer

- Consumers are incapable of producing their own food. These are also known as Heterotrophs or phagotrophs (other nourishing).
- Consumers depend on organic food derived from plants, animals or both.

The consumers can be divided into two broad groups namely macro and micro consumers:

(a) Macro Consumers

Herbivores (Primary Consumers)

- The consumers or organisms that feed on autotrophs are called herbivores. Examples : Deer, rabbit, cow, goat, grasshopper, rat, etc.
- All the herbivorous animals which directly consume the plants are called primary consumers. Among the aquatic animals, certain kinds of fish, crustaceans, molluscs etc. which survive on phytoplankton are also primary consumers.

Carnivores (Secondary Consumers)

- Carnivores are further subdivided into First, Second and Third order.
- These animals predate on herbivorous animals.

Omnivores (Tertiary Consumers)

- Omnivorous animals eat herbivorous animals as well as plants. Examples: Sparrow, crow, fox, wolves, cat, dogs, snakes etc. belong to this category.

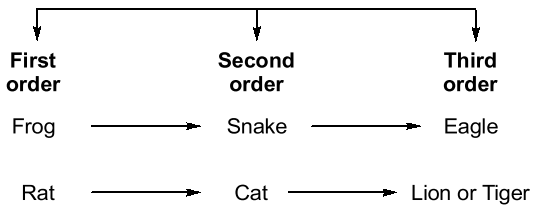


Fig: 2.6 Orders of Carnivores

- Human being is the best example of omnivores because they can take their food from any stage of food chain i.e. they are dependent on autotrophs as well as on heterotrophs.
- Besides, there are strictly carnivorous animals that prey upon carnivores, herbivores, and omnivorous organisms. Lion, tiger, vulture etc. are regarded as tertiary consumers.

(b) Micro Consumers

- Micro consumers are popularly known as decomposers or detritus. They breakdown complex compound of dead remnants of flora and fauna. They also decompose tissues of plants and animals into micro-nutrients. These are also known as Saprotrophs.
- They obtain energy and nutrients by decomposing dead organic substances (detritus) of plant and animal origin. Examples : Bacteria, earthworm, fungi, maggots, termites etc.

Table 2.3: Types of Saprotrophs

Scavengers	• Scavenging is a feeding behaviour in which an animal feeds on either dead animal or dead plant matter. Scavengers are the animals with scavenging habits. • Scavengers' role is vital for the ecosystem as they contribute to the decomposition, while decomposers and detritus feeders are responsible for completing the process. • Vultures, Burying beetle, Raccoons, Jackals, and Hyenas are some prime examples for animal scavengers. Termites and earthworms are good examples for plant scavengers.
Parasites	• Plants and animals that infect other living components of the ecosystem and survive on them are regarded as parasites. • Various types of fungi, bacteria, protozoas, insects and a few flowering plants are parasites.
Phagotrophs and Osmotrophs	• The heterotrophs include all living things that directly ingest food. Such living things are called 'Phagotrophs' or consumers. • There are some creatures called 'Osmotrophs' which secrete digestive enzymes on their food that helps to break it down to tiny parts which they absorb.

Answers

1.	(d)	2.	(a)	3.	(c)	4.	(d)	5.	(a)
6.	(c)	7.	(d)	8.	(b)	9.	(c)	10.	(b)
11.	(c)	12.	(d)	13.	(c)	14.	(c)	15.	(c)
16.	(c)	17.	(d)	18.	(a)	19.	(b)	20.	(c)
21.	(c)	22.	(c)	23.	(a)	24.	(b)	25.	(d)
26.	(b)	27.	(c)	28.	(a)	29.	(d)	30.	(b)
31.	(c)	32.	(b)	33.	(b)	34.	(b)	35.	(d)
36.	(b)	37.	(d)	38.	(a)	39.	(b)	40.	(a)
41.	(d)	42.	(c)	43.	(d)	44.	(c)	45.	(b)
46.	(d)	47.	(b)	48.	(b)	49.	(c)	50.	(d)
51.	(c)	52.	(a)	53.	(c)	54.	(a)	55.	(c)
56.	(a)	57.	(a)	58.	(a)	59.	(b)	60.	(d)
61.	(c)	62.	(a)	63.	(b)	64.	(a)	65.	(c)
66.	(c)	67.	(c)	68.	(d)	69.	(c)	70.	(d)
71.	(a)	72.	(a)	73.	(a)	74.	(c)	75.	(d)
76.	(c)	77.	(d)	78.	(a)	79.	(d)	80.	(c)
81.	(b)	82.	(d)	83.	(a)	84.	(c)	85.	(d)
86.	(d)	87.	(c)	88.	(a)	89.	(d)	90.	(d)
91.	(c)	92.	(d)	93.	(d)	94.	(d)	95.	(a)
96.	(d)	97.	(c)	98.	(b)	99.	(b)	100.	(a)
101.	(c)	102.	(d)						

Explanations

1. (d)
   - Roughly, one-quarter of coral reefs worldwide are already considered damaged beyond repair, with another two-thirds under serious threat.
   - Major threats to coral reefs and their habitats include:
     (i) Climate change
     (ii) Destructive fishing practices
     (iii) Overfishing
     (iv) Careless tourism
     (v) Pollution
     (vi) Ocean acidification

2. (a)
   - Wetlands International is the global not-for-profit organisation dedicated to the conservation and restoration of wetlands.
   - Its work ranges from research and community-based field projects to advocacy and engagement with governments, corporate and international policy fora and conventions. It works through partnerships and is supported by contributions from an extensive specialist expert network and tens of thousands of volunteers.

4. (d)
   - The Convention on Wetlands, called the Ramsar Convention, is the intergovernmental treaty that provides the framework for the conservation and wise use of wetlands and their resources. The Convention was adopted in the Iranian city of Ramsar in 1971 and came into force in 1975.
   - The World Wetlands Day (WWD) is observed every year on February 2, to mark the adoption of the Convention on Wetlands in the city of Ramsar in Iran in 1971.
   - The Indo-Gangetic flood plain is the largest wetland system in India, extending from the river Indus in the west to Brahmaputra in the east. This includes the wetlands of the Himalayan terai and the Indo-Gangetic plains.

7. (d)
   - Mangroves are a group of trees and shrubs that live in the coastal intertidal zone. There are about 80 different species of mangrove trees. All of these trees grow in areas with low-oxygen soil, where slow-moving waters allow fine sediments to accumulate.
   - Mangrove forests stabilize the coastline, reducing erosion from storm surges, currents, waves, and tides. The intricate root system of mangroves also makes these forests attractive to fish and other organisms seeking food and shelter from predators.

9. (c)
   In an ecosystem, organisms at higher trophic level receive energy from more than one trophic level. The best example is man. Humans, for example, are primary consumers when they eat plants such as vegetables. They are secondary consumers when they eat goat. Therefore, humans can obtain energy from more than one trophic level.