UNIT 16

SPECIES EXTINCTION

Structure

16.1 INTRODUCTION

In the unit 16 you have studied about macro-evolution and its mechanism and pattern. In the present unit you will learn regarding species extinction. As you know, there has been a continuous increase in the biodiversity on the earth

ever since first life originated about 3.5 billion years ago. However, this increase has not been steady and characterized by the fast pace of speciation being followed by periods of negligible change and then episodes of mass extinction. Extinction is actually a very common feature of life on the earth when viewed over long (e.g. geological) timescales. More than 99% of the species that have ever lived have gone extinct. The concept of extinction was first proposed by the scientists in the late 18th century. Georges Cuvier, a naturalist studied the fossils of an animal now known as the American mastodon, or *Mammutamericanum*, and arrived at the conclusion that all such creatures must have died out in the distant past. Cuvier is now being praised for being ahead of his time but in his own lifetime, many of his ideas about extinction were harshly criticized.

Extinction is one of the most common of all ecological/evolutionary processes and information on extinction comes from many sources, including laboratory experiments, field studies and the fossil record. **In simple words extinction means death of a taxon.** But in a broad sense extinction also includes the effects of its disappearance from the environment with which it has interacted. Short term extinction involving few species and causes of their extinction can be well understood whereas the causes of long term extinction is still a topic of debate. We will discuss these aspects of extinction in this unit.

Objectives

After studying this unit, you should be able to:

- define various terms related to extinction,
- explain the relationship between extinction and speciation,
- distinguish among different types of extinction,
- analyse the causes and influence of big five mass extinctions, and
- explain the phenomenon of sixth extinction.

16.2 THE MEANING OF EXTINCT

A species is said to be extinct when the last individual of that species disappears. The extinction of the genus is followed by the death of last individual of the last species of that genus and so on. In historical times, the death of the last individual of small number of species followed by its extinction has been observed in reality. For example, the last Tasmanian tiger (*Thylacinus cyanocephalus*), a wolf-like marsupial mammal, died in Hobart Zoo on 7 September 1936. however, unconfirmed sightings of Tasmanian tigers in the wild are still occasionally reported, illustrating that even for such a large and distinctive contemporary animal it is very difficult to verify its extinction.

A species is **extinct** when no member of the species exists anywhere on the earth.

A species is **extinct in the wild** if it exists only alive in captivity.

A species is **locally extinct** if it is no longer alive in its habitat but is still found in other areas.

A species is **ecologically extinct** if it persists in very few numbers so that its effects on other species are negligible and unimportant.

16.2.1 Pseudoextinction

There are two reasons for the species (or higher taxa) extinction. Real extinction is when the lineage has died out and left no successors. This is clearly defined for modern species, but for fossils, real extinction has to be distinguished from pseudoextinction. **Pseudoextinction of a species occurs when all the members of the species are extinct but members of daughter species are alive.** This may be an error or artefact in the evidence, and not because the underlying lineage really ceased to exist.

There are three types of pseudoextinction, the first two of which are due to taxonomic artefacts described as under:

1) Species may sometimes evolve into a new form and may change its taxonomic name. Due to continuous evolution, later forms may look sufficiently different from earlier ones. The ancestor species cease to exist even though there is a continuous breeding lineage and the relationship between the ancestor and the descendant still exists.

2) A higher taxon may cease to have any members if it is defined phenetically and only some divergent lineages persist. A higher taxon, such as a family, can undergo pseudoextinction if the taxon is defined phenetically.

3) Some lineages, called Lazarus taxa, apparently disappeared entirely for short or extended periods by pseudotermination but later it reappears. The first disappearance is a pseudoextinction, and may be misrecorded as a real extinction if the later reappearance is overlooked for some reason.

16.2.2 Vulnerability to Extinction

When environments are damaged by human activity, the ranges and population sizes of many species will be reduced, and some species will go extinct. Rare species must be carefully monitored and managed in the efforts of conservation. Ecologists have observed that particular categories of species are most vulnerable to extinction. The five categories most frequently used in conservation planning are as follows:

- Species with a narrow geographical range
- Species with a single or a few populations
- Species with small population sizes
- Species in which population size is declining
- Species that is hunted or harvested by people

The following categories of species have also been lined up to extinction, though they are not considered as all-encompassing as the previous five categories:

- Species that need a large home range
- Animal species with a large body size
- Species that are not effective dispersers
- Seasonal migrants
- Species with little genetic variability
- Species with specialized niche requirements
- Species that are found in undisturbed and unspoilt environments
- Species that forms permanent or temporary aggregations
- Species that have not had prior contact with people
- Species that have recently become extinct or threatened with extinction of closely related species

Before proceeding further, try to answer the following SAQ:

SAQ 1

Give ansers for each of the following:

i) When all the members of the species are extinct but members of daughter species are alive.

ii) The concept of extinction was first proposed in the late 18th century by the scientists.

16.3 NATURAL CAUSES OF EXTINCTION

Extinction is a unavoidable consequence of natural selection. The discovery that species go extinct was made relatively recently in human history: it dates from the late eighteenth and early nineteenth centuries. As the global flora and fauna became better and better known through the eighteenth century, it became increasingly likely that some fossil forms were no longer alive. Extinction is a normal process but human-mediated extinctions rates have soared over the past few hundred years (Fig. 16.1). Devastating growth in human population over more than 50,000 years has given quantitative negative footprints to the biodiversity. This has led directly or indirectly in the 100- to 10,000-fold increase in the ‘‘natural’’ or ‘‘background’’ extinction rate that normally occurs as a consequence of gradual environmental change, newly established competitive interactions (by evolution or invasion), and occasional chance calamities such as fire, storms, or disease. Estimation of present and future extinction rate is done using variety of measures such as species–area models and changes in the World Conservation Union’s (IUCN)

threat categories over time. Based on the global assessment of all known species, some 31, 12, and 20% of known amphibian, bird, and mammal species, respectively (by far the best-studied of all animal groups), are currently listed by the I**nternational Union for Conservation of Nature and Natural Resources (IUCN)** as under threat.

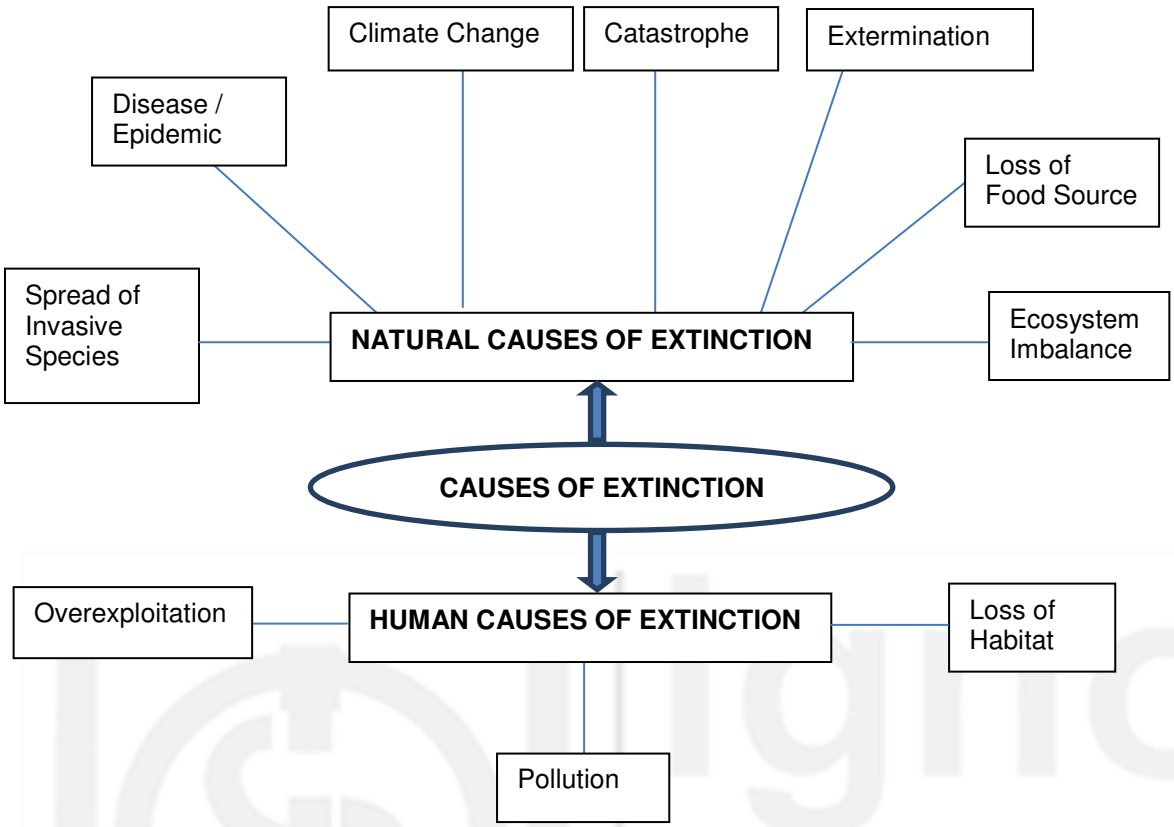

Fig. 16.1: Causes of Extinction.

Let us now discuss about various natural causes of extinction in the following subsection.

16.3.1 Climate Change

Climate Change is caused by a number of things and its effect on the extinction is very big. Sometimes periodic natural climate changes that occurred too rapidly resulted in the death of certain organisms that have not been able to move or adapt. Huge species extinction occurred in the last ice age and also the extreme warming made the environment intolerable to the cold adapted creatures. Atmospheric change like the rapid evolution of plants and hence increase in oxygen led to the extinction of approximately all other life forms. As for those oxygen was toxic. Great lives were lost in the deep past as a result of sudden increase in methane. And today, we are in the midst of another great extinction, this one is due in part to the sudden increase in CO2 and in part to toxins introduced by human industry. The changes in sea levels and currents are a result, in part, of the melting freshwater. The currents on which the marine life depends was formed when the denser, saltier water sinks. Small rise in the ocean floor can displace a lot of water onto the already occupied land. Therefore, spreading and rising of ocean floor also affects sea level. The gases from the volcanic activity absorbed by the water can change the chemical composition hence making it unsuitable for some life forms.

16.3.2 Catastrophe

All sorts of catastrophic events can cause extinctions. In the Earth's history, at times, the atmosphere has been made so toxic and hot due to massive volcanic eruptions that many organisms were not able to survive. The great meteor that struck Earth 65 million years ago destroyed the impact site completely at that time. It is well known that a meteor impact on the Yucatan peninsula in Mexico caused the disappearance of the dinosaurs 65 million years ago. Hypothesis says that too much exposure to cosmic radiations. Can cause gene mutation. But, it is extremely difficult to avoid these radiations as they are sourced from space and the sun. Supernova remnants are one source of cosmic radiation.

16.3.3 Loss of Food Source

Massive disasters like fire and floods may lead to food starvation of organisms. Organisms that are incapable of moving or changing their food habits or lack adequate nourishment are supposed to become extinct. Mass starvation is the quick, one-way, sure-fire route to extinction—specially since hunger-weakened populations are much more prone to disease and predation—and the effect on the food chain can be disastrous.

16.3.4 Disease/Epidemic

Due to climate change, certain species become more susceptible to disease and epidemics which can lead to their eventual extinction. Many types of diseases –from fungi, viruses, bacteria—spread and kill faster than the antibodies and other defences can adapt. For example: a fungus is spreading rapidly in the isolated population of Tasmanian wolf and the future prospects of their survival is negligible. Amphibian chytridiomycosis (a fungal infection that ravages the skin of frogs, toads, and salamanders and causes death within a few weeks) and Tasmanian devil facial tumour disease (DFTD) currently are the two very infectious diseases, threatening to cause extinctions in Australia. Anthropogenic changes are most probably going to enhance emerging disease threat to biodiversity and it is critical to further develop strategies to manage these threats. Anthropogenic changes include movement of diseases and hosts, habitat destruction and fragmentation and climate change.

16.3.5 Spread of Invasive Species

Invasive species spread foreign territory and utilize the resources of the other species. Once competition increases, as a result of the survival of the fittest plan, usually the natural species will die off. Invasive species may be the prime cause of extinction in island ecosystems. The prime cause for the global extinction of local flora and fauna continues to be introduction of predators, parasites and pests by human beings, especially to islands. For Example, introduction of European red foxes had negative influence on many species, and were responsible for the extinction of the desert rat kangaroo and feral cats. That would have resulted in the extinction of several ground-dwelling birds.

According to National Geographic, examples of some of the species that became extinct because of invasions include:

- In 1979, the Yunnan lake newt in part of China went extinct after the introduction of exotic frogs and fish in their habitat.
- In 1985, invasive predators made the Hawaiian thrush extinct in part.
- In 1983, the extinction of the Guam broadbill, a bird was marked as the result of introduction of the brown tree snake to its habitat.

16.3.6 Extermination

In case of accidental transplant of a plant or animal of one ecosystem into another (usually by an unwitting human or an animal host), it can reproduce wildly, resulting in the extermination of the native population. Some massive animals like mastodons of North America were possibly eliminated by Stone Age humans. Past two centuries have witnessed deliberate eliminations as well as exterminations of many species of mammals, birds, fish and plants by hunting done by humans.

16.3.7 Ecosystem Imbalance

All organisms live within a system of interdependent relationships with other species.

Elimination or extinction of any one key species within the system is capable of bringing an unfortunate elimination of several others. For example, elimination of top predators such as sharks (killed for their fins) can cause disturbance in the ecological balance and leading to the loss of one or more species within their specific ecosystem.

16.4 HUMAN CAUSES OF EXTINCTION

Extinctions caused by humans are not necessarily new phenomena according to the studies done by **IUCN** but today it is becoming much more rapid. Some experts estimate the present rapid loss of species to be between 100 and 1,000 times higher than the natural extinction rate, unlike other's estimated rates as high as 1,000-11,000 times higher. In comparison to other large bodied animal small bodied species are more likely to suffer from the changes that happened to the planet due to indulgence by humans.

Extinctions can disrupt our ecological processes like pollination and seed distribution and a collapse of the food chain which can cause more extinction. Regardless of the state their presence (alone or in combination), these stressors result in small, fragmented populations of wild flora and fauna that get highly influenced to inbreeding, and to the risks of small abundance that is also known as demographic instability. Stressed population usually decline further when not interfered with and become endangered.

16.4.1 Overexploitation

Overexploitation or unsustainable hunting and harvesting causes mortality at high rates and the population becomes severely reduced in numbers. In fact

their populations can drop to an extent from which they cannot recover. The pattern of overexploitation of plants and animals in many cases are very similar. Several examples like the ivory of the elephants, the fur and organs of the tiger, the deliciousness of tuna and the supposedly medicinal effect of shark's fin, clearly tell why we have hunted animals to the point of extinction. Also, the dodo, passenger pigeon, great auk, and Steller's sea cow were hunted to extinction. Then there are thousands of rare species worldwide which are harvested and sold for the various purposes like pets, houseplants, wood, or herbal medicine. According to the report of The World Wide Fund (WWF), 23% of extinctions are solely caused by overhunting. Over-consumption and killing of many animals by humans for economic gains is a reason of their forced extinction. In early times overhunting has caused extinctions of giant lemurs and elephant birds in Madagascar, Miss Waldron's red colobus monkey in Ghana, moas in New Zealand, Alagoascurrasow in northeastern Brazil and giant kangaroos in Australia.

Commercial fishing and whaling demonstrate this pattern well, with the industry working one species after another to the point of diminishing returns, a process sometimes termed "fishing down the food chain". Since the eighteenth century, most of the world's baleen whale species, and several toothed whales are threatened with extinction due to commercial whaling for the purpose of meat and oil.

16.4.2 Pollution

Pollution is increasingly becoming an important factor in the detriment of wildlife and biodiversity. Pesticides, cleaning agents, drugs, carbon emissions, and other chemicals used by humans are making their way into the food webs of many ecosystems around the globe. When unnatural chemicals get introduced into air, soil and sea, contamination caused to these interferes with the metabolism of animals which is intolerable to them.

Carbon monoxide, sulphur dioxide and nitrogen oxides are air pollutants. Water and soil pollutants include heavy metals such as mercury, cadmium and lead – and pesticide and herbicide compounds.

All of these factors work in alliance with each other, causing the extinction at a very high pace. The bald eagle is a common example of a species that became endangered due to the use of a pesticide called DDT. This led to the discovery of bioaccumulation and biomagnification, which is the steady increase in concentration of a contaminant with increasing level in the food chain. DDT is not metabolized and does not break down in the body and since it is not excreted, the carnivore accumulates most of the DDT that was present in all of the prey organisms. DDT interferes with calcium deposition in eggshells, causing them to be thin, fragile, and often crushed by the parents in the nest.

Acid deposition is the falling of acids and acid-forming compounds from the atmosphere to Earth's surface. Acid deposition includes acid rain, acid snow, acid smog, and other acidic material. The burning of fossil fuels like nitrogen oxides and sulphur oxides are combined with air where they combine with water to form nitric acid and sulphuric acid which result in acid rain. Acid rain

dissolves nutrients in the soil, including calcium and potassium, rendering them unavailable to plant life. It is lethal to microorganisms, hence preventing decomposition from returning nutrients to the soil. Acid deposition also reduces agricultural yields and corrodes marble, metal, and stonework, an effect that is noticeable in cities. Thus, the forests in these areas are dying and acidification of lakes directly kills algae, invertebrates, amphibians, and fish, ultimately increasing the rates of extinction.

16.4.3 Loss of Habitat

Climate change and natural disasters can destroy habitat. But the biggest cause of extinctions today is human population. The land use practices like deforestation, urban and suburban development, agricultural cultivation, and water management projects put tremendous pressure on organisms and/or destroy their natural habitat.

It is opined that we will lose all our rainforest in next coming 100 years if we are incapable of ceasing deforestation. Thirteen million hectares of forest have been either destroyed completely or converted. Our coral reefs are also under threat. These are home to around 25% of marine animals and unfortunately 27% of coral reefs have been destroyed till date. Where the large animals, including elephants, buffalo and the predator cats, cannot adapt to their shrinking territories, some species are able to move to new territories. But many are perishing.

SAQ 2

Give one/two words answer for each of the following:

i) The reason that caused the disappearance of the dinosaurs 65 million years ago-

ii) The phenomenon of the steady increase in concentration of a contaminant with increasing level in the food chain, is called as.

16.5 MASS EXTINCTION AND SPECIATION

Extinction is a natural process. Background extinction and Mass extinction are of two types of extinctions.

16.5.1 Background Extinction

Considering ecological factors such as climate change, competition between species, loss of habitat and available resources, the average rate of extinction across geological history has been about 10-25 species per year. This is known as background extinction and is a regular event in the process of evolution. It is **caused by the poor adaptation to the ongoing changes in the environment and** the rate of the background extinction is steady over geological time.

16.5.2 Mass Extinction

Mass extinction occurs due to rapid environmental changes and **exposure to harsh conditions during a short period of time** where species do not have sufficient time to adapt to the changes. Mass extinction has been periodical process throughout the existence of life on Earth. A mass extinction is a relatively sudden, global decrease in the diversity of life forms within a short period of geological time.

Occurrence of following is essential for a mass extinction:

- Extinctions occur all over the world.
- A great number of species go extinct.
- Different and many types of species go extinct.
- The extinctions are arrayed in a small periods of geological time (a few million years).

Similarities between Background Extinction and Mass Extinction

- Background extinction and mass extinction both are involved in the elimination of species from the earth.
- Background extinction and mass extinction both occur due to either continuous or fast environmental changes.

Difference between Background Extinction and Mass Extinction

- Ecological factors such as the climate change, loss of habitat, and competitive disadvantages related to other species cause the background extinction while mass extinctions are caused by the overly rapid, widespread environmental changes and catastrophic global events.
- Background extinction requires a long time but Mass extinction occurs within a short period of time.
- Background extinction is a continuous process, which is a result of the evolution. Mass extinction occurs due to rapid environmental changes.

16.5.3 Speciation

Speciation is the evolutionary process by which populations evolve to become distinct species. Destruction of biodiversity due to extinction is incomprehensible, but this destruction, however, is not the whole story. One method to acknowledge as to how extinction develops new niches is to review mass extinction events – geologically brief periods where great numbers of species go extinct simultaneously. During the period of extinction, the changes in the environment were very fast and most of the species were not able to keep evolutionary pace with the changing environment. As a result almost 90% species living in the world in that era went extinct. But extinction is a driving force for novelty and every mass extinction was followed by speciation.

In fact, this pattern is the rule and not an exception. For example, following the Permian mass extinction, we observe a constant increase in new species. But there are many species that were earlier not known in the fossil record. The Permian extinction caused the loss of so many species and changed the evolutionary landscape for the surviving species. This resulted in the explosion of speciation that appears very fast when viewed in geological time scale. The most famous Cretaceous – Paleogene (KPg) extinction event was similarly followed by outbreak of mammalian speciation, as small mammals that survived the extinction radiate and fill niches left open up by the dinosaurs. Without this event, the direction of evolution of mammals would certainly look very distinctive.

SAQ 3

Fill in the blanks:

i) A relatively sudden, global decrease in the diversity of life forms within a short period of geological time is …….. .

ii) Every mass extinction is followed by …… .

16.6 BIG FIVE MASS EXTINCTIONS

Mass extinctions are very mysterious phenomena. According to the scientists, when a great number of species go extinct simultaneously, at the same time, something traumatic must have happened during the ancient past environment. Thus, they identify mass extinctions by tracking the life spans of species through the fossil record. Mass extinctions were not at all instantaneous but were really a combination of a number of large scale extinction events that would have occurred within a relatively short span of time (which in geologic past could mean a few hundred thousand years) leaving devastating effects.

There have been five episodes of natural mass extinction in the fossil record. During each of the five episodes of natural mass extinction a large percentage of species disappeared (Table 16.2). A sixth episode, beginning around 30,000 years ago up to the present time, incorporates the effects of hunting and habitat loss as human populations have spread across the continents (explained in Sixth Extinction).

Table 16.2: Periods of Extinction and their respective effects.

Period of Extinction	Millions of years ago (mya)	Losses	Type of Life Effected
Ordovician-Silurian	439	85% of all species	corals, trilobites, branchiopods, echinoderms and similar marine organisms

Devonian	360	75% of all species	corals, brachiopods, bryozoans, ammonoids fish, placoderms, acanthodians and agnathans
Permian-Triassic	251	96% of all species	trilobites, molluscs, brachiopods and many vertebrates
Triassic-Jurassic	205	95 percent of marine species and more than 70 percent of terrestrial ones	Molluscs, sponges, marine vertebrates, large amphibians
Cretaceous–Paleogene	65	75% of all species	Ammonites, marine reptiles, dinosaurs, microscopic marine planktons, bivalves and echinoderms

Many minor extinctions have occurred through the Earth's history.

16.6.1 The Ordovician-Silurian Extinction

The very first mass extinction in Earth's history was the Ordovician-Silurian Extinction about 439 million years ago(mya). In fact, the Ordovician-Silurian extinction was the second most devastating mass extinction in the eartht's history. This extinction event ocurred during the Hirnantian Age of Ordovician Period followed by Rhuddanian Age of the Silurian Period. The end-Ordovician extinction is generally characterized by two factors: the first phase of extinction is widely known to have occurred due to rapid cooling at the end of the Ordovician Period, and the second phase as caused by the sea-level fall associated with the glaciation. The drop in sea level would have caused the draining of the large epicontinental seas and subsequent reduction in the available habitat for organisms living in these areas. There are no records that would suggest a collision (meteorite or comet) impact like the one identified at the end of the Cretaceous Period as no concentration of iridium has been identified near the extinction. Considering that much of the flora and fauna of that time was adapted to shallow, warm waters, this was really devastating. These species were not able to tolerate the colder, deeper oceans and many were diminished. Almost 85% of the species on the earth went extinct such as corals, trilobites, and similar marine organisms. It was so bad that over 100 families went completely extinct, including about 1/3 of all families in the phylum *Brachiopoda* (animals that created many of the seashells of the ancient world).

Scientists earlier believed that the mass extinction was caused by an ice age which happened when one of the four supercontinents – Gondwana moved to the South Pole. While ice age is still one of the most popularly accepted theories for this mass extinction event, there are other theories also. According to one other theory, a sudden burst of gamma rays triggered the extinction.

There was a ten-second burst that left the earth's atmosphere bare of almost half of its ozone instantaneously, exposing most of the organisms to high levels of UV radiation. But volcanism and weathering were considered to be the final possible climatic causes that would have led for the extinction.

According to a new hypothesis, galactic Bow Shock (a bow shock forms when material in front of a moving object is compressed) event may also be a possible cause of the Ordovician-Silurian extinction. Our Milky Way galaxy moving at a rapid pace through space, may compress the intergalactic gas in front of it. Once the Solar System is out of the protective magnetic field of the galaxy, it becomes exposed to the cosmic rays that are caused by Bow Shock created by the Milky Way. Thus, it is possible that radiations from galactic Bow Shock could have caused the Ordovician mass extinction with deadly radiations causing DNA damage and genetic mutations that would have wiped out more than 60% of life forms on the earth.

16.6.2 The Devonian Extinction

The Late Devonian extinction that took place approximately 360 million years ago is a complex and poorly understood. Another global cooling trend and lowering sea levels led to the **Devonian extinction**, when about 75% of all species went extinct. The impact of an extraterrestrial body such as a comet has also been considered as one of the possible cause. Tropical species that lived in shallow seas were the most affected. Particularly most affected were bryozoans, ammonoids, corals, brachiopods and fish. Marine animals were hard hit though freshwater fish were barely affected. Placoderms, acanthodians and almost all agnathans were not able to survive and vanished once for all. The Late Devonian mass extinction is considered to be a prolonged marine biotic crisis extending for 20-25 million years (late Middle Devonian to the Devonian/Carboniferous boundary) and punctuated by 8-10 extinction events. The two most extensive extinction events are to be the Kellwasser Event (at the Frasnian-Famennian boundry) and the Hangeberg Event (at or near the Devonian-Carboniferous boundry). One of the most interesting theories of the Devonian extinction is the "Devonian Plant Hypothesis". The theory, first proposed by Thomas Algeo, Robert Berner, J. Barry Manard and Stephen Scheckler in 1995, acclaimed the spread of land plants as the eventual cause for mass extinctions in the tropical oceans.

16.6.3 The Permian-Triassic Extinction

The next mass extinction occurred 251 million years ago, right at the border between the Permian and Triassic periods when life nearly ended entirely. According to Douglas Erwin it is the "Mother of Mass Extinctions". About 150 years ago, John Phillips used this extinction to define the end of the Paleozoic Era and the beginning of the Mesozoic. The Permian-Triassic extinction is also known as the "Great Dying," because 96% of all species on the planet wiped out and over 50% of all families of living things. Every living thing that have existed in the last 250 million years evolved from the 4% of life that survived. This extinction hit plants, terrestrial animals, marine animals, and even bacteria so badly that it has rewritten earth's evolutionary history. This period led to the extinction of trilobites, molluscs, brachiopods and many vertebrates. The insects suffered the only mass extinction of their history.

The Permo-Triassic (PT) extinction is a major watershed in the history of life on the earth, especially for life in the ocean. The event was complex and spread over millions of years, with at least two separate phases of extinction. Various explanations have been put forth for this extinction event such as asteroid impact, flood basalt eruptions, methane release, decrease in oxygen levels, disturbances in sea level or a combination of some of the above activities. Current causes of Permian extinction events were aimed at the biological and physical causes of disturbing the biological nutrient cycles. The studies of oxygen isotopes and the proportions of calcium to magnesium in the fossil shell materials from Permian era were the basis of the hypothesis as regards temperature crisis in the shallow marine (surface) waters. According to several studies differences in the carbon isotope record may give an indication of a disturbed biological cycle.

While there are several hypotheses, the leading explanation is that a piece of the planet's core burnt its way to the surface and exploded into massive volcanic eruptions that lasted a million years. The outcome was disturbances in weather patterns, consequential global warming, acid rains etc that would have been really catastrophic for the living organisms having air, water, and sunlight requirements. A sudden increase in methane due to methane producing microbes in the atmosphere is thought to have resulted in warming temperatures, ocean acidification, and other changes to the carbon cycle. According to the other hypothesis, the warming and drying of the land environments during the Permian Period decreased the amount of organic matter buried in sediments as coal or petroleum, which disturbed the amount of organically fixed carbon dioxide recycling through the atmosphere.

16.6.4 The Triassic-Jurassic Extinction

The Triassic-Jurassic extinction, also known as **End-Triassic extinction** occurred 205 million years ago. Out of the five major extinctions, **End-Triassic extinction** ranks fourth in the severity. This mass extinction event spread over 18 million years and was a combination of smaller mass extinction periods (two or three phases of extinction). This mass extinction vacated terrestrial ecological niches, which allowed dinosaurs to become dominant. Thus, this period drove the evolution of dinosaurs.

There are several different hypotheses such as climate change, flood basalt eruptions and an asteroid impact as a reason for the loss of life during this extinction. It is quite likely that some massive disturbance, such as widespread volcanic eruptions (perhaps from the breakup of the supercontinent Pangaea), a collision with an asteroid, or both, would have caused the dramatic change in the Earth’s climate that could have resulted in the end of so many species.

The exact number of species killed in this event is unknown, but very high. It eliminated more than 95 percent of marine species and more than 70 percent of terrestrial ones, it did result in drastic reductions of some living populations. Most of the dominant vertebrates were killed off in this era of rapid warming. The creatures left standing were the archosaurs, ancestors of the dinosaurs. Roughly half of all the species alive at the time such as molluscs, sponges, marine vertebrates, and large amphibians became extinct. Strangely, plants were not so badly affected.

16.6.5 Cretaceous–Paleogene Extinction

Cretaceous–Tertiary extinction (K–T extinction) is also known as **K–Pg extinction** or **Cretaceous–Paleogene extinction**. This extinction is responsible for knocking out approximately 80 percent of all species of animals. This occurred at or very close to the boundary between the Cretaceous and Paleogene periods, about 66 million years ago. This extinction is perhaps the most well-known of the big five mass extinctions as the end of the Cretaceous-Paleogene brought on the extinction of dinosaurs. Many other species of ammonites, marine reptiles, microscopic marine planktons, bivalves and echinoderms among other groups of animals, also went extinct. The absence of food and requirement of breathing oxygen affected mostly the largest animals, like the land dwelling dinosaurs. Smaller animals that require less oxygen and were able to store food survived the unfavourable conditions and then could flourish after the extreme conditions that had passed. This event effectively ended 75% of life on the earth but allowed for the evolution of mammals on the land and sharks in the sea.

A combination of volcanic activity, asteroid impact, and climate change are some of the causes of this extinction.The impacts of extremely large asteroids are considered to be the most important cause of the fifth mass extinction. High levels of iridium was found as an evidence in the layers of rock that is very commonly present in asteroids, comets, and meteors. This layer of rock is also called the **K-T boundary**. The K-T impact crater,one of the largest impact structures identified so far is a 180 km, roughly egg-shaped geological structure called Chicxulub that would have been deeply buried under the sediments of the Yucatán Peninsula of Mexico.

Try to attempt the following SAQ before proceeding further.

SAQ 4

i) Which mass extinction is known as “Mother of Mass Extinctions"/Great Dying?

ii) Which was the very first mass extinction in Earth's history about 439 million years ago (mya)?

16.7 SIXTH EXTINCTION

There are several records of extinctions that occurred in our geological past and most of them were caused by natural catastrophe such as volcanic activity and collision comets. But the Earth is in the middle of a sixth mass extinction today. The current fate of Bluefin Tuna, Rhinos, Tigers and Gorillas is not natural. Species are disappearing at an alarming rate. The sixth extinction is anticipated to be the most destructive extinction event ever since the occurring of asteroid impact that eliminated out the dinosaurs once forever. In the past, the rate of extinction and the rate of evolution of new life forms were completely balanced owing to the subsistence of the biological cycle and balance of the ecosystem. But this balance has been disturbed with the advent of the human race. The current rates of extinction are 1000 times faster than the natural rate and therefore, it has become difficult for the biological cycle to keep up with the pace.

The Sixth Extinction is also called the Anthropocene, or Age of Man extinction since it is being caused by the human race (Fig. 16.2). Loss of habitat, over-hunting, pollution,climate change and genetic mutations are being credited as the major causes of this mass extinction which has been named the Holocene Extinction. Human actions like increasing temperatures, introduction of exotic species and simplification of land forms are causing homogenization of global faunas which if left unchecked, could ultimately lead to the elimination of whole lines of phyla. Our current extinction crisis is exclusive in Earth's history according to geologists and biologists due to its some unique features:

1) Spread of non-native species all over the earth.

2) Single species (human beings) taking over an important proportion of the earth's primary production (25 to 40% of the planet's net primary production)

3) Evolution increasingly directed by human actions resulting in the growth of something called the technosphere.

4) Humans have become the top predator both on land as well as across the sea.

The impacts of a still-avoidable sixth mass extinction would be catastrophic, widespread and, of course, irreversible. The destruction of flora and fauna will have serious ecological, economic and social consequences. Scientists give an example of the lions that were once distributed over most of the Africa, southern Europe, and the Middle East, all the way to north-western India. The vast majority of lion populations have been wiped out today which is a matter of great concern for all of us. The new study that has generated so much conversation estimates that as many as three-quarters of animal species could be extinct within several human lifetimes (Fig. 16.2).

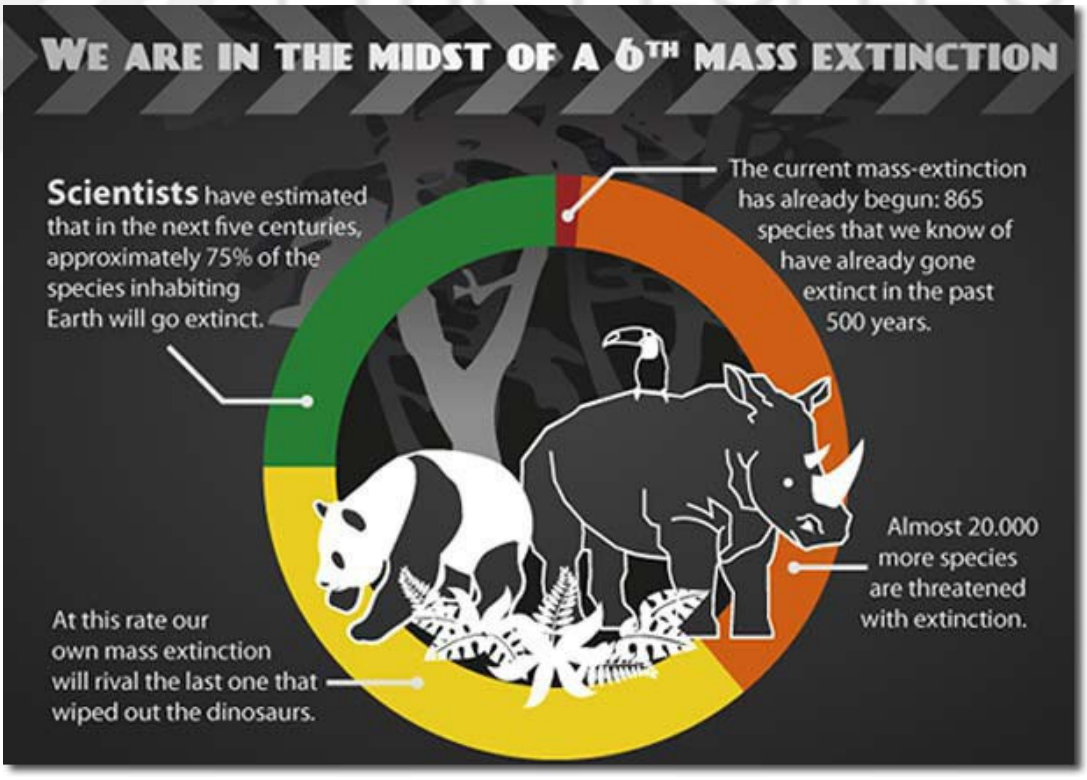

Fig. 16.2: Sixth Extinction.

16.8 ROLE OF EXTINCTION IN EVOLUTION

Evolution and extinction are mutually exclusive but go hand in hand with one another. The one, in a sense, “needs” the other. Extinction cannot occur unless evolution had already produced organisms that could meat of the ultimate fate. One can’t understand evolution, really, without understanding extinction. And you can’t understand extinction without first grasping ecology: the rules that govern how organisms of different species live in the same ecosystems, and control system determining the number of organisms, and number of different species living in any given specific habitat area.

Mass extinctions reduce drastically the diversity of the species by destroying the specific lineages and also their descendent species. But mass extinction can also play an imaginative role in evolution. On one hand it cuts the branches of a tree but on the other hand, it can also stimulate the growth of other branches. The elimination of plants and animals in a short span of time, occupying a particular habitat creates freedom, reduce competition for resources and increase new resources for remaining species. Over the period of natural selection, these lineages and their daughter lineages may evolve specializations and adapt themselves to the never opportunities taking the place of previous species in the ecosystem, or may evolve different, new ecological strategies. Thus, mass extinction allows lineages having minor roles earlier to spread and diversify to become more extensive. The surviving lineages are able to fill the vacant niches left behind by mass extinctions. For example, mammals occupied a small group of rodents-like organisms most of that time, even though they are present for more than 200 million years. In the end-Cretaceous mass extinction occurred, when dinosaurs went extinct 65 million years ago, mammals were able to get diversified and in less than 20 million years, they evolved into the great variety of mammals.

Our present understanding of the role of extinction in evolution is appallingly meagre. Extinction apparently comprises three main components:

(i) The species, geographically widespread can only go extinct when the stress is beyond the experience of the species, and thus outside the reach of natural selection.

(ii) The largest mass extinctions result in reconstitution of the environment wherein minor groups are allowed to expand and diversify, eliminating some of the successful groups.

(iii) It is unpredictable, in fact, that which species will be victimised due to an extinction event. Except for a few cases, there is very little evidence of extinction being selective in the positive.

Extinction was a crucial part of the theory given by Charles Darwin, the grand father of evolution, (1861) in *Origin of Species*. He wrote, “So profound is our ignorance, and so high our presumption, that we marvel when we hear of the extinction of an organic being; and as we do not see the cause we invent cataclysms to destroy the world, or invent laws on the duration of the forms of life!” Special importance was attached to extinction by Darwin keeping in view the same number of species getting extinctions in the history of life as the number of new species originate. An evolutionary biologist cannot ignore

extinction as the present day biodiversity is the result of cumulative accumulation of all those that originate. The same selective pressures that forces some species to go extinct, drives others to adapt and evolve. The end-Permian event wiped out many of the dominating species and allowed new groups to evolve, including the earliest dinosaurs, crocodiles and relatives of mammals and lizards. Similarly, the end-Triassic event then again eliminated many prominent groups, and set the environment suitable for the dinosaurs to take over.

Extinction event (of a single species, or perhaps a few of species) cause changes in the ecosystem of the remaining species, sometimes influencing their reproduction ability also. The extinction of one species in competition might give an opportunity to the other species to increase in number. At the same time, there may be a decrease in the number of other species also owing extinction.

SAQ 5

i) What is the number one cause of Sixth Extinction?

ii) The extinction of species is not normally considered an important element of…… theory, in contrast to the opposite phenomenon, speciation.

16.9 SUMMARY

In this unit we have learnt that:

- Extinction is a natural process. Extinction is quite simply the 'death' of a taxon. But it is not only the disappearance of single specie but it is also the effects of its disappearance to the environment that it interacts with.
- Pseudoextinction of a species occurs when all the members of the species are extinct but members of daughter species are alive. There are three types of pseudoextinction.
- Extinction is a normal process but human-mediated extinctions rates have soared over the past few hundred years. The climate change, disease, spread of invasive species; extermination, ecological imbalance etc. are the natural factors causing a species to become extinct. Overexploitation, pollution and loss of habitat are man-made causes of extinction.
- The two types of extinctions are background extinction and mass extinction. Background extinction is a natural regular event in the process of evolution. It is **caused by the poor adaptation to the ongoing changes in the environment and** the rate of the background extinction is steady over geological time. A mass extinction is a relatively sudden, global decrease in the diversity of life forms within a short period of geological time.

- Destruction of biodiversity due to extinction is incomprehensible, but this destruction, however, is not the whole story. Every mass extinction was followed by speciation.
- Mass extinctions are very mysterious phenomena. Mass extinctions were not at all instantaneous but really a combination of a number of large scale extinction events that occurred within a relatively short span of time (which in geologic time could mean a few hundred thousand years) leaving devastating effects.
- There have been five episodes of natural mass extinctions in the fossil record- Ordovician-Silurian, Devonian, Permian-Triassic, Triassic-Jurassic and Cretaceous–Paleogene extinction.
- The Sixth/Holocene Extinction is also called the Anthropocene, or Age of Man extinction since it is directly linked to human evolvement to the changes of the planet. Humans have become the top predator both on land and across the sea. The impacts of a still-avoidable sixth mass extinction would be catastrophic, widespread and, of course, irreversible.
- Evolution and extinction go hand in hand together. The one, in a sense, "needs" the other. Extinction cannot occur unless evolution had already produced organisms that could suffer that ultimate fate.

16.10 TERMINAL QUESTIONS

1. Explain the similarities and differences between background and mass extinction.
2. How did mammals survive the Triassic inspite of their smaller size?
3. Explain the phenomenon of Pseudo extinction along with its three types.
4. Discuss the role of human beings in Sixth Extinction?
5. Explain the role of extinction in evolution with examples?

16.11 ANSWERS

Self Assessment Questions

1. i) Pseudoextinction; ii) Georges Cuvier.
2. i) A meteor impact on the Yucatan peninsula in Mexico.
   ii) Biomagnification.
3. i) Mass Extinction, ii) Speciation.
4. i) The Permian-Triassic Extinction.
   ii) The Ordovician-Silurian Extinction.
5. i) Human Race, ii) Neodarwinian.

Terminal Questions

1. Refer to Sub Section 16.4.1.
2. Refer to Sub Section 16.5.4.
3. Refer to Sub Section 16.2.1
4. Refer to Section 16.6.
5. Refer to Section 16.7.

SUGGESTED READINGS

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9. The Sixth Extinction: An Unnatural History by Elizabeth Kolbertpublished by Henry Holt & Company, 2015
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ONLINE TOOLS AND WEB RESOURCES

- https://www.coursera.org/learn/molecular-evolution.
- https://www.coursera.org/learn/genetics-evolution.
- https://swayam.gov.in/courses/4062-environmental-biology-genetics-and-evolution.

GLOSSARY

Adaptive radiation : The tendency of successful species to diversify into all types of ecological niches.

Allopatry : Organisms belonging to same species are separated by space and occupy different territories.

Carrying capacity : The capacity of the environment to sustain and optimal population size.

Coevolution : Simultaneous evolution of two or more ecologically related species.

Endemic : Refers to organisms which are narrowly restricted in their distribution.

Fossil : Petrified remains of the organisms of the past.

Genetic drift : Changes in gene frequency in small populations because of random processes.

Group selection : A selection which aims the extinction of certain populations so that other populations could be propagated. This concept of selection suggests that populations in the unit of selection and not the individual.

Huntington's chorea : A rare hereditary disease affecting brain resulting in choreiform (dance like) movement, intellectual deterioration and psychosis.

Hybrid sterility : The sterility of the offsprings of the interspecific crosses.

Interspecific sterility : Failure in mating because of the inability of the sperm of one species to reach the egg of another species in animals and that of pollen to reach the ovules in plants.

Kin selection : Selection favouring the altruistic behaviour of an individual towards its own relatives or individuals having some of its own gene.

Palaeontology : The study of the life of the past through fossil records.

Pangenesis : A theory of inheritance proposed by Darwin according to which all organs in the body produce pangenes, that is minute particles that are carried away by the blood stream and segregated out into gametes.

Peripatry : Populations living in isolation at the peripheral territory of a parent population.

Post-mating isolating mechanism : The isolating mechanism taking effect after mating.

Pre-mating isolating mechanism : The isolating mechanism taking effect before mating.

Radioactive dating : Determining the age of geological deposits and fossils based on the rate of decay of radioactive elements.

Rassenkreis : The mechanism by which a sub-species slowlv evolves and becomes a new species by geographical isolation.

Speciation : Formation of new species from parent population.

Stabilising selection : Natural selection which maintains a well-adapted condition by eliminating any marked deviations from it (it is also called normalising selection_.

Sympatry : Individuals belonging to a species living in the same area.

Ungulates : Hoofed mammals.