CHAPTER

3 Biodiversity

Animation 3.1 : Ecology- Man and his environment
Source & Credit: Wikispaces

At least 10 million kinds of organisms inhabit the Earth but less than one third of these have been studied and catalogued (put in record) by biologists. Diversity among the Earth's organisms is more obvious than the fundamental unity of life. We see that all organisms share many biological characteristics. Five principal groups of organisms are prokaryotes, protists, fungi, plants, and animals. In this chapter we will focus on the differences among different groups of organisms. We will also see how are organisms classified and named and what are the concerns with the existence of biodiversity.

3.1 Biodiversity

The term "biodiversity" has been derived from 'bio' and 'diversity'. "Diversity" means variety within a species and among species. Biodiversity is a measure of the variety of organisms present in different ecosystems.

The diversity of plants' (flora) and animals' (fauna) in a region depends on climate, altitude, soils and the presence of other species. Biodiversity is not distributed evenly on Earth. It is richest in the tropics. Temperate regions also have many species while there are fewer species in the polar regions. Biodiversity found on Earth today is the result of 4 billion years of evolution. The origin of life is not well known to science, though limited evidence suggests that until 600 million years ago, all life consisted of bacteria and similar unicellular organisms.

Importance of biodiversity

Biodiversity provides food for humans. A significant proportion of drugs are derived, directly or indirectly, from biological sources. A wide range of industrial materials e.g. building materials, fibres, dyes, resins, gums, adhesives, rubber and oil are derived directly from plants.

Biodiversity plays important role in making and maintaining ecosystems. It plays a part in regulating the chemistry of our atmosphere and water supply. Biodiversity is directly involved in recycling nutrients and providing fertile soils.

Figure 3.1: Variety of plant life in a tropical (left) and temperate (right) region

3.2 Classification - Aims And Principles

There is a large collection of very dissimilar forms of organisms, found on Earth. Over 1.5 million types of animals and over 0.5 million types of plants are known to biologists and these are only a small percentage of the total types estimated to live on Earth. They range in complexity from small and simple bacteria to large and complex human beings. Some of them live in sea, some on land; some walk, others fly, and still others are stationary. Each has its own way of life i.e. getting food, avoiding unfavourable environmental conditions, finding a place to live, and reproducing its kind. When there are so many diverse kinds of organisms, it becomes difficult to learn about the characteristics of each.

To study such a large collection, biologists classify the organisms into groups and subgroups and for this task they require some system. Biological classification is a method by which biologists divide organisms into groups and subgroups.

Figure 3.2: Variety of animal life in polar regions

Aims of Classification

The branch of biology which deals with classification is called **taxonomy** and the branch which deals with classification and also traces the evolutionary history of organisms is known as **systematics**. The main aims of both these branches are;

- To determine similarities and differences among organisms so that they can be studied easily.
- To find the evolutionary relationships among organisms.

Basis of Classification

Classification is based on relationship amongst organisms and such relationship is got through similarities in characteristics. These similarities suggest that all organisms are related to one another at some point in their evolutionary histories.

However, some organisms are more closely related than others. For example sparrows are more closely related to pigeons than to insects. It means that the former two have common evolutionary histories. When biologists classify organisms into groups and subgroups, the similarities are seen in external and internal structures and stages of development. Modern genetics provides another type of information to taxonomists. The similarities and differences in the DNA of two studied organisms can be used for getting idea about similarities and differences in their structures and functions.

Taxonomic Hierarchy

The groups into which organisms are classified are known as taxonomic categories or taxa (singular "taxon"). The taxa form a ladder, called taxonomic hierarchy. All organisms are divided into five kingdoms. So kingdom is the largest taxon. On the basis of similarities, each kingdom is further divided into smaller taxa in the following way:

- **Phylum** (Division: for plants and fungi): A phylum is a group of related classes.
- **Class**: A class is a group of related orders.
- **Order**: An order is a group of related families.
- **Family**: A family is a group of related genera.
- **Genus**: A genus is a group of related species.
- **Species**: A species consists of similar organisms.

Members of lower taxon resemble one another more than do the members of a higher taxon. Table 3.1 illustrates the classifications of humans (*Homo sapiens*) and pea (*Pisum sativum*).

Table 3.1: Simple classification of two organisms

Taxa	Human	Pea
Kingdom	Animalia	Plantae
Phylum	Chordata	Magnoliophyta
Class	Mammalia	Magnoliopsida
Order	Primates	Fabales
Family	Hominidae	Fabaceae
Genus	*Homo*	*Pisum*
Species	*H. sapiens*	*P. sativum*

Species - The Basic Unit of Classification

Species is the basic unit of classification. "A species is a group of organisms which can interbreed freely among them and produce fertile offspring, but are reproductively isolated from all other such groups in nature." Each species possesses its own distinct structural, ecological and behavioural characteristics.

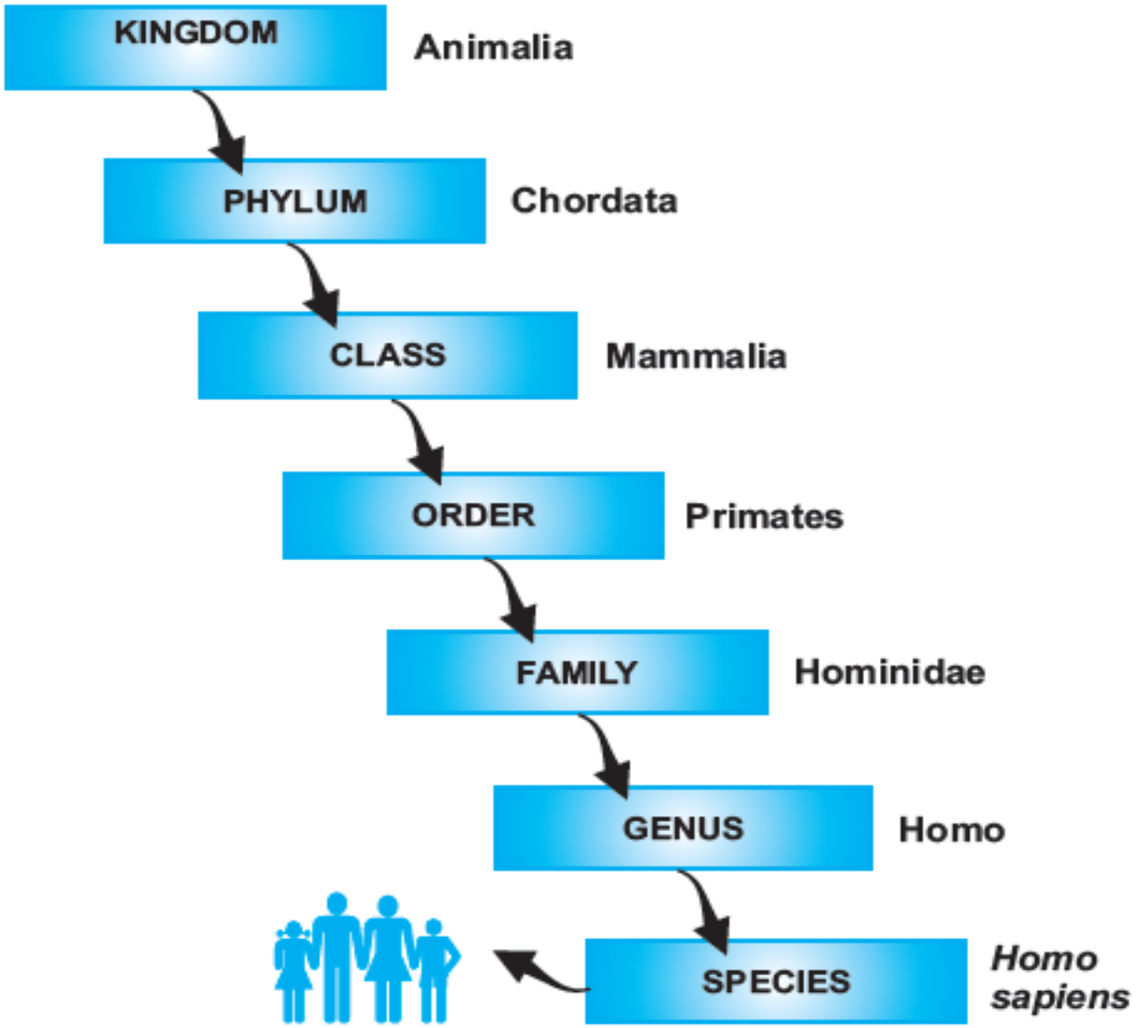


Figure 3.3: Taxonomic hierarchy

In the definition of species we must emphasize "in nature" because two organisms related to two different but closely related species can cross-breed under artificial conditions. In such unnatural crosses they produce infertile offspring. For example, a cross between a male donkey and a female horse produces an infertile offspring i.e. mule (Figure 3.4).

The criteria of interbreeding cannot be used for species recognition in organisms who reproduce asexually and do not interbreed with one another (for example many unicellular organisms).

Use internet and find the classification schemes of a fungus and a bacterium.

Figure 3.4: Infertile mule

3.3 History Of Classification Systems

The earliest known system of classification of organisms comes from the Greek philosopher **Aristotle.** He classified all living organisms known at that time as either in the group 'plantae' or in 'animalia'.
In 700s, **Abu-Usman Umer Aljahiz** described the characteristics of 350 species of animals in his book. He wrote a lot about the life of ants. In 1172, **Ibn Rushd (Averroes)** translated Aristotle's book "de Anima (On the Soul)" in Arabic. In the end of 15th century, many biologists had started work on classification methods e.g.

Carolus Linnaeus divided nature into three kingdoms: mineral, vegetable and animal. Linnaeus used five ranks in classification: class, order, genus, species, and variety. Linnaeus is best known for his introduction of the method still used to formulate the scientific name of every species.

Andrea Caesalpino (1519-1603 AD)	Divided plants into fifteen groups and called them "genera".
John Ray (1627-1705 AD)	Published important works on plants' classification.
Augustus Rivinus (1652-1723 AD)	Introduced the taxon of "order".
Tournefort (1656-1708 AD)	Introduced the taxa of "class" and "species".
Carolus Linnaeus (1707-1778 AD)	Grouped species according to similar physical characteristics.

Biologists prefer such a system that can provide maximum information about the basic differences and similarities among different organisms. According to earlier classification system, organisms were classified into two kingdoms but now taxonomists agree on five-kingdom classification system. We will see the basis of these classification systems and the drawbacks in the two-kingdom and three-kingdom classification systems.

3.3.1 Two-Kingdom Classification System

It is the oldest system and classifies all organisms into two kingdoms i.e. Plantae and Animalia. According to it, all organisms that can prepare food from simple inorganic materials and thus can store energy, are autotrophs and are included in kingdom plantae. On the other hand, the organisms that cannot synthesize their food and depend on autotrophs or others are heterotrophs and are included in kingdom animalia. According to this system, bacteria, fungi and algae were included in kingdom plantae.

Some taxonomists found this system unworkable because; many unicellular organisms like Euglena have both plant-like (presence of chlorophyll) and animal-like (heterotrophic mode of nutrition in darkness and lack of cell wall) characters. So there should be a separate kingdom for such organisms. This system also ignores the difference between organisms having prokaryotic and those having eukaryotic cells.

3.3.2 Three-Kingdom Classification System

In 1866, **Ernst Hacke**l solved the first objection and proposed a third kingdom i.e. protista to accommodate euglena-like organisms. He also included bacteria in kingdom protista. In this system, fungi were still included in the kingdom plantae.

This system did not clear the difference between prokaryotes and eukaryotes. Some biologists disagreed about the position of fungi in kingdom plantae. Fungi resemble plants in many ways but are not autotrophs. They are special form of heterotrophs that get their food by absorption. They do not have cellulose in their cell walls rather possess chitin.

3.3.3 Five-Kingdom Classification System

In 1937, **E-Chatton** suggested the terms of, "Procariotique" to describe bacteria and "Eucariotique" to describe animal and plant cells. In 1967, **Robert Whittaker** introduced the five-kingdom classification system. This system is based on;

- The levels of cellular organization i.e. prokaryotic, unicellular eukaryotic and multicellular eukaryotic
- The principal modes of nutrition i.e. photosynthesis, absorption, and ingestion.

On this basis, organisms are classified into five Kingdoms: monera, protista, fungi, plantae and animalia.

In 1988, **Margulis and Schwartz** modified the five-kingdom classification of Whittaker. They considered genetics along with cellular organization and mode of nutrition in classification. They classified the organisms into the same five kingdoms as proposed by Whittaker.

3.4 The Five Kingdoms

The general characteristics of the five kingdoms are as follows (See Table 3.2 also);

1. **Kingdom monera:** It includes prokaryotic organisms i.e. they are made of prokaryotic cells. Monerans are unicellular, although some types form chains, clusters, or colonies of cells. Prokaryotic cells are radically different from eukaryotic cells. Most are heterotrophic but some perform photosynthesis because they have chlorophyll in their cytoplasm. Within this kingdom, there are two different kinds of organisms i.e. bacteria and cyanobacteria.

2. **Kingdom protista:** It includes eukaryotic unicellular and simple multicellular organisms. There are three main types of protists.
   - Algae are unicellular, colonial or simple multicellular. They resemble plant cells with cell walls and chlorophyll in chloroplasts. Simple multicellular means that they do not have multicellular sex organs and do not form embryos during their life cycles.
   - **Protozoans** resemble animals whose cells lack chlorophyll and cell walls.
   - Some protists are **fungi-like.**

3. Kingdom fungi: It includes eukaryotic multicellular heterotrophs which are absorptive in their nutritional mode e.g. mushrooms. Most fungi are decomposers. They live on organic material, secrete digestive enzymes and absorb small organic molecules formed by the digestion by enzymes.

4. Kingdom Plantae: It includes eukaryotic multicellular autotrophs. Plants are autotrophic in nutritional mode, making their own food by photosynthesis. They have multicellular sex organs and form embryos during their life cycles. Mosses, ferns and flowering plants are included in this kingdom.

5. Kingdom Animalia: It includes eukaryotic multicellular consumers. Animals live mostly by ingesting food and digesting it within specialized cavities. They lack cell wall and show movements.

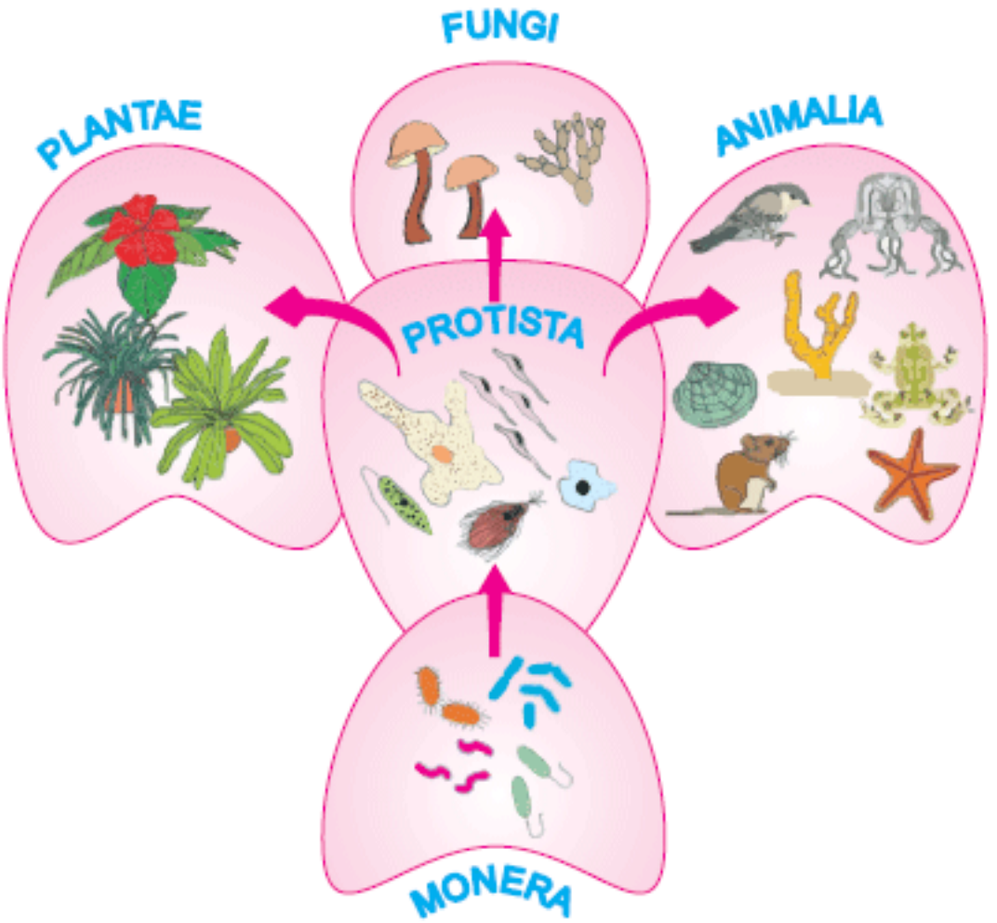


Figure 3.5: The Five kingdoms of classification

? How can you divide the five Kingdoms into two groups on the basis of types of cells?

(a) Kingdom monera including organism with prokaryotic cells and
(b) Kingdom protista, fungi,plantae and animalia include organisms with eukaryotic cells

Table 3.2: Distinguishing characteristics of the five kingdoms of life

Kingdom	Cell Type	Nuclear Envelope	Cell Wall	Mode of Nutrition	Multi-Cellularity
Monera	Prokaryotic	Absent	Non-cellulose (polysaccharide plus amino acids)	Autotroph or heterotroph	Absent
Protista	Eukaryotic	Present	Present in some forms, various types	Photosynthetic or heterotroph, or combination	Absent in most forms
Fungi	Eukaryotic	Present	Chitin	Absorptive heterotroph	Present in most forms
Plantae	Eukaryotic	Present	Cellulose and other polysaccharides	Photosynthetic	Present in all forms
Animalia	Eukaryotic	Present	Absent	Ingestive heterotroph	Present in all forms

Status of Viruses

Viruses are at the borderline of living and nonliving. Due to their crystalline nature, they are considered as non-living. They are acellular i.e. they do not have cellular organization yet show some characters of living organisms (e.g. they possess DNA). Viruses contain either RNA or DNA, normally encased in protein coat. They reproduce only in living cells, where they cause a number of diseases. They are not considered as organisms and thus are not included in the five-kingdom classification system. Prions and viroids are also acellular particles and are not included in the five-kingdom classification system.

3.5 Binomial Nomenclature

Binomial nomenclature is the method of giving scientific names to living organisms. As the word "binomial" suggests, the scientific name of a species consists of two names: the first is **genus** name and the second one is the name of **species**. Swedish biologist Carolus Linnaeus (1707-1778 AD) first introduced and adopted the system of binomial nomenclature. His system spread rapidly and became popular. Many of his names are in use today.

Some of the rules which are universally adopted while suggesting and documenting scientific names, are:

- Scientific names are usually printed in italics, such as *Homo sapiens*. When handwritten they are underlined.
- The first term (generic name) always begins with capital letter, while species name is never capitalized (even when derived from a proper name).
- The scientific name is generally written in full when it is first used. But when several species from the same genus are being listed, it may then be abbreviated by just using an initial for genus; for example Escherichia coli becomes E. coli.

Prions are composed of protein only and Viroids are composed of circular RNA only. Both these particles cause infectious diseases in certain plants.

Significance

In biological research, common names cause many problems. Different regions have different names for the same organism. For example; common name of onion in Urdu is 'Piyaz' but in different regions of Pakistan it is also known as 'ganda' or 'bassal' or 'vassal'. In other countries, it has other sets of names. In science, it is known with a single name as *Allium cepa*. In some cases, different organisms are called by the same common name. For example; the name 'black bird' is used for crow as well as for raven.

Common names have no scientific basis. For example; a fish is a vertebrate animal with fins and gills. But several common names of 'silver fish', 'cray fish', 'jelly fish', and 'star fish' do not fit the biologist's definition of a fish. To avoid all these confusions, organisms are given scientific names by using binomial nomenclature . The value of this system is due to its widespread use and the stability of its names. In binomial nomenclature, every species can be unambiguously identified with just two words. Same name can be used all over the world, in all languages, avoiding difficulties of translation.

Sometime organisms are named in honor of the research workers who described and classified them. For example; the Orchid tree (Mountain-ebony) was named as *Bauhinia variegata* after the Swiss botanists Bauhin. *Bauhinia variegata* is an ornamental tree found in southeast Asia.

Examples:

Common Name	Scientific Name
Onion	*Allium cepa*
Common sea star (starfish)	*Asterias rubens*
House crow	*Corvus splendens*

3.6 Conservation Of Biodiversity

During the last century, loss of biodiversity has been increasingly observed. In the modern era, due to human actions, species and ecosystems are threatened with destruction to an extent rarely seen in Earth history. A species that no longer lives in an ecosystem is called extinct in that ecosystem. When species of an ecosystem become extinct, the stability of ecosystem is harmed. Biologists warn that global ecosystem would collapse if biodiversity continues to be reduced at the same rate.

Many plant and animal species have gone extinct in Pakistan. Examples of endangered and extinct animal species are lion, tiger, Asiatic cheetah, Indian one-horned rhinoceros, swamp deer, Indian wild ass, hangul, blackbuck etc (Figure 3.6).

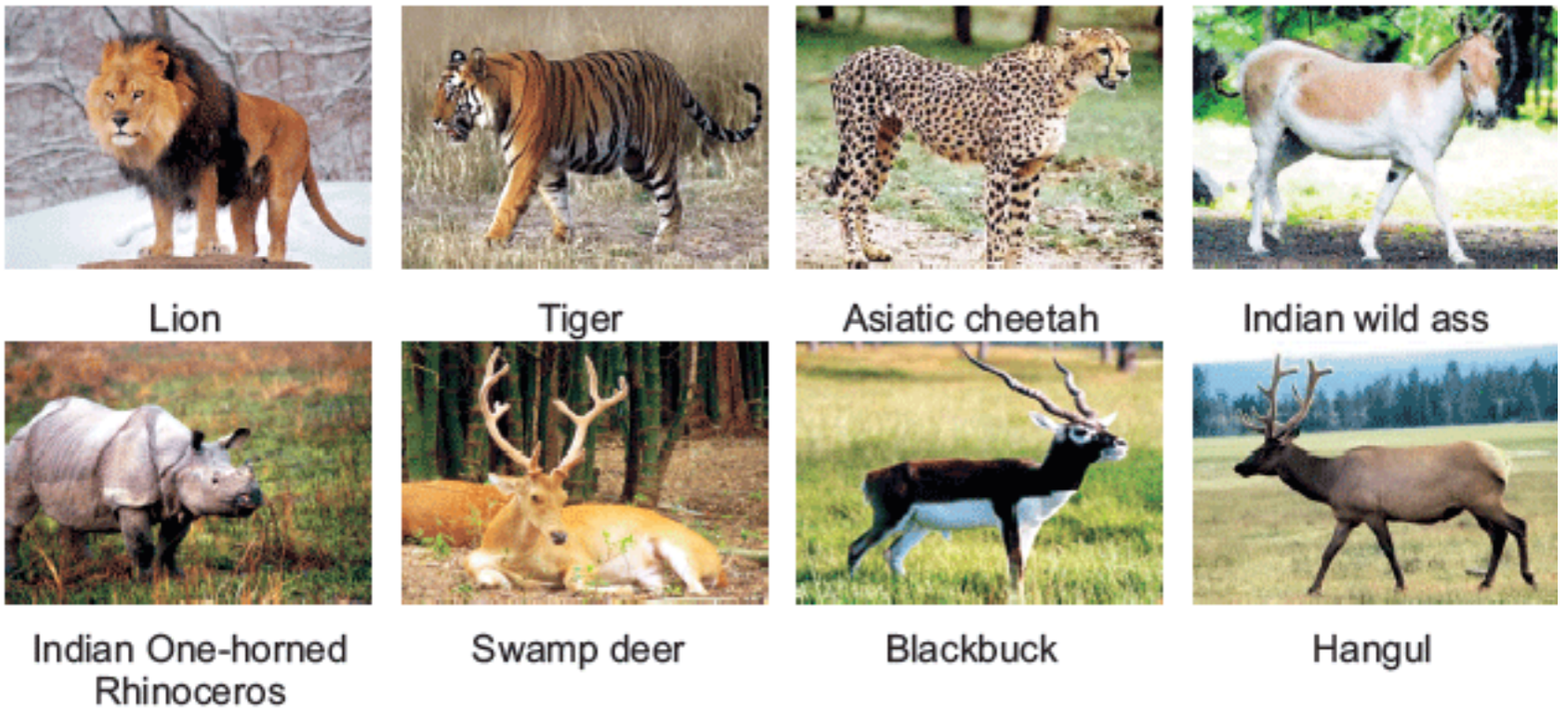


Figure 3.6: The animals that have gone extinct in Pakistan

3.6.1 Impact Of Human Beings On Biodiversity

By 10,000 years ago there were about 5 million people on Earth. With the advancement in agriculture and industry, human population began to grow rapidly. Today around 600 million people live on Earth.

To improve the living conditions for 600 million humans, we are imposing serious threats to the survival of biodiversity. Habitat loss, deforestation, over-hunting, introduction or removal of species, pollution and climate change are the major causes of species extinction.

In an ecosystem, a species is called extinct when there is no doubt that the last individual of that species has died in that ecosystem. A species is called endangered when it is at risk of extinction in near future.

More than 260,000 people are added to the world population each day, or more than 180 each minute!

Habitat loss is probably the greatest threat to biodiversity on Earth today.

Eucalyptus plants were imported from Australia and introduced in Pakistan. These plants consume more water and have disturbed the water table (level of underground water). It harms other small plants that grow near *Eucalyptus* trees.

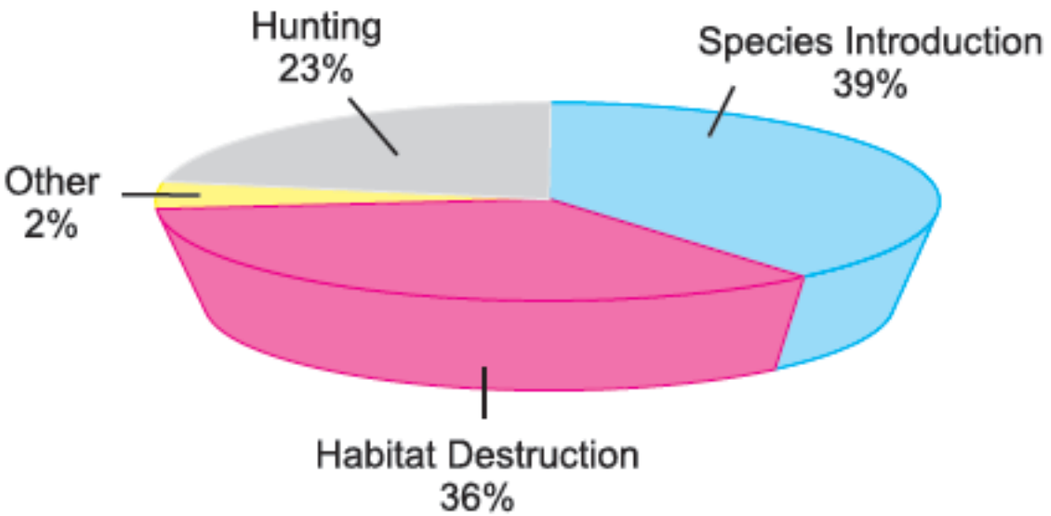


Figure 3.7: Known causes of species extinctions

Sea star (starfish) eats mussels. If sea stars are removed from a region in ocean, mussels rapidly increase in number. Large number of mussels prey on small animals and become dangerous for their existance.

The race to produce cash through fruits, spices, sugar, tobacco, soap, rubber, paper, and cloth has stimulated many to get them by using soil and by destroying the forests.

3.6.2 Deforestation And Over-Hunting

Deforestation means cutting down of trees for the conversion of a forest to non-forest land. The destruction of significant areas of forest has resulted in a degraded environment with reduced biodiversity.

Causes and effects of deforestation

Sometime there is slow forest degradation and sometime sudden and catastrophic clear-cutting for urban development. Deforestation can be the result of deliberate removal of forests for wood, agriculture or urban development.
Deforestation affects the amount of water in soil and moisture in atmosphere. When there are no trees to keep soil in place, there are more chances of soil erosion. Heavy rainfall washes soil into rivers (Figure 3.8). Essential nutrients are washed out of soil. Rivers become choked up with mud and silt, which can cause floods. The silted water gets stored in dams and it reduces their water storage capacity. Deforestation also contributes to decreased transpiration, which lessens cloud formation. This ultimately reduces the sources of rains.

In developing countries, almost 3 billion people rely on wood for heating and cooking.

Figure 3.8: Soil erosion

Figure 3.9: Chopping up of trees for the construction of roads

Forests support considerable biodiversity. The utilization of forest products, including timber and fuel wood, have played a key role in human societies. Today, developed countries continue to utilize timber for building houses and wood pulp for making paper.
The forest products industry is a large part of the economy in developed and developing countries. Short-term economic gains made by conversion of forest to agriculture often leads to loss of long-term income.

Forests extract carbon dioxide and pollutants from the air, thus contributing to biosphere stability. Forests are also valued for their aesthetic beauty and tourist attraction. These important aspects of forests are also harmed due to deforestation. In Pakistan too, deforestation is a great threat to biodiversity. In the province Khyber Pakhtunkhwa, the closed canopy forests are shrinking at approximately 1% per year.

Over-hunting

Over-hunting has been a significant cause of the extinction of hundreds of species and the endangerment of many more such as whales, ibex, urial, markhor (the national animal of Pakistan) etc. Commercial hunting, both legal and illegal, is the principal threat.

The threat to biodiversity is among the hot topics discussed at the UN World summits.

3.6.3 Steps For The Conservation Of Biodiversity

Conservation of biodiversity has become a global concern. Biologists urge the national policy makers to state a set of rules necessary to protect a species. They demand that laws should define species which are threatened by extinction and must be protected.

Though rich in biodiversity, Pakistan today faces severe threats to its animal and plant species. The greatest concern is the loss of natural habitats. Main causes of this loss are rapid growth in human population and the prevailing poverty in rural areas of Pakistan. In addition, low literacy rate is also a reason for the failure of conservation measures taken so far.
The International Union for the Conservation of Nature and Natural Resources **(IUCN)** and the World Wildlife Fund-Pakistan **(WWF-P)** work in close coordination with Pakistan's Ministry of Environment and other government and non-government institutions. The IUCN has prepared the first national Red List (list of endangered or threatened species).

Following are a few examples of environmental work that has been carried out in Pakistan in order to conserve species and associated habitats.

1. **National Conservation Strategy:** In 1980's, IUCN and the government of Pakistan formulated the National Conservation Strategy for Pakistan for the conservation of Pakistan's biodiversity.

2. **UN Convention on Combating Desertification (CCD):** This is an international treaty against damage and poverty in drylands. Pakistan signed this in 1997.

The northern areas provide habitats to Musk deer, Snow leopard, Astore markhor and Himalayan ibex, Woolly flying squirrel and the Brown bear.

It is estimated that about 200,000 of the one million migratory birds passing through Chitral are killed during migration.

3 **Himalayan Jungle Project (HJP):** It started in 1991 in the Palas Valley, in Khyber Pakhtunkhwa (KP). It aimed at protecting one of the richest areas of biodiversity in Pakistan.

4. **Conservation of biodiversity of the Suleiman Range, Balochistan:** Suleiman Range Chilghoza Forest is the largest Chilghoza forest in the world. In 1992, the WWF-P started its conservation program.

5. **Northern Areas Conservation Project:** The northern areas of Pakistan serve as a habitat for a number of wildlife species. The survival of these species is under threat. The NACP is a project of WWF-P which is successful in implementing a ban on the hunting of these species.

6. **Conservation of migratory birds in Chitral, KP:** Chitral lies on the migratory route of several important bird species. These birds face enormous hunting pressure. WWF-Pakistan initiated efforts to reduce the hunting pressure in 1992. The efforts proved successful.

7. **Conservation of Chiltan Markhor:** Hazarganji National Park is located close to Quetta and is the only remaining habitat of Chiltan Markhor in the country. WWF-Pakistan developed the management plan of the park.

8. **Ban on games:** Foreigners visit the northern areas and play many games in which bears are used. WWF-Pakistan has been successful in imposing a ban on this illegal practice.

The herders capture the bear cubs and sell them to the trainers who train them and sell to the foreigners.

3.6.4 Endangered Species In Pakistan

Due to human activities, the biodiversity in Pakistan is facing a great loss. Here are a few examples of endangered species in Pakistan.

Indus dolphin

According to WWF-P, only 600 animals of the species of Indus dolphin are left today in the Indus River. The population of this species declined due to water pollution, poaching, and destruction of habitat.

Marco Polo sheep

Marco Polo sheep are mostly found in the Khunjerab National Park and nearby areas. Their numbers have been rapidly decreasing in the last two decades and WWF-P has started projects for its conservation.

Houbara bustard

This bird flies to Pakistan in winter season from former Soviet territory and settles in Cholistan and Thar deserts. The decline in its population is due to hunting by foreigners and destruction of its habitats.

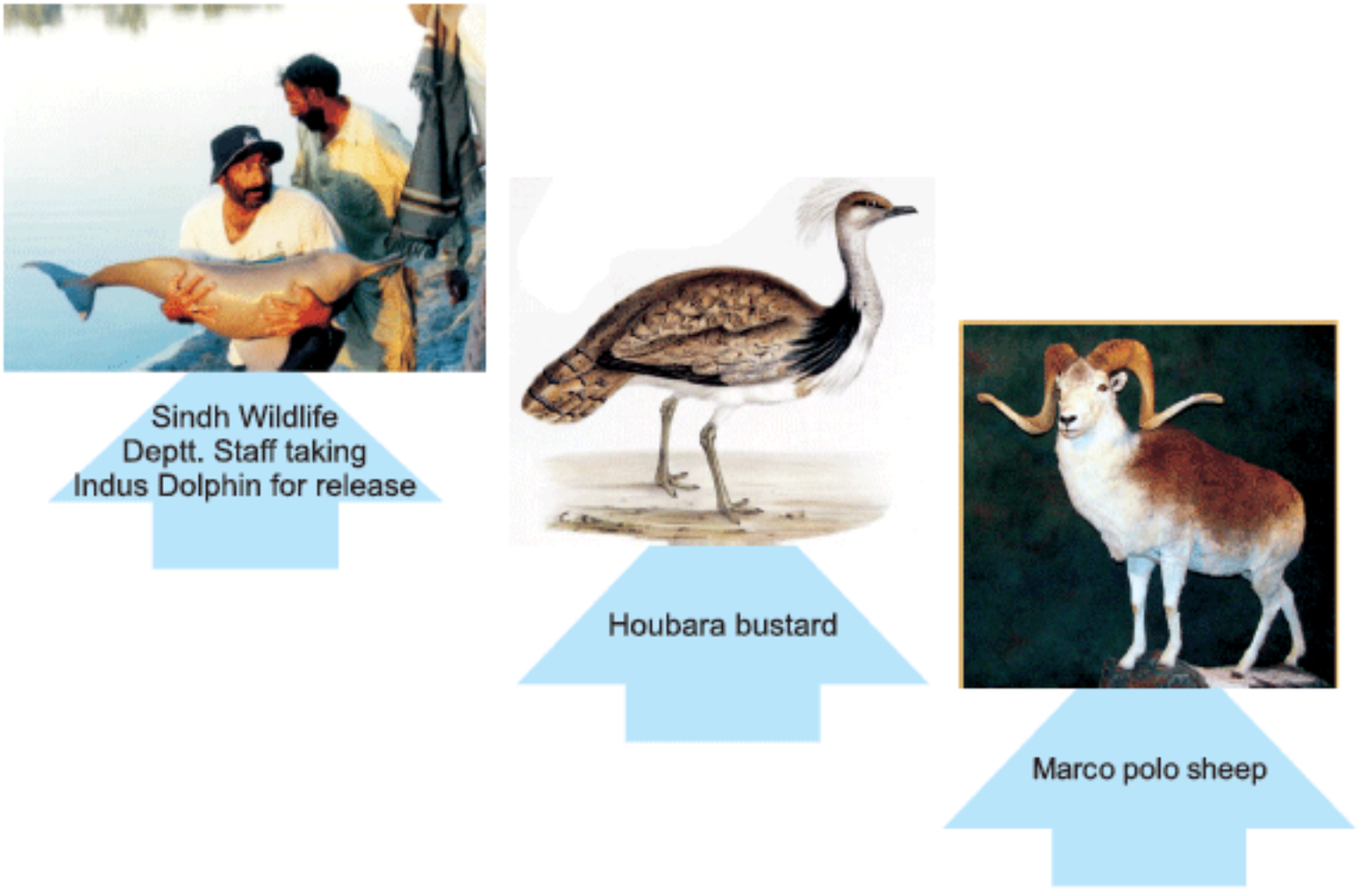
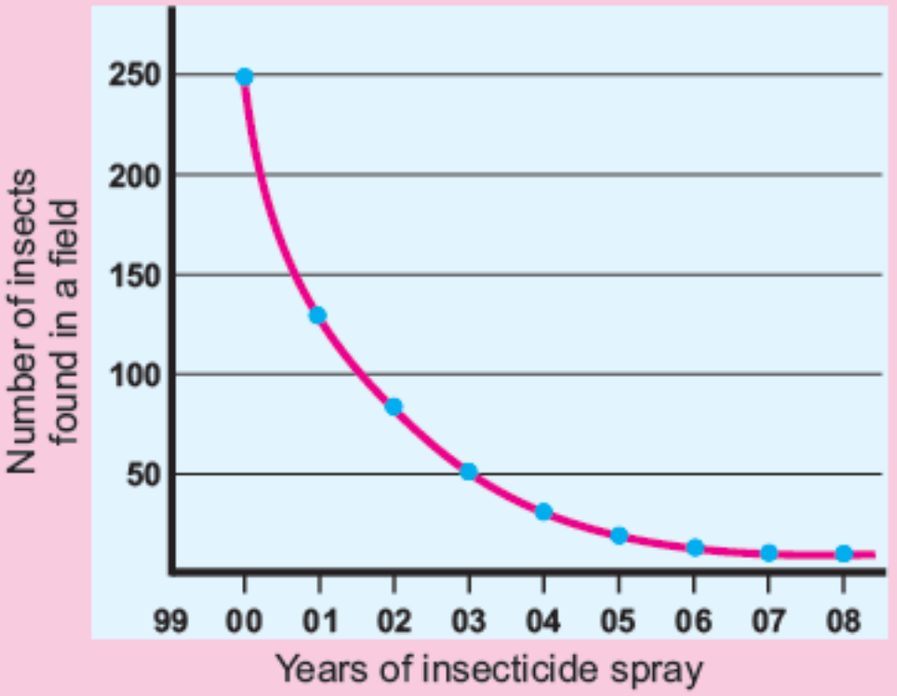


Figure 3.10: Indus Dolphin, Houbara and Marco polo sheep

Analyzing and Interpreting

Note: By this activity we will test our abilities of making a graph from available data. We should also be able to analyse and interpret the graph for drawing conclusions.

Most insecticides kill beneficial insects along with pest species. The following graph shows an example of the effect of an insecticide on an insect population of a field. Hypothesize whether the usage of insecticide may be the factor responsible for the endangered status of this insect.



Write a short article for publication in newspaper about endangered species.

Find out from books / internet the biological names of local plants and animals and sort out their generic and specific names.

Did you know?
Markhor is the National animal of Pakistan.

Did you know?
Chakor patridge is the National bird of Pakistan.

UNDERSTANDING THE CONCEPTS

1. Relate the importance of biodiversity with natural ecosystem through examples.
2. Explain the aims and principles of classification, keeping in view its historical background.
3. Explain the base for establishing five kingdoms of living organisms.
4. Justify why virus are excluded from the Five-Kingdom classification system.
5. Describe the aims and principles of binomial nomenclature.
6. Explain the impact of human beings on biodiversity.
7. Identify causes of deforestation and its effects on biodiversity.
8. Describe some of the programs running in Pakistan for the conservation of biodiversity.

SHORT QUESTIONS

1. What is the difference between the modes of nutrition of fungi and animals?
2. It is difficult to use the criterion of interbreeding to define species of unicellular organisms. Why?
3. How are taxonomy and systematics related?
4. Differentiate between the terms “extinct” and “endangered”.
5. What are the contributions of Whittaker, Margulis and Schwartz in taxonomy?

THE TERMS TO KNOW		
Acellular	Family	Prion
Animalia	Fauna	Protista
Binomial nomenclature	Flora	Soil erosion
Biodiversity	Fungi	Species
Class	Genus	Systematics
Classification	Monera	Taxon
Conservation	Order	Taxonomic hierarchy
Deforestation	Phylum	Viroid
Endangered species	Plantae	WWF

INITIATING AND PLANNING

1. Match the binomials of some common local organisms from a two column list on the basis of generic and specific names.
2. Describe ways in which society benefits from biodiversity.
3. Describe the reasons why an established animal species becomes endangered due to human interference. (e.g. Houbara bustard, Indus dolphin and Marco polo sheep).

ACTIVITIES

1. Observe the distinguishing taxonomic characters from fresh and preserved specimens and recognize plants and animals on the basis of these characters.

SCIENCE, TECHNOLOGY AND SOCIETY

1. Analyze the impact of human beings on biodiversity.
2. Associate advancements in scientific understanding with classification of organisms to develop a more reliable system.
3. Apply the knowledge of classification to assess the characteristics of different organisms when visit to zoos, herbaria, and gardens.
4. Explain the importance of binomial nomenclature in developing a more comprehendible sharing of scientific research.

ON-LINE LEARNING

1. http://www.pakistanwetlands.org/
2. http://hwf.org.pk
3. www.biodiversity.iucnp.org/
4. edu.iucnp.org/
5. www.wildlifeofpakistan.com/WildlifeBiodiversityofPakistan/
6. en.wikipedia.org/wiki/Biodiversity_Action_Plan