

ECOLOGY ACTIVITIES

Web of Life

Each ecosystem type is unique and has several fundamental characteristics that it derives from the interactions of its components. In order to understand these characteristics, the ecosystem including the inter-relationships must be understood in its entirety. However, many of the connections within an ecosystem are often not understood as they are not obvious. It is difficult to visualize the link between a kingfisher and farmland, unless one traces the link between the topsoil from the farm field which ends up in the nearest water body, which is the feeding ground for the kingfisher. This activity demonstrates one of the laws of ecology—that everything is connected with everything else.

Objective

To demonstrate the interconnectedness of various elements in the environment.

Activity

Based on the list provided below, make a set of cards, each with the name of an animal/bird/plant/resource, etc. The cards can be made using chart paper and cutting out rectangular pieces of about 5x8 cm. The same can also be made using the blank side of old visiting cards. A safety pin can be put through the top of each card, or 'U' pins can also be used to pin on the card.

List of some components of the ecosystem

| | | | |
|-----------|-----------|-----------|-------------|
| Sun | Air | Water | Buffalo |
| Soil | Tree | Parrot | Grasshopper |
| Algae | Fish | Eagle | Moss |
| Turtle | Insect | Frog | Fungus |
| Mosquito | Lizard | Butterfly | Spider |
| Rat | Butterfly | Ant | Kingfisher |
| Student | Grass | Dead Leaf | Squirrel |
| Earthworm | Shrub | Mongoose | Dead wood |
| Dragonfly | Monkey | Snake | |

Subject

Science, Social Science

Place

Outdoor or indoor in a large hall

Duration

45 minutes

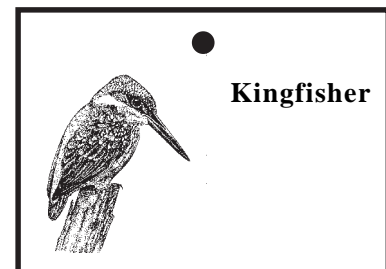
Group size

Entire class

Materials

Chart paper (used visiting cards), colour pencils, scissors, a ball of string, safety pins

Sample Card



Ask the students to sit in a circle. Distribute one card each to each student. Make sure to include and distribute cards depicting the four main elements of nature, 'Sun', 'Soil', 'Air' and 'Water'. Also distribute a pin to each student.

Ask the students to pin their cards on their dresses so that everyone in the group is able to see who they are. The students can take turns to tell the group who they represent.

Now ask the students from whom the game should start. Suggestions may be several. Prompt the students by asking them whose energy makes life possible on earth. It is appropriate to begin with the Sun because it is the primary source of all energy that makes life possible.

Take the ball of string and give it to the 'Sun'. Ask the 'Sun' to wind one end of the string around her/his finger. The task for 'Sun' is to throw the ball of string to any component of nature with whom the sun has a relation. For example, the sun gives energy to the plant. So the 'Sun' can throw the ball to the student having the 'Tree' card. But before giving the ball, the 'Sun' has to explain the relation s/he has with the 'Tree'.

The 'Tree' then winds the string firmly once or twice around her/his finger and then passes it to another component s/he feels related to, e.g. 'Soil', explaining that trees draw nutrients and water from the soil. In this way, the line of relationships continues as the string unwinds and begins to form a pattern which the students hold together. The ball of string is thus completely used up.

Ask the students to see the web-like effect of the string. Then ask them to raise the web chest high. Let them hold it tightly so that if the web is pressed down, it does not sag and touch the ground.

Discussion

Tell the students that the web they have made is the 'web of life'. It represents the relationships amongst different components in an ecosystem. An ecosystem may be subject to a variety of pressures. To illustrate this pressure, press the web down with your hand for a minute and release it. Ask the students to observe what happens. Because the web is intact and firm, it bounces back. This signifies that a healthy (undisturbed) ecosystem with all its components viable can restore its balance.

Now ask the students what would happen if some of these elements were destroyed, e.g., trees are cut. Let the student representing these elements drop the string. Notice the visual effect. More elements may be dropped to dramatize the effect. Now press the web down. It would probably touch the ground because it is loose and not bounce back. Conclude the game by emphasizing on the interrelationships in nature and their importance.

In order to study nature, scientists have classified the life forms in nature—that is, put them into groups. Organisms are classified according to how closely they are related. Large groups are broken down into smaller and smaller groups. A kingdom is the largest unit of classification. There are five kingdoms in nature.

One of those kingdoms is Animalia, or the animal kingdom. There are two main groups of animals: vertebrates and invertebrates. Vertebrates are a subgroup of the Phylum Chordata, or animals that have a spinal chord. These include fish, amphibians, reptiles, birds and mammals. Invertebrates are animals without a spinal chord, These include sponges, jellyfish, worms, arthropods (insects, shrimp, spiders), mollusks (snails, clams, octopuses), and echinoderms (sea urchins, sea stars).

Objective

To help the students use deductive logic in identifying diverse elements of nature and gain an insight into characteristics of a particular element.

Activity

Make the students stand or sit in a circle. Ask one student to volunteer. Affix a card on the back of the student. The student is not told what the card is. Now ask the student to walk around the circle, so the other students can see what the card represents.

The task for the student is to identify who he/she represents by asking relevant questions. The others must answer questions only with either a 'yes' or a 'no'. The student can ask up to a maximum of 10 questions.

As the number of questions is limited, the student should be very careful in the choice of questions and should frame them logically, e.g. based on classification of animals and plants. For example, they may ask:

Am I a mammal?

Am I a bird?

Do I eat meat?

Am I domestic?

As the game progress, bring down the number of questions to make it more competitive.

Subject

Science, Social Science

Place

Outdoor or indoor in a large hall

Duration

30 minutes

Group size

Entire class

Materials

'Web of Life' cards, paper clips or safety pins. If cards are not available, teachers may prepare he cards including biotic and abiotic components of the environment (See 'Components of Ecosystem' list on page 77).

Play the game in 10–15 rounds with different students as volunteers.

Discussion

How did the students arrive at the answers?

Which classification principles did they use?

Classification of Asian Elephant

| | |
|---------|----------------|
| Kingdom | Animalia |
| Phylum | Chordata |
| Class | Mammalia |
| Order | Proboscidea |
| Family | Elephantidae |
| Genus | <i>Elephas</i> |
| Species | <i>maximus</i> |

Classification of Animals

There are millions of animals and plants. If these were not classified, it would be almost impossible to study them or to conserve them.

Every living thing has a family tree. This “family tree” shows the relationship of one living thing to other living things. Scientists call the study of how living things are related, as **taxonomy**. Taxonomy is the arrangement of living organisms into groups of similar species. In the 1700’s **Carolus Linnaeus** developed a system of classifying living things into specific kingdoms like plant kingdom or animal kingdom. This system was called Binomial nomenclature, as the organisms were given two part names. He looked at ways organisms are alike and different. Then he sorted them into categories that showed their relationships to each other. These categories had Latin names.

Each kingdom is divided into many phyla. Phyla branch out into many classes.

A system of classification not only shows how organisms are related to each other, but it also conveys information about the animals themselves. For example, when a biologist is told that “Y” is a mammal, he/she will immediately know that “Y” has hair, nurses its young, and has several other characteristics specific to mammals.

This classification has two functions. The first is to recognize and describe as completely as possible the basic taxonomic units or species. The second is to devise a way of grouping these units on the basis on their resemblances and relationships.

Species is the defining unit of class. Closely related species belong to the same genus, related genera belong to a family, related families to an order and so on through classes, phyla and finally the kingdom. There are fewer divisions at each level, so while there are million of species, there are only five kingdoms.

A taxonomic key is a device by which each type in a group of types may be identified. For making such a key, we have to identify the distinguishing features of each member of the group. Next we have to ask questions about them in such a way that only one of two answers i.e. ‘yes’ or ‘no’ is possible.

Organisms interact with their surroundings, including other organisms, in a variety of way. When any two organisms have some activities or requirements in common, such as food, shelter, habitat, etc. they interact with each other. These interactions may occur between individuals of the same species or between individuals of different species. One such relation is that of the predator and prey. Predators kill and eat prey. In an ecosystem, the sequential chain of eating and being eaten is called a food chain. These food chains are not isolated but a number of food chains are interconnected, thus forming a food web.

Objective

To understand various inter-relationships in an ecosystem.

Activity

Choose a set of characters in a food chain. For example: Insect, Frog, Snake, Eagle.

Make five cards for each of the characters. For example, write 'Insects' on five cards, 'Frog' on five cards, etc. There should be one card each for each student in the group. If the group has more than 20 students, then choose a longer food chain, for example: Grass, Grasshopper, Frog, Snake, Eagle. Alternately the game can be played in two groups, one after the other, or you can make more number of cards for each character depending on the size of the group. For example, for a group of 50 students you can have 10 cards each for each of the characters, in the Flower, Moth, Frog, Snake, Eagle food chain.

Distribute the cards to the students. Ask the students to stand in a large circle around you. The game proceeds as in musical chairs, with the students running in the circle as long as the music is on. Stop the music and call out a number. The number you call out should be not be more than the number of charactes you have chosen. For example, for the food chain Flower, Moth, Frog, Snake, Eagle, which has five characters, you can call out the number five or a number less than five.

The students have to stop running when the music stops and gather in groups having the same number of individuals as the number called out. For example, if you have called out the number three, the students gather in group of three members each.

Subject

Science,

Place

Outdoor or indoor in a large hall

Duration

30–60 minutes

Group size

Entire class

Materials

Cards with names of animals. Pins for clipping cards on to clothes, any instrument to make some noise (as in musical chairs)

This grouping has to be on the basis of some relationship. For example, animals of the same species can group together, or animals having a prey-predator relationship can group together.

For the number three, some examples of the possible groups are:

Three frogs

One snake and two frogs

One frog, one snake and one eagle

After the students form their groups, ask each group to explain the relationship on the basis of which they have grouped.

It is possible that a few students who have not been able to find a group quickly will be left out. Tell the students that they can try for a group in the next round.

Have different rounds with different numbers.

Discussion

What is population?

What is a food chain?

What other relationship exist between different species— e.g. symbiosis, parasitism.

Extension/Variation

After three or four rounds, you can tell the students that groups on the basis of species is no longer valid. They must now group on the basis of prey-predator relationships.

Another variation may be that the group should have only one animal from each species. For example, two frogs or two snakes are not allowed. This variation will lead to making a food chain.

Ask the students to observe food chains around them—for e.g. in a pond they could find following food chain phytoplanktons—zooplanktons—fish—heron.

The same game can be played using the cards prepared for 'Web of Life' game. The students can be asked to group on the basis of 'families' i.e. insects group together, mammals group together, reptiles group together, etc.



Where Do I Belong?

Activity

The habitat of an organism is the space that the organism inhabits, the place where it lives. It is any place where a particular animal or plant species lives. Examples of a habitat include a lake, a desert, or forest, or even a drop of water. Many insects, birds and animals live in trees or bushes, which provide them protection from predators and a place to build their homes. Sometimes plants serve as habitats for animals.

An organism's habitat could be identified with particular physical and environmental characteristics like soil type, availability of water, or climatic conditions. Descriptions of environments by temperature and rainfall characteristics are used to group habitats together. Habitats of similar climate and vegetation are called biomes. In different parts of the world, the same biome may contain different species, but will contain similar life forms. For example, trees are the dominant forms of the rainforest, no matter where the rainforest is located.

Objective

To help students to learn about different habitats.

Activity

Ask the students to stand in a circle. At four corners outside the circle, mark different habitats—for example, Wetland, Soil, Forest, City.

The habitats can be marked on the ground with chalk, or they can be simply pointed out to them.

Distribute the Web of Life cards to the students, at random.

Start playing the music. Now the students should pass the cards around in the circle, i.e., give their card to the student on the right and take the card from the student on the left, for as long as there is music.

When the music stops, the students look at the card they have in their hand, and run to the habitat where they think they belong.

Go to each habitat and discuss why each student thinks he/she belongs there.

Subject

Science,

Place

Outdoor or indoor in a large hall

Duration

30 minutes

Group size

Entire class

Materials

Web of Life cards, music making instrument (a bell, spoon and glass, etc.)

(if cards are not available, the teacher may prepare the cards including biotic and abiotic components of ecosystems.)

Discussion

Are all the animals and plants in their correct habitat?

Why do animals live in a particular habitat? What does the habitat offer the animal or plant?

What are the interrelationships among the species represented in each habitat?

What happens to each species when a particular habitat is destroyed?

Extention/Variation

Instead of giving the students a card each, you may try putting all the cards in the centre of the circle which the students form (either on the ground or in a box).

When the music stops, the students run to the centre of the circle, pick up a card each and then run to the respective habitat.



Predation is a type of interaction where predator feeds on parts or all of a prey. Often predator-prey relationships are thought to be one-sided, where the predator always benefits and the prey loses. However, this relationship does have value for the prey as well. Prey species have a higher reproductive rate than predator species, thus they are higher in number. For example, field mice may have 10 to 20 offsprings per year, while hawks typically have two to three. Because of this high reproductive rate, prey species can endure a high mortality rate. The individual who got killed does not benefit but the species does. It works like this: the resources (food, water, etc.) are always limited. If the prey population grew unchecked, this resource base would be degraded—maybe even beyond recovery. This would affect not only the particular prey species whose numbers would begin to decline because of shortage of resources, but also other species in the habitat. Moreover, the prey organisms that die are likely to be old, slow and less fit members of the population. The healthier, quicker, and fit individuals are more likely to survive. When these survivors reproduce, their offsprings are more likely to have characteristics that help them survive; they are better adapted to their environment. At the same time a similar process is taking place in the predator population. Since poorly adapted individuals are less likely to capture prey, they are less likely to survive and reproduce. Thus this dynamic predator-prey relationship is complex but important to maintain the stability of a community.

The resources that support prey populations are also important determinants of the populations of predators. For example, the largest population of black buck is found in Velavadar grasslands in Gujarat. The wolf and the jackals are the main predators in the Park. Wolves here use shrub land for lying-up, denning and for rendezvous and depend on blackbuck, hare and other small animals as their prey.

Objective

To discuss predator-prey relationships and the importance of adaptations.

Activity

Divide the students into two groups. One group represents the 'prey', and the other groups are 'predators'. There should be approximately one predator for every four to six prey animals.

Subject

Science,

Place

Outdoor or indoor (in a large hall)

Duration

30 minutes

Group size

Entire class

Materials

Chalk, pieces of crumpled waste paper or pebbles, etc. to represent food for the prey animals (there should be at least two food tokens per prey animal)

Tell the students that one end of the playing area has the food and the other end is the shelter for the prey. Mark (with chalk powder or stick) four or five circles (about half a metre in diameter) between the 'shelter' and the 'food' ends. These circles represent temporary shelters for the prey.

Place the food tokens at the 'food' end of the playing area. The prey animals have to stand at the 'shelter' end. The predators stand anywhere between the food and shelter ends, except in the temporary shelter.

At a whistle or clap, each round of the game begins.

The prey animals have to move from the shelter end to the food end, and collect two food tokens. After collecting the food tokens, they must return to the shelter. Unless they collect two food tokens they die (that is, they are out of the game in the next round). The predators try and catch at least two prey animals each. Otherwise they die. Captured prey are taken to the side by the predator who catches them.

The prey animals have two ways to prevent themselves from being caught: they may 'freeze' i.e. stand still when a predator is about half a metre away from them, or they may stand in the temporary shelters. If a prey animal freezes, the predator has to look for other prey. The prey can remain still or be in the temporary shelters for as long as they like, but if they do not have enough food and at the end of the activity, they die.

Discussion

What methods did the prey use to escape? Which methods were easiest? Which methods were effective?

What means did the predators use to capture prey? Which ways were the best?

Discuss the need for animals to strike a balance between safety and food.

Extension/Variation

The activity could be conducted for three or four rounds. Record the number of captures in each round. Ask the students who are captured to become predators, and each predator not getting enough food become a prey animal in the succeeding round. This quickly leads to the concept of dynamic balance as prey and predator populations fluctuate in response to each other.

Although organisms interact with their surrounding in many ways, there are certain key factors which are vital to a particular species' success. Shortage or absence or excess of a key factor would adversely effect the growth and restrict the success of the species; thus this factor becomes a limiting factor.

Limiting factors could be either biotic or abiotic and could be different from one species to another. For example, many plants are limited by scarcity of water or specific plant nutrients. Animals may be limited by climate or the availability of specific food. For many species of fish, the amount of dissolved oxygen in the water is a limiting factor. Each species has a range of tolerance for the various key factors, beyond which the species may not be able to cope with that condition.

Objective

To enable students to understand that food, water, and shelter are three essential components of habitat; understand the concept of 'limiting factors' and recognize that some fluctuations in wildlife populations are natural, as ecological systems undergo constant change.

Activity

Divide the students into four groups. All the groups should have an equal numbers of students. Give one of the following names to each group:

- Deer
- Food
- Water
- Shelter

Mark two long parallel lines on the ground or floor. The lines should be 3-5 meters apart. Have the 'deer' line up behind one line; the others (food, water and shelter) should line up behind the other line.

Tell the students that the essential components of a habitat are food, water and shelter. Deer need good habitat in order to survive.

Decide different hand gestures to symbolize the three basic needs— food, water and shelter. Ask the students to remember the gestures. The activity starts with all students lined up behind their respective lines

Subject

Science,

Place

Outdoor or indoor in a large hall

Duration

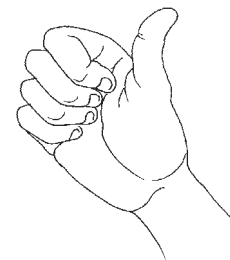
30 minutes

Group size

Entire class

Materials

An open space large enough for students to run, writing materials



(deer on one side, habitat components on the other side). The 'deer' and the 'habitat components' should not face each other. Instead, they should stand with their backs to each other.

Begin the round by asking all of the students to make their symbols. Each student (both the deer and the habitat components) has to choose one of the three symbols: food, water or shelter.

If a deer is making the 'water' symbol, it means that it needs water. Making the 'shelter' symbol means it needs shelter, and so on.

At the count of three or at a whistle or clap, the deer must run towards the habitat line, select the component it needs and stand in front of it. Each deer must make the sign of what it is looking for, until it gets to the habitat component with the same sign.

Each deer that reaches its necessary habitat component takes the 'food', 'water', or 'shelter' back to the 'deer' side of the line. This represents the fact that the deer has successfully met its needs. A deer that fails to find its food, water, or shelter partner dies and becomes one of the habitat component. So in the next round, the deer that died is a habitat component and so is available as food, water, or shelter to the deer that are still alive.

Record how many deer are there at the beginning of the activity, and at the end of each round. Continue the activity for approximately four to five rounds.

Discussion

At the end of the activity, discuss the game. Encourage students to talk about what they experienced and saw. For example, at the start there was a small herd of deer that could meet its needs in the habitat. As the population of the deer expanded over two to three rounds of the activity, the habitat become depleted. As a result there was not sufficient food, water and shelter to satisfy the needs of the members of the herd. At that point, some deer starved or died of thirst or lack of shelter, and they became part of the habitat. Explain that such things happen in nature also.

More About Ecology



From microorganism to blue whales, life forms on earth are connected in a vast complex web. These life forms are also interconnected with non-living components like sunlight, water, air, and soil. These intricate connections between various components of nature can be seen in the following example: Green plants take nutrients and water from the soil. Their leaves, fruits and other parts may then be eaten by a bird, or a deer, and when these die, a part of their dead remains are eaten up by bacteria, fungi, etc., while the remainder is broken down into smaller molecules like nitrogen, carbon, sulphur, etc., and go back to the soil.

The living and non-living components are bound together by various complex biological and chemical processes. Geological and climatic factors affect these processes. Thus a dynamic networking of biological, chemical and physical interactions of living organisms and non-living components is always in process.

The study of these interconnections, and the interdependence of plants, animals and their environment is called **ecology** (derived from the Greek word '*oikos*' meaning household and '*logos*' meaning study). Literally then, ecology is the study of 'life at home'. A large number of such connections exist in nature. In order to understand these connections among various components, various levels and parts of these components and their links need to be understood.

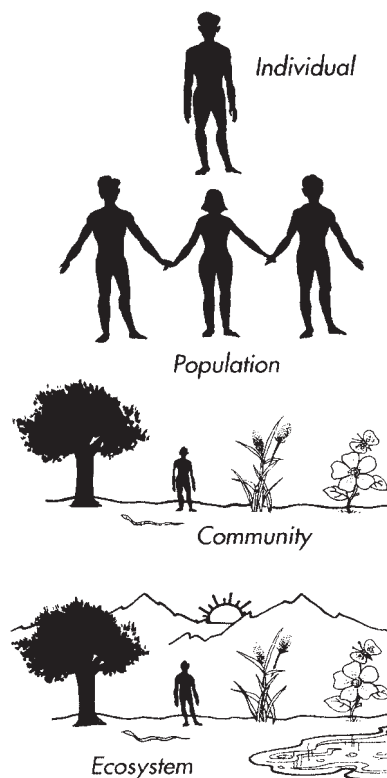
Levels of Organization in Nature

Perhaps the best way to understand ecology is to consider the concept of 'levels (hierarchy) of organization' that ecology focuses on. These levels are: organisms (individuals), species, populations, communities, and ecosystems. Interaction with the physical environment (energy and matter) at each level produces characteristic functional systems.

This provides a convenient framework for dealing with complex situations, because each of these levels has some special features and hence the study of ecology, in parts, at these levels, becomes easier. Let us understand these levels one by one.

Organisms—any form of life present on earth, from single-celled amoeba to huge whales, from microscopic blue-green algae to massive *peepal* tree.

Species—group of similar individuals/organisms, resembling each other in appearance, behaviour, chemistry and genetic structure. For example, all human beings (*Homo sapiens*) are grouped together under the species (*sapiens*). Organisms of the same species can breed with one another and produce fertile offspring under natural conditions.



Ecology can be studied at various levels

Population—is a group of individuals of the same species occupying a given area at a given time. For example, tigers in Corbett National Park or elephants in Rajaji National Park, make a population.

Community—Populations of various species occupying a particular area at a given time and interacting with each other make up a community—for example, when we say, ‘the community of the Corbett National Park’, we refer to the tiger population, the deer population, the grass population, the cattle and the population of all kinds of life forms present there. Thus, community comprises of several species interacting with each other.

Ecosystems—are communities of organisms involved in biological, chemical and physical interactions, between themselves and with the non-living components. Such interactions sustain the system and allow it to respond to changing conditions. Thus, an ecosystem includes living and non-living things.

Ecosystem components: As we have seen, there are two parts to every ecosystem; the living (biotic) components like plants and animals, and the non-living (abiotic) components like water, air, nutrients and solar energy. Let us analyze them one by one.

| Abiotic Components | |
|---------------------------|-------------------------------------|
| Physical Factors | Chemical Factors |
| Sunlight | Percentage of water and air in soil |
| Temperature | Salinity of water |
| Precipitation | Dissolved oxygen in water |
| Latitude and altitude | Dissolved nutrients in soil |
| Nature of soil | |
| Fire | |
| Water current | |

Living components:

Living organisms in an ecosystem can be classified as either producers or consumers, depending on how they get their food. In an ecosystem, producers are the only organisms that trap energy from the sun



and make new organic material from inorganic material, whereas other organisms rely on producers as a source of food.

Non-living components: Non-living (abiotic) components of an ecosystem include various physical and chemical factors that influence living organisms, like air, water, soil, rocks, etc. Too much or too little or absence of any factor can adversely effect the growth of a population.

Levels of Organization: Their Characteristics

Each level of organization i.e. organisms, species, populations and communities has specific characteristics which make them unique and distinct from one another. Let us now understand some of these.

Characteristics of Organisms

A unique feature of all organisms is their ability to adapt to the surrounding environment.

(a) Adaptations: Organisms exhibit responses to changes (beyond the optimum range) in the environment. Such responses exhibited by an organism to its environment are called adaptations. Adaptations enable organisms to adjust to their environment and to changes in the environment. For example, during summers, when water becomes scarce, deciduous trees shed their leaves. This response to water shortage helps them adjust better to summers by reducing the rate of transpiration as rate of transpiration is directly proportional to the leaf area. Similarly,

| How Organisms Get Their Food | | |
|-------------------------------------|---|---|
| Type | Role/Action | Example |
| Producer | Converts simple inorganic molecules into organic molecules by the process of photosynthesis | Trees, flowers, grasses, ferns, mosses, algae |
| Consumer | Uses organic matter as a source of food | |
| Herbivore | Eats plant directly | Deer, rabbits, cattle |
| Carnivore | Kills and eats animals | Cats, dogs, eagles |
| Omnivore | Eats both plants and animals | Pigs, rats, cockroaches, humans |
| Scavenger | Eats meat of dead animals | Vulture |
| Decomposer | Converts organic material to inorganic material | Fungi, bacteria, mites |

seeds of certain grass species can tolerate excessively high temperatures during a forest fire by remaining in a dormant state. As soon as normal environmental conditions are restored, they become active and germinate. These adaptations are short-term or temporary. Adaptations may also be long-term or permanent e.g. mangrove plants are adapted to grow in saline waters, with their aerial roots growing above the ground which helps the mangrove plants capture the atmospheric oxygen. These are evolutionary adaptations. Such adaptations develop slowly over many generations and are hereditary.

Characteristics of Species

Like organisms, species also have certain characteristics or linkages which help us differentiate them from populations and communities. Some of these are:

- (a) **Habitat:** Habitat is the type of environment naturally occupied by a species. For example, the Velavadar grassland in Gujarat is the habitat of the black buck. Similarly the Jim Corbett National Park in the state of Uttar Pradesh is the habitat of the tiger. Individuals of a species are

adapted to the particular ecological conditions (biotic as well as abiotic) of their habitat. For example, plants of the cactus species can survive under water-scarce conditions.

- (b) **Ecological niche:** The physical space occupied by a species, along with its functional role in the community and its position in environmental gradients of temperature, moisture, pH, soil and other conditions of existence, are its ecological niche. Thus ecological niche describes all the physical, chemical and biological factors that a species needs to survive and reproduce in an ecosystem. Each species has a defined and unique role in the ecosystem and hence no two species in the same general territory can occupy the identically same ecological niche for long. Each species has a particular habitat and niche resulting from its interaction with its environment.

Characteristics of Populations

The following features characterize a population:

- (a) **Population size:** It is the number of individuals making up a population. For example, the population size of India has reached 1 billion.

Species Found in Ecosystems

1. Native species which normally live and thrive in a particular ecosystem.
2. Endemic species are native to a particular region, and found only in that region.
3. Exotic species is a species, occurs outside its natural ranges and dispersal potential.
4. Invasive species is a species occurring beyond its accepted normal distribution as a result of human activities and which threatens valued environmental, agricultural or personal resources by the damage it causes.

(b) Population growth: It refers to the increase in the number of individuals in a population. The factors that effect growth in a population are birth, immigration, death and emigration.

(c) Population density: It is the number of individuals of a population per unit area at a given time. Thus to calculate the population density of India for the year 1997, divide 990 million (population size) by 3,287,263 sq km (total land area of India). Could you find out the number of individuals occupying 1 sq km of land in the country?

(d) Population dispersion or distribution: It refers to the general pattern in which the members of a population exist in their habitat. Population distribution may be random, clumped, regular, or may show a gradient. For example, in a cropland, the crop population is usually distributed in a regular pattern with similar distance between two crop plants, whereas in a natural forest, the same plant may be dispersed in clumps in those areas where there is no tree shade and where sufficient sunlight is available for their growth. Thus population dispersion depends on various factors like availability of food, shelter or protection.

(e) Age structure: It is the proportion of individuals in each age group in a population. Common age categories are pre-reproductive, reproductive and post-reproductive. A larger percentage of individuals in pre-reproductive and reproductive categories means greater population growth. Understanding the age structure of human population is important for framing development policies and plans. The age structure helps to visualize future projections of the nation's population growth.

Natural populations maintain a balanced age structure, because in nature there is always the survival of the fittest. However human actions may drastically change such balances.

Characteristics of Communities

When individuals of several species come together and interact with each other, they give rise to communities. Following are some of the features of communities:

(a) Species diversity: It refers to the variety of species present in a community. Each community has a unique set of species. For instance, the types of species found in a grassland community will be different from those found in a desert or in an estuarine community.

b) Ecological succession: In most communities, the variety of species in a given area changes slowly over a period of time. This gradual process of change in the composition and function of communities is called ecological succession. Ecological succession is a way in which communities respond to changes in their environment.

Succession is a normal process and is driven by various kinds of interactions between different species of a community and the environment. Natural, uninterrupted ecological succession leads to development of young fragile communities into more mature, developed and sustainable ones. When not interrupted by

outside forces, succession is reasonably directional and predictable.

Primary and secondary succession: Primary succession is the process of initial establishment of a community in an area where no life forms existed before. e.g. ferns colonizing a barren rock.

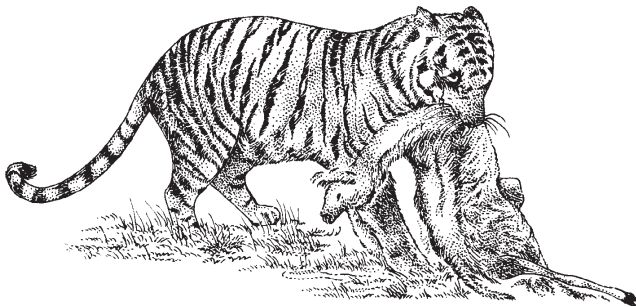
Secondary succession follows destruction of all or a part of an earlier community, e.g. grass seeds germinating after a forest fire.

As succession progresses, communities become relatively stable. Such a community, which has reached the final stages of succession and where the pace of succession becomes almost zero, is called a climax community, e.g. sal forest is the climax community of the Chota Nagpur Plateau.

- c) **Living interactions:** Different species in a community do not stay in isolation from each other. When any two organisms have some activities or requirements in common, they interact with each other. These interactions may occur between individuals of the same species or between individuals of different species.

The principal types of these living interactions are: Predation, Competition and Symbiosis.

Predation: This is one common type of interaction. It occurs when one animal (predator) kills and eats another (prey). Some examples of predator-prey relationships are lions and deer, birds and worms, and frogs and insects. Predation is important to maintain the stability of a community as it helps keep prey population within the habitat's carrying capacity.



Competition: In most communities, competition occurs when one or more species strive to obtain the common limited resources. Whenever a resource is in limited supply, organisms compete for it. The competition could be **intraspecific** (when members of the same species compete), and **interspecific** (when competition occur between organisms of different species).

The more similar two species are, the more intense the competition between them is. If one of the two competing species is better adapted to live in the area than the other, the less fit species must evolve into a slightly different niche, migrate to a different geographic area, or become extinct. Irrespective of who competes with whom, the successful species emerges from the interaction better adapted to its environment.

Competition can be of two types: **interference** and **exploitation**.

Interference is when one species hinders another species' access to some resource, say food, water, shelter, etc. irrespective of the fact whether the resource is abundant or scarce. For instance, some coral animals kill other nearby corals by poisoning them.

In **exploitation**, two competing species have equal access to a particular resource, but differ in how quickly or efficiently they exploit it. In this way, one species gets more of the resource, thereby hampering the growth, reproduction and survival of the other species. This kind of competition is usually exhibited when a resource is scarce. For instance, grasses thrive better in deserts because their root systems are more efficient in absorbing more water in a short time than those of other plant systems.

Symbiosis: This is a close, long-lasting, physical relationship between two different species. While often symbiosis is understood as a mutually beneficial relationship, in ecology the term also includes also parasitic relationships. Symbiosis can be broadly categorized as mutualism, commensalism and parasitic.

Mutualism: Two species interact in such a manner that both species are mutually benefited. A common example is the interaction between flowers and insects, where the flower is benefited by being pollinated and the insect gets the nectar. In some cases the mutual relationship has become so close that species involved cannot survive without each other. For example, certain species of fungi and algae live in close association as lichens. The fungus gets its food from the algae, while the algae get protection. If separated, neither can survive.

Commensalism: It is a cooperative relationship where one partner gains from the interaction while the other neither gains nor is harmed. For example, in dense forests, where sunlight does not reach the ground in sufficiently quantity, orchids grow on other tree species. The orchid is benefited by getting sufficient light, but the tree is neither benefited nor harmed.

Parasitism: It is a relationship where one organism (parasite) lives in or on another organism (host) from which it derives nourishment. It is a one-way relationship where the parasite gains and the host is adversely affected. Parasites are usually smaller than their hosts. They do not kill or consume the hosts but derive their nutrition from them. For example, ticks attach themselves to dogs and suck blood. Similarly tapeworms are found in human intestine.

Characteristics of Ecosystems

What are the different types of ecosystem and how does an ecosystem function? What makes an ecosystem stable and sustainable? To understand this, let us try to understand the various processes and interactions taking place in an ecosystem.

Because of the influence which abiotic factors exert on living organisms, different ecosystems develop differently. The interactions of these factors, like temperature, rainfall, soil type (nutrient availability) and local and geographical topography result in large areas with distinctive vegetation types which ecologists use as a basis for classification of terrestrial (land-based) ecosystems, called biomes. Biomes

are very large ecosystems, characterized by their own distinctive combination of flora, fauna and microbial communities. Each biome is typically classified by the dominant form/s of vegetation e.g. grassland or tropical rainforest. The sum total of all the ecosystems on the planet earth is called as biosphere. The biosphere thus includes the atmosphere (air), the lithosphere (land) and the hydrosphere (fresh and marine water bodies).

Major Ecosystem Types of India

India, the seventh largest landmass in the world, possesses a variety of ecosystems. These include mountains, plateaus, rivers, wetlands, lakes, mangroves, forests and coastal ecosystems. This section looks at the ecological profile of India.

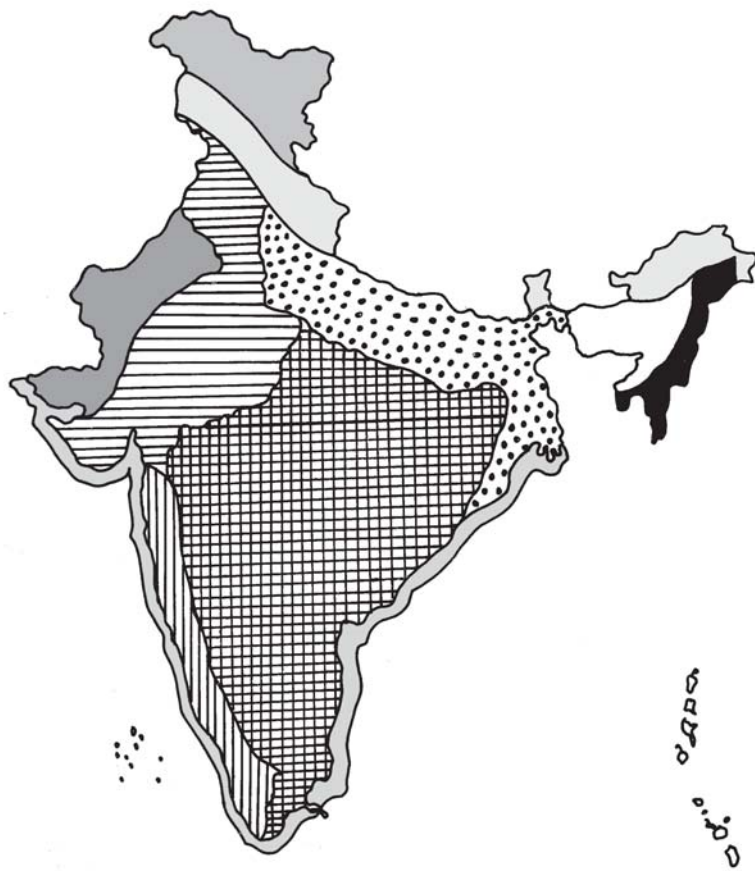
Ecosystem Types










Aquatic Ecosystems

- Swamp and marsh
- Lake and stream
- Open ocean
- Upwelling zones
- Continental shelf
- Algal beds and reefs
- Estuaries and brackish waters

Terrestrial Ecosystems

- Tropical rainforest
- Tropical seasonal forest
- Temperate evergreen forest (taiga)
- Temperate deciduous forest
- Boreal forest
- Woodland and shrubland
- Savannah
- Temperate grassland
- Tundra
- Desert/semidesert shrub
- Extreme desert, rock, sand and ice
- Cultivated land



| | | |
|---|--|--|
|  Trans-Himalayan |  Semi-arid |  Deccan Peninsula |
|  Himalayan |  Western Ghats |  North-east India |
|  Indian Desert |  Gangetic Plain |  Coasts |

The Himalayan Region

Sparse vegetation and rare fauna that includes snow leopards, wild pigs and tigers, characterize the trans-Himalayan region. The Himalaya, the highest mountain range in the world, is one of the richest areas of India in terms of habitat and species diversity. Both altitudinal as well as longitudinal variations are seen in the Himalayan belt. Three distinct sub-zones, each with its characteristic species diversity, are recognized—Himalayan foothills from the eastern frontiers of Kashmir to Assam; Western Himalaya, which are the higher altitude region from Kashmir to Kumaun (in Uttaranchal); and the Eastern Himalaya (in the north-east part of the country).

The Gangetic plains with their rich alluvial soil make excellent crop fields. It is in this area that the floodplains are found, which makes this region important for flood control too.

The Desert

For kilometers together, one may not find any signs of vegetation in the desert. Water, or the lack of it, is the single-most significant feature in the desert. In this region, both plants and animals face the problem of maintaining the water balance of their bodies under extreme diurnal temperature variation. They show many adaptations to cope with this. For instance, to reduce water loss, desert trees are mostly thorny, with highly reduced leaf surfaces, and their roots go deep in search of water. The desert regions of the north-west also have large expanses of grasslands in patches. Desert animals also show adaptations to the climate. A large number of desert mammals are burrowing in nature. This helps in overcoming extreme temperature variations. Similarly, desert vertebrates like the camel have efficient kidneys which secrete concentrated urine, therefore reducing water loss. The Asiatic Wild Ass, found in the salt flats of the Little Rann of Kachchh, has great tolerance to dehydration.

Rodents probably represent the largest group in desert fauna. A common example is the desert gerbil. Other commonly found desert animals include blackbuck, desert cat, desert lizard, snakes and the Great Indian Bustard.

The North-East

In contrast to the north-west, the north-eastern region has lush green rain forests. The forests consist of very dense and lofty trees with multitudes of species occurring in a given area. The unique plant species include mosses, ferns, epiphytes, orchids, lianas and vines. The rich plant diversity of

these forests is home to an equally rich diversity of animals, including elephants, barking deer, hoolock gibbon, golden langur, macaque species and other primates.

The Western Ghats

While the Western Ghats with an evergreen forest cover make biodiversity-rich zones, the Nilgiris, an off-shoot of the Western Ghats, have extensive grassy areas interspersed with densely forested evergreen vegetation known as *Sholas*. They provide shelter to elephants, gaur and other large animals. Many of the trees and also some of the animals found in these high *Sholas* are also found in the high altitude forests of the north-eastern region.

Islands

India also has two major groups of islands—Lakshwadeep islands in the Arabian Sea, and Andaman-Nicobar islands in the Bay of Bengal. These islands receive both the south-west and the north-east monsoons. Being tropical in climate, these islands are home to tropical rainforests.

Wetlands

India, with its varied terrain and climate, supports a rich diversity of inland and coastal wetlands. A total of 21 **wetlands** have been declared as National Wetlands. An important wetland of the country is the Keoladeo National Park in Bharatpur,

What is an Island?

Islands are small bodies of land surrounded entirely by water. As a geologic formation, an island is transitory. Even at this very minute, islands are in the process of making and breaking. Two physical types of islands are broadly recognized—those of continental origin and those of oceanic origin. Continental ones are those which have got separated from the mainland masses due to underground plate (tectonic) movements. Oceanic ones are created as a result of volcanic activities.

Islands differ from one another in terms of sizes, shapes, distances from continents, average temperature, rainfall, soil types, etc. Each island is unique in its features/characteristics and each fosters the evolution of different animal and plant communities.

Islands are places where species of plants and animals have become isolated from related species, The island ecosystem includes a unique variety of native trees, shrubs, wildflowers, grasses, ferns, mammals, insects, birds, reptiles, amphibians, fungi, lichens, and other forms of life. Some are very specific to the island, while others are widespread. They all participate in a complex web of biological and physical interactions and processes.

At the same time, due to isolation from the mainland, island ecosystems are highly vulnerable to any outside interventions. It is so because after years and decades and millennia of existing in a stable world protected from outsiders, the plant and animal life of islands is extraordinarily vulnerable to the outside world.

Some of the features typical of island life forms include gigantism, flightlessness, fearlessness and relative sluggishness. For example, an organism established in an island ecosystem, in most cases, loses its ability to disperse (flightless birds are common in island systems). Another characteristic of island organisms is their fearless or non-aggressive behaviour. This is attributed to the absence of predators on islands. Thus island organisms do not have well-developed defense mechanisms. Also, island organisms tend to have lower rates of reproduction, and mature slowly as compared to related mainland populations. This makes island populations highly vulnerable to human-induced changes.

Maintaining the health of the species by preserving and restoring the habitats they need to survive, and by allowing ecological processes to function without major human intervention, is very crucial.

What are Wetlands?

Wetlands are areas where water is the primary factor controlling the environment and the associated plant and animal life. They occur where the water table is at or near the surface of the land or where the land is covered by shallow water.

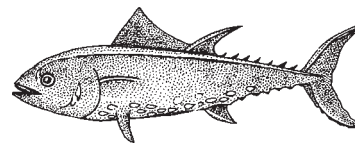
Wetlands are among the world's highly productive environments. They are cradles of biological diversity. Wetlands are also important storehouses of plant genetic material. Wetlands perform a number of ecological functions—water storage, flood mitigation. Shoreline stabilization, groundwater recharge and discharge, water purification and stabilization of local climate conditions, particularly rainfall and temperature.

Besides the ecological values, a number of economic values can also be assigned to wetlands. These include fisheries, agriculture, transport, wildlife resources, recreation and tourism opportunities. Wetlands also have special attributes as part of the cultural heritage of humanity.

Rajasthan, which is a human-made wetland. Among the various migratory species of birds that visit this Park almost every winter, is the endangered Siberian Crane (*Grus leucogeranus*). Another important wetland is Chilika (1,100 sq km), the largest brackish water lake in India, situated in Puri and Ganjam district of Orissa.

The Marine Wealth

India has the world's seventh largest coastline measuring over 7,500 km. The Indian coastline is broadly divided into the Western coast and the Eastern coast. The Western coast borders the Arabian Sea and the Eastern coast is along the Bay of Bengal. The Western coast is divided into three parts: the Saurashtra coasts along the northern part; the middle portion called the Konkan coast; and the southern part known as the Malabar Coast. The Eastern coast extends from Kanyakumari to the delta of the Ganga in the Bay of Bengal. The southern half of the coast is called the Coromandel coast.



Biodiversity

Biodiversity refers to the number, variety, and variability of all life forms on Earth. This includes millions of plants, animals and micro-organisms, this includes diversity within species, between species and of ecosystems. Biodiversity is part of our daily lives and livelihoods.

Biodiversity is usually described in terms of three levels: genetic, species and ecosystem diversity. These three levels are intimately connected.

Genetic diversity: This is the diversity of the basic units of hereditary information (genes) within a species, which are passed down the generations. Genetic diversity results in variations. It is this type of diversity that gives rise to several varieties of rice and wheat. For example, *Basmati* rice is distinct from *Jirasar* rice. Some variations are easy to see, such as size or colour; some, such as taste or flavour, can be perceived by other senses; and some, such as susceptibility to disease, are not obvious to the senses.

Species diversity: Species is the unit used to classify the millions of life forms on Earth. Each species is distinct from every other species. Horses and donkeys are distinct species, so are lions and tigers. What unites members of a species is the fact that they are genetically so similar that they can produce fertile offspring. Species diversity is usually measured in terms of the total number of species within a defined area.

Ecosystem diversity: An ecosystem is a set of life forms (plant, animals, and micro-organisms) interacting with one another and with the non-living elements (air, soil, water, minerals etc.). Ecosystem diversity is therefore the diversity of habitats (i.e., place or site where an organism or a population of organisms naturally occurs), which include the different life forms within. Ecosystem diversity can refer to two phenomena. It can refer to the variety of species within different ecosystems, i.e., the more abundant the species within an ecosystem, the more diverse that ecosystem is considered to be. It is also used to refer to the variety of ecosystems found within a biogeographical or political boundary.

Status of Biodiversity in India

India is one of the world's 12 megadiversity countries. It contains 5 per cent of the world's biodiversity on 2 per cent of the earth's surface. India has tremendous biodiversity, genetic as well as of species and ecosystems. India contains 5 per cent of the world's biodiversity on 2 per cent of the Earth's surface. It is estimated that 45,000 wild species in plants and over 77,000 wild species of animals occur in our country. India has a tremendous amount of ecosystem, species and genetic diversity. At least 166 species of crops and 320 species of wild relatives of crops are known to have originated in the Indian Subcontinent.

India has 51 species of cereals and millets, 104 species of fruits, 27 species of spices and condiments, 55 species of vegetables and pulses, 24 species of fibre crops, 12 species of oil seeds, and various wild strains of tea, coffee, tobacco and sugarcane.

India has significant indigenous livestock diversity with 27 breeds of cattle, 40 of sheep and 22 of goats. For example, India's eight breeds of buffaloes represent the entire range of the genetic diversity of buffaloes in the world.

The number of plant species in India is estimated to be over 45,000 which include over 15,000 flowering plants. India's faunal wealth is equally diverse. The total number of animal species is estimated at 81,000.

Value of Biodiversity

Biodiversity touches almost every aspect of our life. The importance of biodiversity can be understood, but it is not easy to define the value of biodiversity, and very often difficult to estimate it. The values of biodiversity may be direct or indirect. Biodiversity has direct consumptive value in agriculture, medicine and industry. The indirect values imply the functions performed by biodiversity such as ecological processes, etc.

Species evolve to fill particular niches or habitats. Many species depend on each other in intricate ways for survival. Specific life forms present in a particular habitat help in providing conditions for other life forms to live in that environment. Destroying one species can lead to further extinctions or changes. The indirect value of biodiversity lies in the services provided by the ecosystems and different groups of organisms by maintaining an intricate network of life forms. For example, a single tree provides not only its products which may have economic value, but is also a habitat for innumerable living things. In addition, it also plays a vital role in conserving soil and water and helping to keep the air clean. These are services for which it is very difficult to put precise monetary value. Sometimes it is even difficult to know what services a species provides.

Threats to biodiversity

Habitat destruction, overexploitation of species, extension of agriculture, pollution, and species introduction are the major causes of biodiversity loss in India. Other factors include fires, which adversely affect regeneration in some cases, and such natural calamities as droughts, diseases, cyclones, and floods.

Major Bio-chemical Processes in Ecosystems

All ecosystems are linked. While it is convenient to divide the living world into different ecosystems for purposes of study, in nature, there are seldom distinct boundaries between them. They are never totally isolated from one another. Any disturbance or change in any one of these, sooner or later, influences the other.

We know that various components of an ecosystem are interdependent and frequent interactions among these components take place. Such dependencies and interactions may be for food, shelter or even reproductive activity.

Besides these interactions, an ecosystem also has several kinds of complex bio-chemical processes. The two major processes which form the basis of ecosystem functioning are **energy flow**, and **nutrient cycling** through several kinds of complex bio-chemical processes.

Energy Flow

An ecosystem is a stable, self-regulating unit. To maintain itself, it must have a continuous input of energy. The ultimate source of this energy is the sun.

Energy flow in an ecological context

Ecosystem functioning requires a continuous flow of energy. For this we must understand the basic principles and laws of thermodynamics.

The first law of thermodynamics states that energy is neither created nor destroyed but it may be transformed from one type of energy into another form.

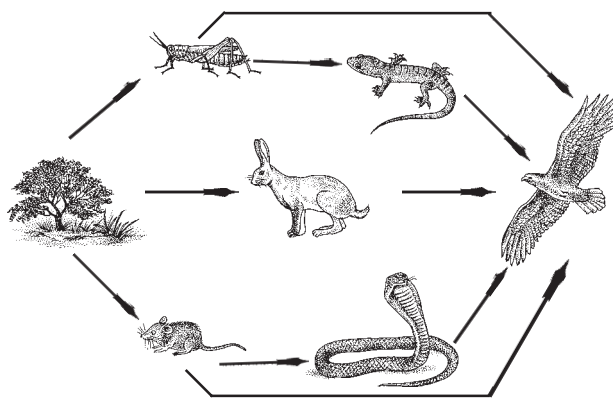
The second law of thermodynamics states that when energy is converted from one form to another, some of the useful energy is lost, usually in the form of heat. Some forms of energy are more useful than others. For example, when high quality energy of electricity flows through the filament of a light bulb, only 5 per cent of the energy is converted to light

energy. The rest is converted to low-quality heat which is lost to the surroundings as waste heat.

The ecological implications of these laws are that energy cannot be produced in ecosystems from nowhere. Thus, when we say ‘productivity of ecosystems’, we refer to the transformation of one form of energy (say, solar) into another (say, in plant bodies as organic matter). Secondly, the process of transformation of energy from one organism to the other is never hundred per cent efficient, i.e. all energy transformations always involve energy losses in the form of unavailable heat energy. The amount of loss may vary from one transformation process to the other, but occurs invariably.

Food Chains and Web

Producers are the only organisms that are capable of trapping the sun’s energy through the process of photosynthesis and making it available to the ecosystem. The energy (food energy) is stored in the form of chemical bonds in large organic molecules such as carbohydrates (sugars, starches), fats and proteins. This food energy stored in the molecules of plants can be transferred to other organisms when they consume plants. The sequential chain of eating and being eaten is called a food chain.



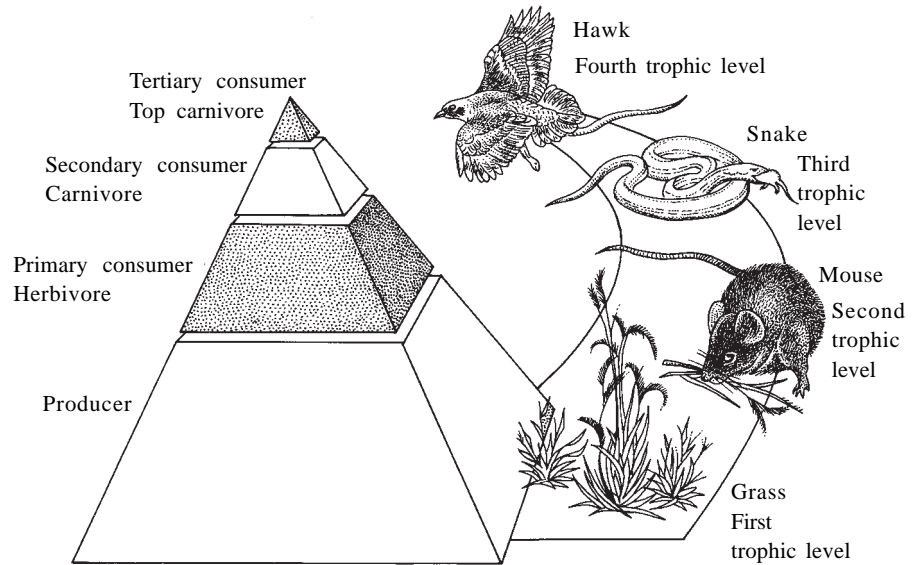
Food chains are linked to each other

Each organism is assigned to a feeding level or **trophic level** depending on whether it is a producer or a consumer and on what it eats or decomposes.

Producers (plants) are at first trophic level. Herbivores that eat plants are at second trophic level. Carnivores that eat herbivores are at third trophic level. Carnivores that eat other carnivores are at fourth trophic level. Omnivores, parasites and scavengers occupy different trophic levels, depending on what they happen to be eating at that time. For example, humans are omnivorous. If we eat grains like wheat or rice, then we are at the second trophic level, whereas if we eat meat of goat or chicken we are at the third trophic level.

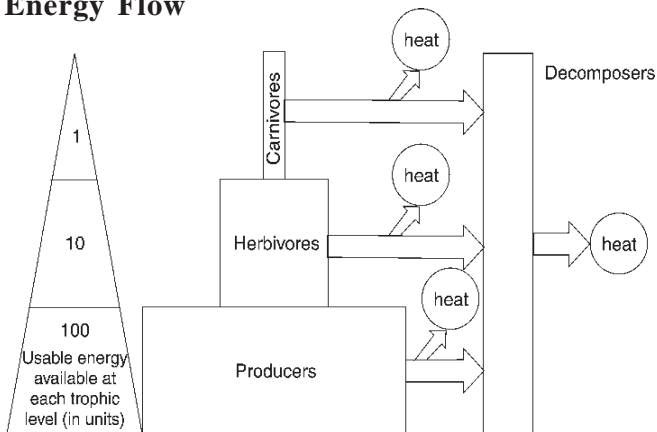
In food chains energy is transferred from one organism to another. Ideally, this transfer or flow of energy from the sun to green plants to herbivores to carnivores should be 100 per cent efficient. But in reality this does not happen. As energy passes from one trophic level to the next, some of the useful energy is lost as per the second law of

Organisms at Various Trophic Level



thermodynamics. At each level about 80 to 90 per cent of the energy is lost. This loss is in the form of low-quality heat, which is dissipated to the surroundings and warms the air, water or soil. Thus, if in a foodchain, the producer at the first trophic level assimilates 100 units of energy, the organism at second trophic level i.e. the herbivore can utilize only about 10 out of 100 units of the energy. Moving to the third trophic level, the organism (carnivore) is able to utilize only 1 unit, of the original 100 assimilated at the first trophic level.

Energy Flow



Trophic Levels

The word 'troph' is the Greek equivalent of the English 'food'. Trophic levels simply means 'food levels'. The trophic level of an organism indicates how far the organism is removed from plants in its level of nourishment. The formal definition of trophic levels would be: "the sequence of steps in a food chain from producer to primary, secondary or tertiary consumer."

Though all food chains comprise of a series of living organisms which are interdependent for food and hence energy, they may not always be similar. In nature there are two major types of food chains: the first starts from a base of green plants and goes on to herbivores and finally to carnivores—called the grazing food chain. The other starts from a base of dead organic matter, proceeding to a variety of other organisms, including scavengers, insects and micro-organisms—called the detritus food chain.

Grazing food chains and detritus food chains are linked, as dead organisms from the grazing food chain form the base for the detritus food chain. This in turn provides nutrients vital to the green plants. A number of food chains interwoven with one another give rise to a structure similar to the delicate web of a spider. These interlocking patterns formed by several food chains that are linked together are called food webs.

In a food web, many kinds of interactions among organisms take place. In this network of interactions several organisms would be affected if one organism were reduced in number.

Nutrient Cycling

Living organisms need food to grow and reproduce. Any element required by an organism to live, grow and reproduce, is called a nutrient. Depending upon the amount it is needed in, it can be classified as a macronutrient (needed in large quantities, e.g. carbon, oxygen, hydrogen, nitrogen, phosphorus, etc.) or a micronutrient (needed in small quantities e.g. iron, zinc, copper, iodine, etc.)

In nature, these nutrient elements and their compounds continuously move from the non-living environment to the living organisms, and back to the non-living environment. This cyclic movement of minerals from their reservoirs (air, water and soil) to the living components and back to the reservoirs is called nutrient cycling or biogeochemical cycles ('life-earth-chemical' cycles). These nutrient cycles, driven directly or indirectly by incoming solar

Biological Magnification

During energy flow and nutrient cycling, it is not only energy and nutrients which get transferred. Toxic substances may be transferred from one trophic level to another too. In such cases the concentration of the toxic substance increases with every increase in the trophic level. This increasing concentration with every link is called biological magnification.

To control mosquitoes, DDT was sprayed in Long Island, U.S. DDT levels used were carefully selected so that they were not directly lethal to fish and other wildlife but to the mosquitoes only. As mosquitoes got killed, the DDT did not get washed out to sea (as was predicted). Rather the poisonous residues got absorbed on detritus and eventually became concentrated in the tissues of detritus feeders and small fishes, and again got concentrated in the top predators such as fish-eating birds. As a result, the shells of eggs produced by these birds were not fully formed and hence could not give protection to the embryo. Thus no chicks hatched. This ultimately wiped out whole populations of predatory birds, leaving the island ecosystem unbalanced.

energy include the carbon, oxygen, nitrogen, phosphorus, sulphur and water cycles.

Balancing Ecosystems

A common way of thinking is that ecosystems are self-maintaining, that nature can take care of itself. Lately we have realized and experienced that whether it is an ecosystem, a community or an organism, they all have their own tolerance limit. In the process of modifying ecosystems to suit our demands, we have created drastic disturbances in the natural system. Pollution of land and various sources of water, over-exploitation of natural resources, developmental activities leading to global climate change, changing lifestyles, increased wastes, are some of the factors that disturb this natural balance. We will see how human activities influence this natural balance.

Disturbing food chains: Felling/cutting of trees/forests destroys thousands of interrelated plants and animals. This disrupts the bottom of the food chain, subsequently affecting the organisms at higher trophic level.

Disturbing natural habitats: Large areas having innumerable species of plants and animals have been reduced to small pockets due to their conversion to agricultural land or for construction of roads and housing. Setting up of large-scale industrial plants or hydroelectric projects leads to the destruction of large natural areas. For example, wetlands are filled up to provide space for more housing, large tracts of forests are submerged for hydroelectric projects. This may lead not only to the loss of species but disappearance of entire ecosystems.

Loss of biodiversity: The earth is facing rapid decline of biodiversity in many ecosystems. The decline is not limited to increased rates of species extinction, but includes losses in genetic and functional diversity. The wide-ranging decline in biodiversity results largely from habitat modifications and destruction, increased rates of invasions by deliberately or accidentally introduced non-native

species, over-exploitation and other human-caused impacts. Biodiversity declines are already obvious in many areas, especially where natural ecosystems have been converted to agricultural fields, timber plantations, aquaculture and construction of road, buildings etc.

Disturbing nutrient cycles: The nutrient cycles are altered in many ways.

Burning of fossil fuels (coal, oil, and natural gas) releases large amount of carbon dioxide into the atmosphere, thus affecting carbon and oxygen cycles.

Nitrogen-rich fertilizers used in agriculture are washed from the fields by rain. They make their way into streams, ponds, rivers, and lakes. Nitrogen stimulates growth of bacteria, which consumes oxygen in the water and thus aquatic life gets disturbed. This affects the nitrogen cycle. The presence of large amount of nitrogen and phosphorus from agricultural fields is discharged to freshwater or saltwater, which results in increased rates of growth of bacteria, algae and aquatic plants. Many algal blooms are toxic resulting in fish kills and human poisoning. (*See chapter 'Agriculture' and 'Pollution' for more information on Eutrophication*)