2 Ecology, Populations and Species

STRUCTURE

2.1

In the last unit, we explored the conditions that make life possible on earth. We also learnt that life has existed on our planet for about 1.4 billion years now, and that Earth is a planet teeming with vitality and is home to billions of plants and animals. How and why did we get here? What processes had to take place for this to happen? And where do we go from here? While the fact is that no one has been able to come close to knowing exactly what led to the origins of life, scientists have made significant progress in understanding what processes and interactions take place in the living world. Such scientific studies enable us understand the totality and pattern of relations between organisms and their environment. Through this Unit, we will try to explore this study, called 'Ecology'.

2.2

On completion of this unit, you should be able to:

- Define ecology
- Appreciate the variety of interconnections in nature and state their significance
- Enlist and define the various levels of organization in nature
- Describe key characteristics of organisms, species and populations

2.3 UNDERSTANDING ECOLOGY, THE DISCIPLINE

In Unit 1 of this module, we looked at what makes our planet the 'living planet'. In the units to come, we will try to explore this 'living world' that exists on the earth. The subject of **ecology** will help us do this. Let us first understand as to what this term 'ecology' means? The word '**ecology**' is derived from the Greek words *oikos*, meaning household, and *logos*, meaning study. Literally then, ecology is the study of 'life at home'. In other words, ecology is the study of the interconnections and interdependences of plants, animals and their environment.

ECOLOGY AND ENVIRONMENT

Many a time, we tend to use the terms 'ecology' and 'environment' as synonyms. But we must understand that there is a difference between these two terms—while ecology limits itself to connections, processes and phenomena occurring in the **natural** word, environment means *'me and my surroundings'* and hence not only includes the natural part of the surroundings, but also all those elements that have been created by **Humans**.

The essence of ecology lies in the study of the togetherness of everything—plants, animals, microorganisms and their environment.

Ponder over the following:

1. Does grass have anything to do with a tiger?
2. How do humans affect the populations of insects on this earth?
3. How can DDT sprayed on a lake endanger the local bird population?

The above listed connections, on the first instance, seem far-fetched. But they are not. It is so because, in nature, everything is connected. There are intricate connections between the various components of nature. For instance, 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 broken down by microorganisms, eventually the broken down matter goes back to the soil, thus connecting them all.

A large number of such connections exist in nature. You can observe many of these in your own surroundings. A number of elements found in nature are listed below; can you connect these to each other, in as many ways as possible, giving an interaction/ link between them? Say, a squirrel is linked to air as it requires air to breathe; the air is linked to earthworm as the earthworm helps in aerating the soil, etc.

Innumerable such connections exist in nature. However, such links are often not very well understood as many of these are not very obvious and it takes time to even identify them.

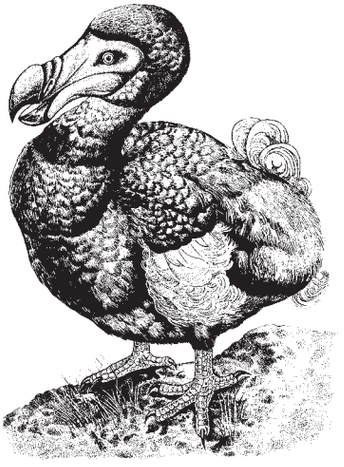
These links are the foundation of the balance in the natural world. These links also explain the two laws of ecology—'we can never do any one thing in nature' (because a single human disturbance in nature could lead to a cascade of impacts) and that 'in nature everything is connected with everything else'.

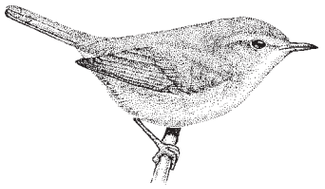
DODO AND THE CALVARIS: THE CONNECTIONS

A good example of interconnections in nature is the 'ripple or domino effects', which help us understand the impact of removal of a species or an addition of species on the larger natural system of which the species is a part.

A good example for this is to understand the impact of extinction of Dodo, a bird found in the island of Mauritius, on other components of the island system. Dodo, a gray colored bird with a large, hooked beak and white feathers attached to its tail may have been a relative of the pigeon family. This wingless bird had no enemies on the island and was safe living on the ground. In 1581, when sailors brought in dogs and pigs onto the island, things changed. Man introduced other species on the island, including pigs, rats and cats. Further humans started hunting the dodo bird, an easy prey. Eventually, the dodo became extinct.

There seem to be many causes for the extinction of Dodo, like the destruction of the forest (which cut off the Dodo's food supply), and the animals that the sailors brought with them, which destroyed Dodo nests. But the impacts of Dodo's extinction are being seen only now—*Calvarias major*, a local tree species, is now becoming rare. It is so because the Dodo and the Calvaris had a mutual dependence on one another. The tree's seeds are encased in a thick-walled protective coat. Earlier, the dodo's use to consume these seeds and in this process, the bird's gizzard (a second stomach for grinding food) would weaken and crack the seed's coat, but not enough to damage the seed inside. When eventually deposited by the dodo (in their excreta), the seed would germinate. Today, without the grinding of the dodo's gizzard to weaken the thick protective wall, the seeds remain trapped in their hard case. Thus When the dodo became extinct just over 300 years ago, Calvaria major's seeds had no way of germinating. So no new trees grew and only a few very old trees survive now.





Hence the essence of ecology lies in a holistic approach to the subject. However, in order to understand the 'whole' and all the connections, let us try to understand the 'parts' or the components. In the next section, we will classify and categorize the natural system into smaller hierarchical units for the convenience of our study about their ecological features and associated processes.

2.3.1

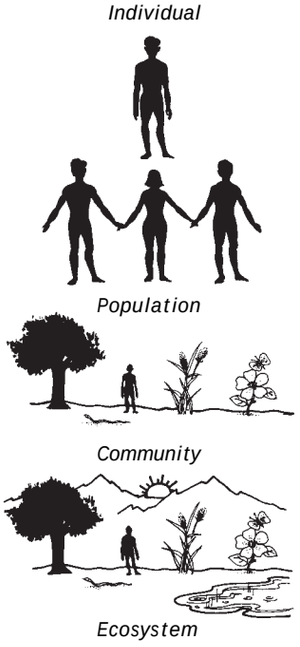
Fill in the blanks

1) Ecology is the study of '_____'
2) Your neighborhood is your _____.
3) "We can never do only one thing" and "in nature everything is connected to everything else" are _____.

2.4 LEVELS OF ORGANIZATION IN NATURE

As revealed in the previous section, ecology can, at times be very complex due to the large number of interconnections in the natural world. And perhaps one way to make the study of the natural world easier is to try to understand it in smaller units.

So let us look at ecology from the point of view of **'levels (hierarchy) of organization**'. 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 **hierarchical theory** of levels of organization 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: An organism is any form of life. A wide range of variety of organisms is present on the earth—from singlecelled amoeba to huge sharks, from microscopic bluegreen algae to massive banyan trees. An organism can also be thought of as an individual member of a species.

Species: Groups of organisms that resemble one another in appearance, behaviour, chemistry and genetic structure form a species. Organisms of the same species can breed with one another and produce fertile offspring under natural conditions. For instance, all human beings (*Homo sapiens*) resemble one another in their body structure, body systems and they all have similar genetic structure. They are thus grouped together under the species *sapiens*.

Population: A population is a group of individuals of the same species occupying a given area at a given time. Can you find out the human population of your district?

Communities: Populations of various species occupying a particular area and interacting with each other make up a community. Here by community we mean an 'ecological community' (so do not confuse it with a social community). For instance, when we say 'the community of say the Gir Forest, we refer to all the various populations, could be the teak tree population, the lion/tiger/leopard population, the deer population, the cattle population, the populations of a variety of grass spp., and populations of all kinds of (birds, plants, animals, microorganisms) present there. Thus, a community comprises several species interacting with each other.

Ecosystems: An ecosystem is a community of organisms involved in a dynamic network of biological, chemical and physical interactions between themselves and with the nonliving components. Such interactions sustain the system and allow it to respond to changing conditions. Thus an ecosystem includes the community, the nonliving components and their interactions.

The sum total of all the ecosystems on planet Earth is called the **biosphere**, which includes all the earth's living organisms interacting with the physical environment as a whole to maintain a steady-state ecosystem.

Can you create such a hierarchical picture for a particular ecosystem that you know of?

2.4.1

1. Match the items in the left column to their level of organization in the right.

1.	Kingfishers	a.	Community
2.	Animals and plants in Kanha Park	b.	Ecosystem
3.	Your friend's cat	c.	Species
4.	An estuary	d.	Population
5.	Langurs in your town/city	e.	Organism

2. In order to understand the repercussions of any small change in nature, let us do a small exercise. Given below is a random listing of events that actually happened in a real-life situation. In the context of ecology, can you try to arrange these in the sequence of their actual occurrence and re-write the actual complete story?

a. Rats increased
b. Lizards slowed down
c. Caterpillar numbers went up
d. ABC Health Services sent DDT to Gyanpur
e. Mosquitoes were wiped out

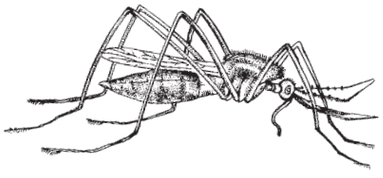
DID YOU KNOW?

The grass family (Gramineae sp.) has about 10,000 different species. Grasses cover over one fourth of the land surface of the Earth. Grasses are found almost everywhere—in snow-covered Arctic areas, in dry deserts, on high mountains, on coasts. Grasses cover the whole range of sizes from tiny shoots under our feet, to the giant bamboos. The grains of grass form the staple food of people all over the world—rice, wheat, maize.

f. Caterpillars ate grass roofs
g. Cats were parachuted in
h. Cats died
i. Cats caught lizards
j. Rats spread the plague
k. Lizards disappeared
l. Lizards ate mosquitoes and stored DDT

THE REAL STORY: CATS PARACHUTED

Some years ago, the ABC Health Services sent supplies of DDT to Gyanpur to control mosquitoes that spread malaria among the people. As the DDT was sprayed, the mosquitoes were quickly wiped out. But there were hundreds of lizards in the village that ate these mosquitoes and, in turn, kept accumulating the DDT in their bodies. Due to accumulation of so much DDT in their bodies, the lizards became very inactive and slow. This made it easier for cats to catch the lizards, one of their favourite foods. About the same time, people also found that hoards of caterpillars had moved in to feed on the roofing materials of their homes. They realized that the lizards, that previously kept the caterpillar population under control, were now been eaten by the cats. And now, all over Gyanpur, cats that ate the lizards died from DDT poisoning. Then rats moved in because there were no cats to control their population. With rats came a new danger: plague. Officials sent out emergency calls for cats. Cats were sent in by airplane and dropped by parachute.



Remember, in the beginning of this unit, we said that **there is a link** between spraying of DDT in a water body and the decline in the bird population. Didn't something similar happen in Gyanpur? Do you remember reading about any other such incident? Would you like to analyze it? Try making a similar seuence of ecological impacts for it.

So far in this unit, we have been trying to understand the significance of interlinkages and interconnections between various elements in nature. Let us now study some of these individual levels of the natural world in greater detail.

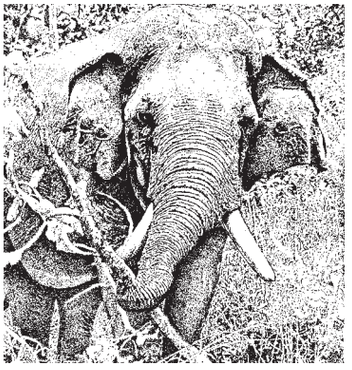
2.5 SPECIES

As we have understood, a species is a group of organisms that resemble one another in appearance, behaviour, chemistry and genetic structure. Organisms of the same species can breed with one another and produce fertile offspring under natural conditions.

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

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. The ecological niche describes all the physical, chemical and biological factors in an ecosystem that a species needs to survive and reproduce. It also defines the role of the species in the 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 niche resulting from its interaction with its environment. Understanding niche requirements is significant for species management.

Species evolution and species extinction: Extinction of existing species and evolution of new ones is a natural phenomenon. New species arise from preexisting ones through the process of **evolution**. The processes of evolution and extinction are very slow and take place over long periods of time. Under natural conditions, these two processes keep pace with changes in the environment. However, in recent times, due to human interference, the rate at which species are becoming extinct has outpaced the rate at which new species evolve. This loss of species is today a global concern and that is why phrases like 'species at risk' or 'the lost world' often make the headlines of newspapers, magazines and journals. For example, the Pinkheaded duck became extinct due to indiscriminate hunting for its flesh and for ornamental value.



2.5.1

State True or False

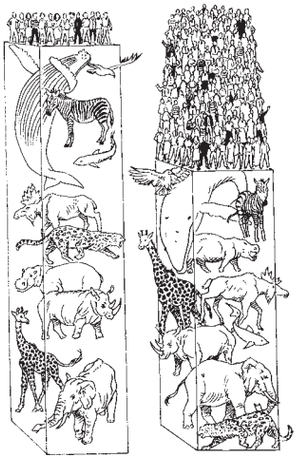
a) Organisms do not affect their environment. True/False

b) Organisms of the same species can breed with one another and produce fertile offspring under natural conditions. True/False

c) Niche of a species defines its place of living True/False

d) In nature, there is no process called species extinction; it is a phenomenon for which humans are solely responsible. True/False

2.6 POPULATION



Population is a term that most of us feel very comfortable with. Perhaps this is because the issues of population and population control are often discussed in the media in India. Can you think of some species whose population is being sought to control in your area?

Ecologically, a population is a group of individuals of the same species, occupying a given area at a given time. All populations are characterized by the following features:

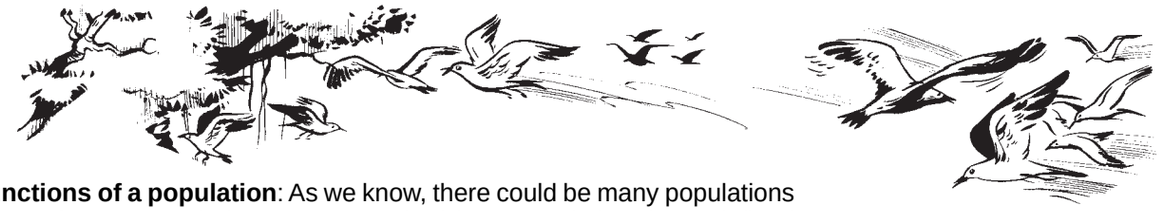
Population size: It is the number of individuals making up a population. For example, the human population size of India is over 1 billion.

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

Population density: It is the number of individuals of a population per unit area at a given time.

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.

Age Structure: It is the proportion of individuals in each age group in a population. Common age categories are pre reproductive, reproductive and postreproductive. A larger percentage of individuals in prereproductive and reproductive categories mean greater population growth.



Functions of a population: As we know, there could be many populations present in a community/ecosystem. Each of these populations has a defined function. This function depends on the position of the population vis-a-vis the food production processes in that system. Hence populations of green plants will be the 'producers' population', that of deers will be 'herbivore population', etc. We will learn more about producers, herbivores etc, in the next unit we will try to understand ecosystem processes.

Growth of a population: In nature, most populations, when they start colonizing an area, start out slowly (this is like an establishment phase). Then, over a period of time, the numbers shoot up exponentially. This is because, by now, a more congenial and suitable environment for the growth of the species has been created (due to interaction between the biotic and the abiotic components of the ecosystem). Once the population reaches the carrying capacity of the system (characterized by optimum utilization of resources, healthy competition and interference from other species) the population stabilizes and may fluctuate slightly above and below the carrying capacity mark. The stabilization of population could be attributed to a number of environmental factors—could be limited food resource, competition with other organisms, lack of resources such as water, etc. The sum total of all the factors that limit the growth of a population is called environmental resistance.

THE LAW OF MINIMUM

A population and its surrounding cannot be considered in isolation, as the environment continuously affects the organism. Many different environmental factors have the potential to control the growth of a population. These factors include the abundance of prey or nutrients that the population consumes and also the activities of predators. Although a given population may interact with many different species and abiotic factors, not all of these interactions are of equal importance in controlling that population's growth. Experiments show that only one or two species/factors dominate the feedback structure of a population at any one time and place (Berryman 1993). The identity of these dominating factors may change with time and location, but the number of factors that limits a given population (i.e. actively controls its dynamics) is usually only one or two.

This is what the Liebig's Law of Minimum states. It says that of all the biotic or abiotic factors that control a given population, one has to be limiting (i.e. active, controlling the dynamics). Thus Liebig's Law stresses the importance of *limiting factors* in ecology. "A factor is defined as limiting if a change in the factor produces a change in average or equilibrium density of a population."

Have you ever observed such a phenomenon around you? Why do you think, a farmer adds fertilizers to the soil? Does this process of adding nutrient to the soil as any link to the Law of Minimum?

In certain cases however, a particular population might temporarily overshoot the carrying capacity. In such cases, population regulation would happen in one of the two ways—migration (large number of individuals of the population move to another area), or die-back (population suddenly crashes to a very low level).

2.7 RECAPITULATION

- Ecology is the study of interrelationships of plants, animals and their environment. Technically, Ecology and Environment are different.
- The laws of Ecology are: In nature: 'Everything is connected to everything else' and 'you can never do any one thing alone'. Hence, interconnections are the essence of ecology.
- For making the study convenient, ecology can be studied at various hierarchical levels, i.e. organism, species, population, community and ecosystem.
- Each hierarchical level has a set of unique features defining/ qualifying it.

2.8 CONCLUSION

To make study easier, ecologist categorize the natural systems into a number of hierarchical levels. Each of these levels has salient features that distinguish them from one another. At the same time these levels, in nature, are intricately and delicately linked with one another and seldom is it easy to draw lines between them.

2.9

1. If ecology is the study of a natural system that is totally unaffected by human actions or products, do you think that there is, technically speaking, any ecological studies taking place in the world today?
2. It is sometimes said that humans don't adapt to their environment, instead they make their environment adapt to them. Can you think of some examples of this?
3. Cities are not natural ecosystems, but many animals are still finding an ecological niche in urban areas. How, for example, have monkeys adapted to human environments? Comment.

UNDERSTANDING CARRYING CAPACITY

Ecologically, carrying capacity is defined as the number of individuals of a given species that can be sustained indefinitely in a given space/area. It is something like traffic authorities not allowing more that two adults on a two wheeler, because the vehicle, by its make, design and machine has 2 adults as its carrying capacity and that having more number of riders on it may not just damage the vehicle but may even lead to an accident.

However in the ecological context, carrying capacity is not a very static given number or quantity, rather in nature, the carrying capacity of a system is affected by many factors, such as seasonal fluctuations in the physical environment, abundance or scarcity of food, competition in and between species, migration of species and its members, any catastrophic events—natural or human-made, etc.

Humans are not exempt from the population overshoot and crashing due to exceeding of natural systems carrying capacities. Technological, social and other changes seem to have extended the earth's carrying capacity for the human species, however it still remains a question as to how long will we be able to carry on with this extended carrying capacity of the planet—planet of finite size and resources.

2.10

The 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 interrelationships, must be understood in its entirety. However, many of the connections within an ecosystem are often not understood as they are not obvious. This also makes it difficult for educators to explain these to students. For instance, it will be difficult to communicate the link between a kingfisher and a farmland, unless one traces the link between the topsoil from farm field which ends up in the nearest water body, which is the feeding ground for kingfisher.

Interlinkages that exist in nature can be understood through this activity called the 'Web of Life'. This activity demonstrates one of the laws of ecology—we can never do any one thing in nature and that everything is connected with everything else.

POPULATION CONTROL THE LEMMING WAY!

Lemming, the smallest of the high-arctic mouse-like rodent is famous for its unique population cycles. Lemming is a key species in Arctic ecosystems (a system with a very sensitive and delicate balance) and is mainly eaten by the Arctic fox. Usually, the two populations maintain the prey-predator balance. However, periodically a population explosion of lemmings occurs and the numbers overshoots the carrying capacity of the Arctic ecosystem. At such times even their predator population fails to keep the numbers within limits. During this time, it has been observed that the lemmings mass-migrate into the sea. Lemmings are actually good swimmers but are not capable of successfully crossing the huge sea barrier and thousands die in the attempt. Some researchers call this as mass suicide, some call it migratory behaviour. But the fact remains that this behaviour of lemmings is actually a mechanism that help this rodent stabilize its population.

Group size: Entire Class

Duration: 45 minutes

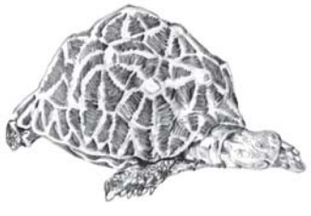
Requirements: Chart paper (used visiting cards), colour pencils, scissors, a ball of string, safety pins

Objective: To demonstrate the interconnectedness of various elements in the environment.

Based on the list provided alongside, make a set of cards with the names of the 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 up the card.

List of some components of the ecosystem:

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



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

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

Now ask the players from whom the game should start. Suggestions may be several. Prompt the players 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 ball of string to any component of nature with whom sun has a relation. For example, the sun gives energy to plant. So the 'Sun' can throw the ball to the player having the 'Tree' card. But before giving the ball, the 'Sun' has to explain the relation s/he has with the 'Tree'.

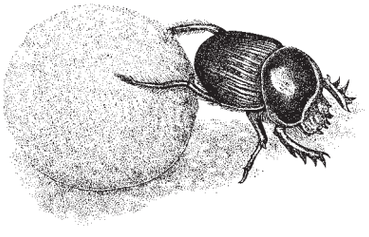
The 'Tree' then winds the string firmly once or twice around her/his finger and then passes it to another component s/he feels related to, e.g. 'Soil', explaining that trees draw nutrients and water from the soil. In this way, the line of relationships continues as the string unwinds and begins to form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

After the game, the teacher may could initiate a discussion on the interconnections in nature. Tell the players 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, such as 'floods'. 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 come back to equilibrium after a disturbance.

Now ask the students what would happen if some of these elements were destroyed. 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 cannot bounce back. Conclude the game by emphasizing on the interrelationships in nature and their importance.



2.10.1 WEB OF LIFE: THE FEEDBACK

(credit points: 5)

a) How many rounds of the game did you play in your class?

b) How many children participated in each of those rounds?

c) How did you involve the remaining children of the class in this activity?

d) What kinds of interrelationships did the children come out with— food, competition, breeding, protection, etc.

e) Did you have any problems during the activity? What were these?

f) Did you lead or follow the game with a theory session? If yes, please describe.

g) Do you think the activity helped your students? How?