Cours « Anglais scientifique »

Master 1

Ecologie et environnement

Protection des écosystèmes

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Scientific English course (Ecology M1)

Chapter 01: English scientific writing

1-Sentenses

A sentence (Clause or phrase) is defined as a group of words that makes sense and expresses a complete thought. With at least one subject and one verb, clauses allow us to combine ideas to show their cohesion in speech and writing language.

1-2-Sentence Functions

There are four types of sentences by function (Meaning) in English language:

Declarative Sentence (statement)

Declarative sentences make a **statement**. They tell us something, give us information and normally end with a full-stop. The usual word order for the declarative sentence is:

- Subject + Verb...

Declarative sentences are the most common type of sentence and can be positive or negative. Examples:

positive	negative
I like coffee.	I do not like coffee.
We watched TV last night.	We did not watch TV last night.

Interrogative Sentence (question)

Interrogative sentences mark a **question**. They ask for information, and always end with a question mark (?). The usual word order for the interrogative sentence is:

- (*wh-word* +) auxiliary + subject + verb...

⇩

(why, who, when….etc)

Interrogative sentences can be positive or negative. Examples:

positive	negative
Do you like coffee?	Don't you like coffee?
Why did you go?	Why didn't you go?

Imperative Sentence (command)

Imperative sentences give a **command**. They tell us to do something, and end with a full-stop or exclamation mark (!).The usual word order for the imperative sentence is:

- Base verb...

Note that there is usually no subject, because the subject is understood, it is *YOU*. Imperative sentences give an order and can be positive or negative. Examples:

positive	negative
Stop!	Do not stop!
Give her coffee.	Don't give her coffee.

Exclamative Sentence (exclamation)

Exclamative sentences express strong emotion, an exclamation**,** and always end with an exclamation mark (!).The usual word order for the exclamative sentence is:

- *What* (+ adjective) + noun + subject + verb
- *How* (+ adjective/adverb) + subject + verb

Examples:

form	function	example
How!	make an exclamation	How silly I am.
What!		What a great car you have!

1-3- Scientific clause types:

- **Independent Clause:**

A simple sentence (Main clause) that expresses a complete thought and can be used alone **Examples**:

1. Earth is all living beings home.
2. Forests represent the most important source of oxygen.

- **Dependent Clause:**

An incomplete thought (Subordinate clause) that cannot stand by itself. A dependent clause is introduced by subordinating conjunction (**after, as, before, if, though, while, whose, unless, although, because, even though, since, when, until, which, so that……),** that connects its different parts in order to complete the meaning. **Examples**:

1. **If** you heat ice, it melts
2. Domestic animals never attack humans, **unless** it is self- defense.

2-Scientific paragraphs

One of the most important goals in scientific writing is communicating complex ideas clearly. Preparing a strong structural English paper means that the reader can get a clear idea of where the argument is going, merely by skimming down the first line of each paragraph. For this, we have to:

A- **Construct a strong, clear topic sentence.**

- Try to keep topic sentences simple.
- As a general rule, topic sentences should be clear enough that a reader can get the gist of your paper just by reading the first sentences of each paragraph.
- The topic sentence should identify the main point of your paragraph.
- Once you've written your paragraph, it's helpful to go back and check the meaning and the language.

B-Each paragraph should make one main point.

- In general, try to keep paragraphs between 3 and 5 sentences.
- If your paragraph is getting too long, it is probably making more than one main point, and it may be time to break it into two different topics.

C- Placing old information first and new information last.

- Example:

Farmers had been trying for the last years to provide optimal growing conditions for crops **(Old information)**, by using soil additives as agricultural limestone in order to adjust the pH level **(New information).**

3-Scientific article

A scientific article is a publication that supports a specific hypothesis and by which scientists communicate a significant portion of their experimentation. The scientific article must follow a uniformed structure with different parts that help readers to find expected information and analysis:

3-1-Structure of a scientific article:

Most journals use a conventional IMRD structure:

1. Title
2. Abstract
3. keywords
4. Introduction
5. Methods
6. Results
7. Discussion
8. References

- ***Title***

The title should reflect the topic to be presented in the scientific text and the scope of the paper. It should be very limited and specific in order to translate the clear information developed. Name and affiliation of authors must be placed under the title.

- ***Abstract***

A brief summary of the purpose that represents what the study is about and explains why it matters. It should provide a sentence or two of the study's background, a brief overview of the basic methods used, a summary of results, and a part interpretation of the data. In general, abstracts consist of only one paragraph with about 50-100 words that should globally state the goals and the main conclusions of the scientific experimentation.

- ***keywords***

A list a few words or phrases placed at the end of the abstract, which indicates the most important scientific concepts and terms in the abstract.

- ***Introduction***

This is where the authors sketch out the background of the study and explain the objectives of their investigation. It is important to have enough citations to develop and provide the arguments leading to the hypotheses tested.

The introduction section is a historical study including previous research relevant to the problem and gradually narrows to the specific topic addressed by the report.

- ***Methods***

This section describes what, when and how it is done from the site study location and the numbers of organisms used to the equipment, the procedures and all the techniques applied. Every chemical reaction, experimental design, statistical method and program must also be identified.

- ***Results***

In this section, simply results of the investigation are reported without long interpretation or elaboration. They must be organized into tables and figures with essential statistical information in order to be understood and compared. Tables and figures must be located after the text in which they are introduced. They must also be accompanied with a brief legend.

- ***Discussion***

This section discusses the results and comments on whether the argument research supports the original hypotheses or answers the research questions. During this section, the authors are asked to examine the results in the context of other published studies. It is important to explain how the study adds to or supports, existing knowledge. It's also important to mention future prospects in order to continue deeper researches in the studied domain.

- ***References***

The Bibliography section present all the references used in the paper for the different sections. It lists and indicates information and details concerning the sources used in the article. Most journals require authors to follow the journals' Instructions and to be up to date to recent issues of the journal.

3-2- How to study a scientific paper?

Scientific texts are those written papers that contain information about concepts, theories or other series of topics based on scientific knowledge, which is why they are written in a special technical language for the audience to which they are addressed.

The purpose of a scientific text is to inform, or to provide an explanation in a framework that holds all the different parts together. For analyzing scientific texts, we have to follow some steps and to answer the questions on the table below:

Table 01. Steps for analyzing scientific texts.

Reference details	Author: Title: Year: Other bibliographic details:	
Background	Why did they do this research?	
Research Aims	What were their questions?	
Research Method	How did they investigate the questions? (e.g. experiments, surveys)	
Data Collection	How did they collect their data? (e.g. soil samples, species counts, mapping)	
Data Analysis	What did they do with their data? How did they analyse the data?	
Results/Findings	What did they *expect* to find and what *did* they find?	
Discussion	How does this research contribute to the field?	
Conclusion	What recommendations are provided for future research?	

3-3-Plagiarism:

Plagiarism is a form of academic misconduct in which the authors represent someone else's phrases as their own. It is acceptable to incorporate someone else's idea in your paper only if you clearly indicate that the words are someone else's and this by putting them in quotation marks and citing the source (s). Plagiarism can be detected on two forms:

- **Plagiarism of words:** when authors present someone else's exact words as if they were their words without quotation marks or documentation.
- **Plagiarism of ideas**: If the authors put someone else's ideas into their own words and then present the ideas as theirs.

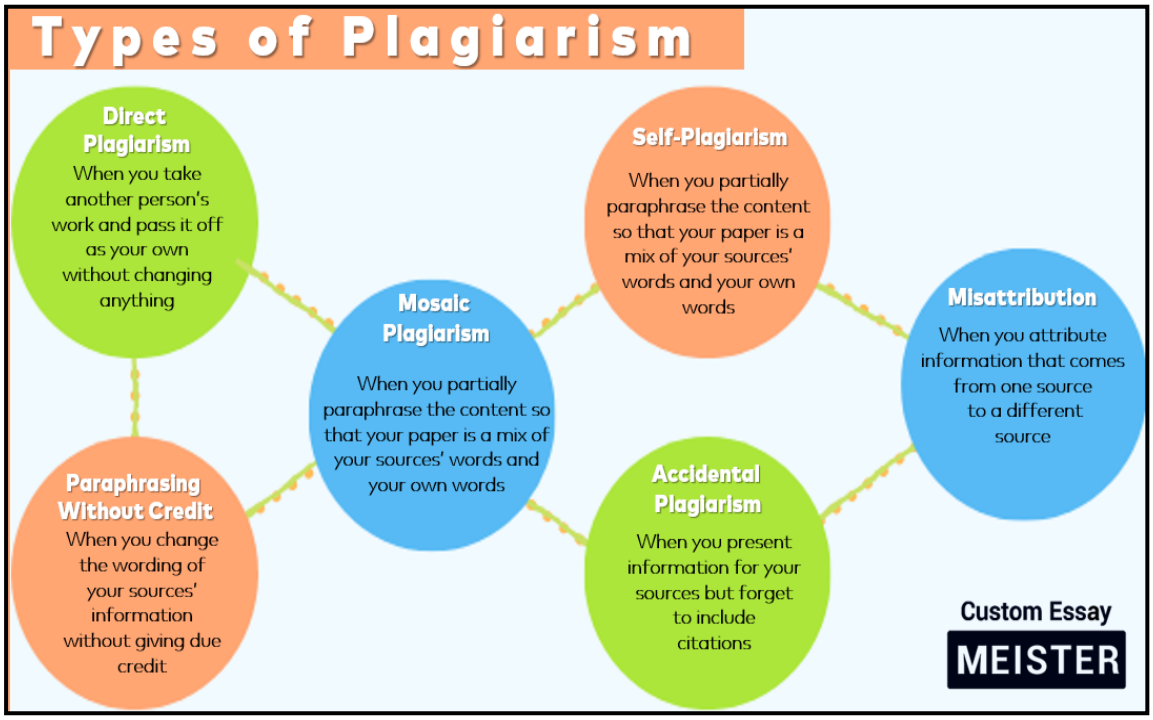


Figure 01. Different types of plagiarism

3-3-1-How do I avoid plagiarism?

The following simple three rules are effective to help any scientific writer to avoid plagiarism and use bibliography study correctly**:**

- **Think.** Think about your paper topic and the research you have done. Make sure you have actually thought about everything in your paper well enough to explain it in your own words.
- **Write.** Generate your own words to express your own understanding. Other people's words should always be a supplement, not a substitute, for your own writing.
- **Signal.** Clearly signal whenever you are using someone else's words, whether you are using them by direct quotation or paraphrase. Any direct quotation must be indicated by two things: quotation marks and a reference to the source.

Chapter 02: Introduction to Ecology (Principal concepts):

1-Organization of living being:

Levels of organization in ecology help scientists generally study the anthropogenic impact**,** energy flow and changes in population dynamics. Natural organisms can be studied at small or large levels:

- **Organism:** We focus at this level on the relationship of an individual organism with its abiotic environment (temperature, moisture, light, soil etc….)
- **Population:** A group of individuals of the same species in a specific area; ecologists are interested in the biotic and abiotic factors that affect a population's size and distribution.
- **Community:** It's about populations of different species in an area, with a focus on community structure, composition and the biotic interactions between these groups, such as predation and competition.
- **Ecosystem:** A community together with its function, which is the pools and fluxes of energy and matter within and between biotic and abiotic factors.
- **Ecoregion (Landscape):** Recurring patterns of ecosystems, associated with characteristic combinations of soil and landform. Ecosystems within an ecoregion are more similar to each other than to ecosystems elsewhere.
- **Biosphere:** It represents all of the Earth's organisms interacting with each other and the global environment.

Figure 01. Organization levels of living beings

2-Concept of Ecology:

The word **ecology** is derived from the greek "oikos" meaning house and "logos" meaning study (Study of the natural house of species). The word ecology is of recent origin having been first proposed by the German biologist **ERNST HAECKEL** in **1869;** as the study of organisms, populations, and communities, as they relate to one another and interact in the ecosystems they comprise.

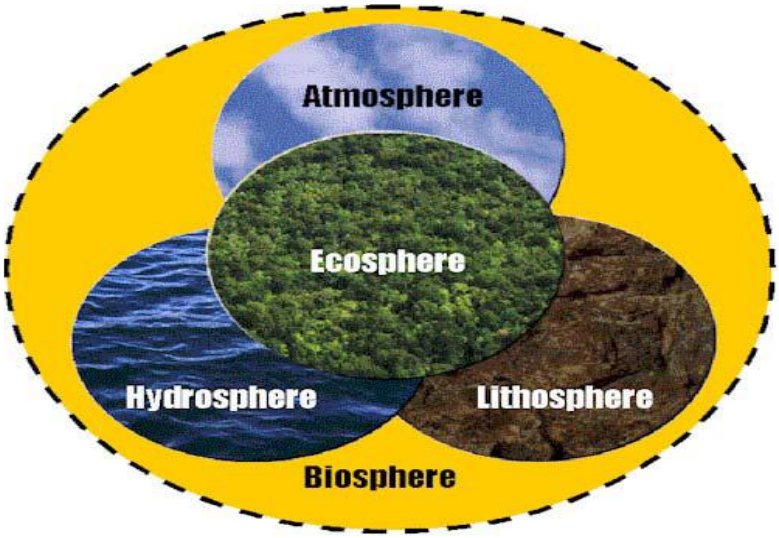


Figure 02. Position of the Ecosphere in the Biosphere

2-1-Types of Ecology:

According to the group of organisms to be studied, there are three types of Ecology:

- **Autecology or species ecology:**

It deals with the study of an individual species of organisms in its population. The ecologists study the behavior and adaptations of a particular species to the environmental condition at every stage of that individual's life cycle.

- **Demecology or Ecology of population:**

It includes the study of populations of different species with concern to birth rate, death rate, different factors affecting number, growth, and sizes of populations.

- **Synecology or Ecology of communities**:

It deals with the study of communities and Ecosystems, their composition, their behavior and their relation with the environment.

2-2- The main axes of ecology:

The study of Ecology deals with:

- The spatial distribution and abundance of organisms.
- The temporal changes in the occurrence, abundance and activities of organisms.
- The interrelations between organisms, communities and populations.
- The structural adaptation and functional adjustments of organisms to the change in environment.
- The behavior of organisms under natural environment.
- The productivity of organisms and energy to mankind.
- The development of interactive models for predictive purposes.

2-3- Concept of ecological niche:

The Niche is the set of biotic and abiotic conditions in which a species is able to persist and maintain stable population sizes. It is a complete description of how the organism relates to its physical and biological environment, as well as his principal role within a community, mainly translated by the variable behavior recorded at different seasons and different times of the same day.

2-4- Factors affecting an Ecosystem:

The structure of an ecosystem explains the relationship between the major abiotic and biotic components:

- Biotic (living) components.
- Abiotic (non living) components.

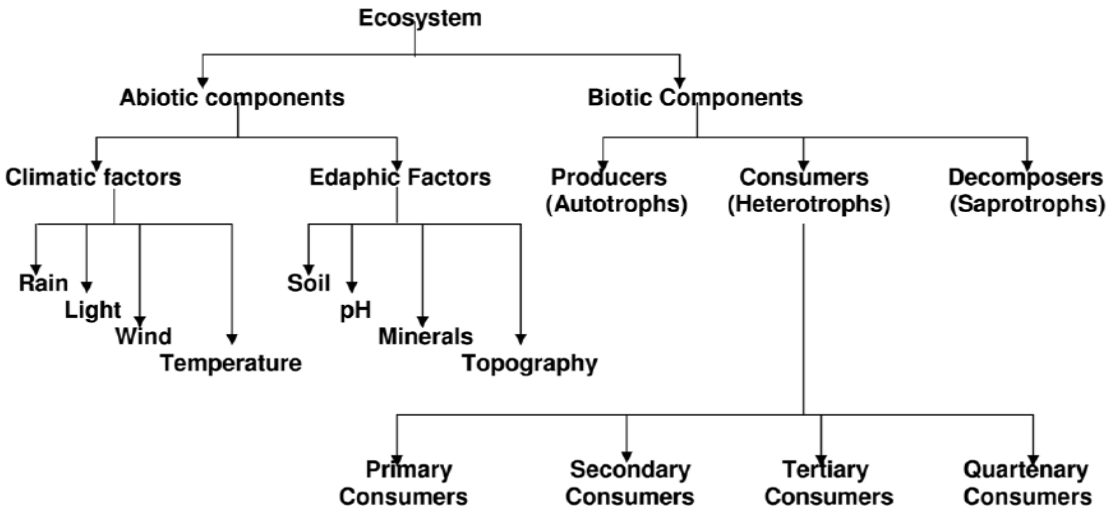


Figure 03. Biotic and Abiotic factors affecting an ecosystem.

2-4-1-Abiotic factors:

Abiotic factors are the non-living components of the ecosystem, including the chemical and physical factors, (light, radiation, temperature, water, chemicals, gases, wind and ph…..), present in the atmosphere, the hydrosphere, and the lithosphere. Without suitable abiotic factors, living organisms wouldn't be able to eat, to grow, to reproduce, and to exist.

2-4-2-Biotic factors:

They include interactions between organisms, like interspecific and inraspecific interactions (predation, parasitism, and competition among species……). In addition, living organisms themselves are biotic factors; they fall into three main categories: producers, consumers, and decomposers.

3-Energy Flow in Ecosystems:

Energy flows from the sun through ecosystems and from one organism to another. This energy cycles through ecosystems from producers to consumers and back into the nutrient pool through decomposers. Trophic levels describe the feeding levels of organisms.

3-1-Concept of food chain:

The food chain is a linear sequence of organisms where nutrients and energy are transferred from one organism to another organism. It begins with the producer, follows the chain with the consumers and ends with the decomposer organisms. After understanding the food chain, we realize how one organism is dependent upon another one for survival. Every food chain is consisted of:

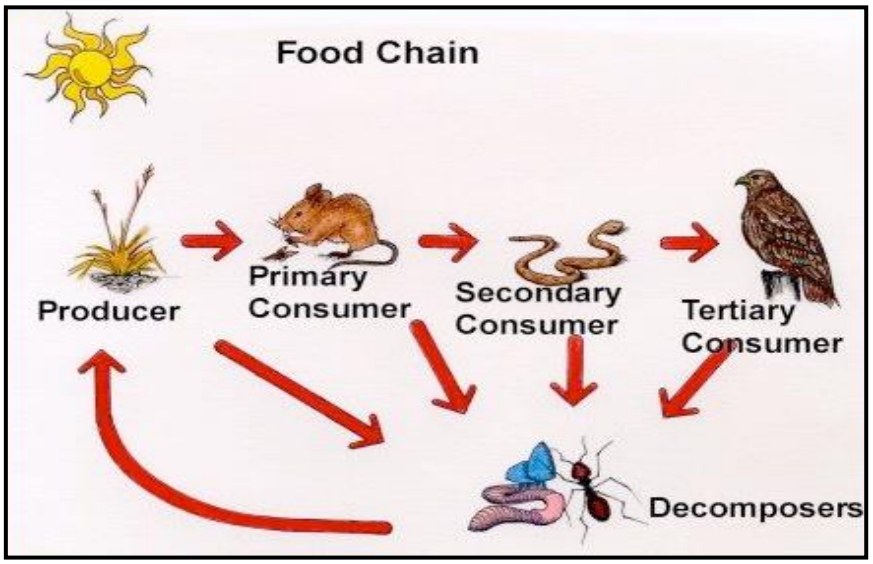


Figure 04. Example of a food chain.

- **Producers**

Producers are plants that produce, or create, their own food by using light energy from the sun, carbon dioxide from the air, and water from the soil. The process that makes them Autotrophs is called photosynthesis.

- **Consumers**

Animals are consumers. They cannot produce their own food, so they get their nutriments and their energy by consuming (eating) other plants and animals. There are 3 groups of consumers: carnivores, herbivores, and omnivores.

- **Decomposers**

Bacteria and fungi are decomposers. They eat dead plants and animals, break them down and decompose or dispose of them. When that happens, they release nutrients and minerals back into the soil, which are then used by plants during photosynthesis.

3-2-Concept of Food Webs:

A food web is made up of interconnected food chains. Most communities include various populations of producer organisms which are eaten by any number of consumer populations. The green crab, for example, is a consumer as well as a decomposer.

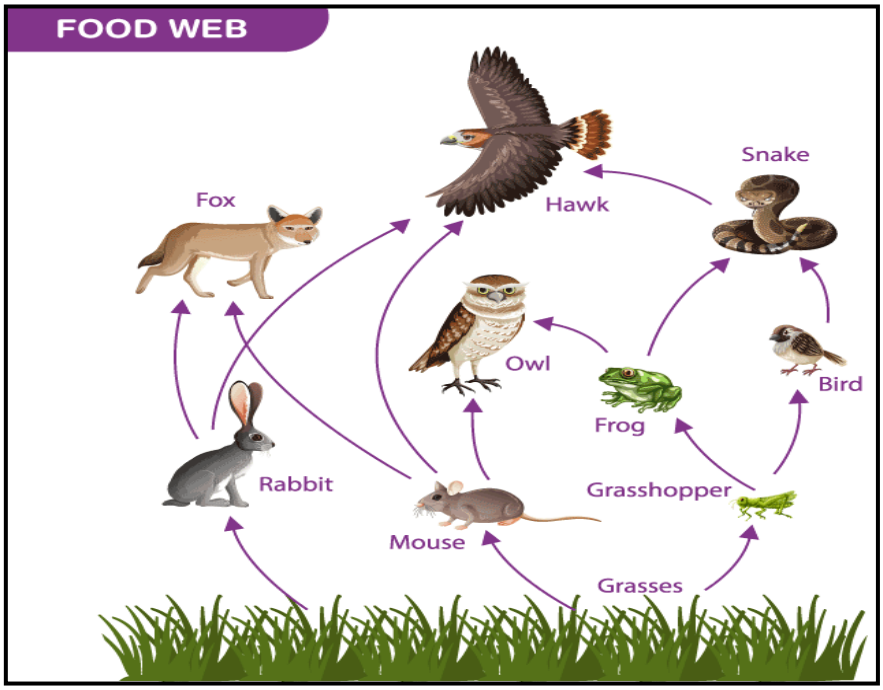


Figure 05. Example of a food web

3-3-Concept of Productivity in Ecology:

In ecology, productivity is the rate at which energy is added to organisms in the form of biomass. It is simply the amount of matter that's stored in the bodies of a group of organisms. Productivity can take units of either energy or biomass. There are two types of productivity in food chains:

3-3-1-Primary productivity:

Primary production in biology is different compared to primary productivity; it’s the amount of organic biomass produced in a given frame of time. Primary production is the amount while primary productivity is the rate. It can be estimated by:

- **The gross primary productivity** (**GPP)**: The rate at which solar energy is captured in sugar molecules during photosynthesis (per unit area per unit time). Producers such as plants use some of this energy for metabolisms as cellular respiration and some for growth (building tissues).
- **The net primary productivity** (**NPP)**: which is the gross primary productivity minus the rate of energy loss to metabolisms and maintenance (**RR**: Respiratory rate). In other words, it's the rate at which energy is stored as biomass by plants or other primary producers and made available to the consumers in the ecosystem.

$$\mathbf{NPP = GPP - RR}$$

3-3-2-Secondary productivity

It stands for the production of biomass from organic matter. The main conversion is of one form of organic molecules to some other form of organic molecules. It is performed by the "heterotrophs*"* production in the ecosystem; hence the productivity of human beings, and other animals.

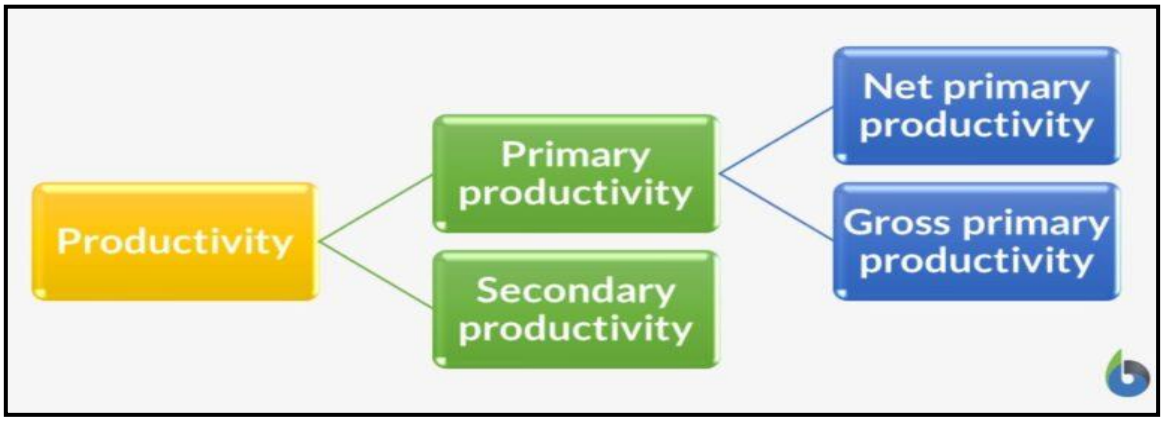


Figure 06. Flow of energy between Primary and secondary productivity

3-4-Energy pyramids

Ecological Pyramid is a graphical depiction which is meant to illustrate the relationship between different living organisms at different level in an ecosystem. Energy pyramid consists of horizontal bars showing specific trophic levels which are arranged sequentially from primary producer level through herbivores, and carnivores. The number, biomass and energy of organisms gradually decrease with each step from the producer level to consumer level and the diagrammatic representation takes a pyramid shape according to the following cases:

3-4-1-Pyramid of Numbers

Pyramids of number allow us to compare the number of organisms present in each trophic level at a particular time. They often show a reduction in number of organisms as you move along the food chain.

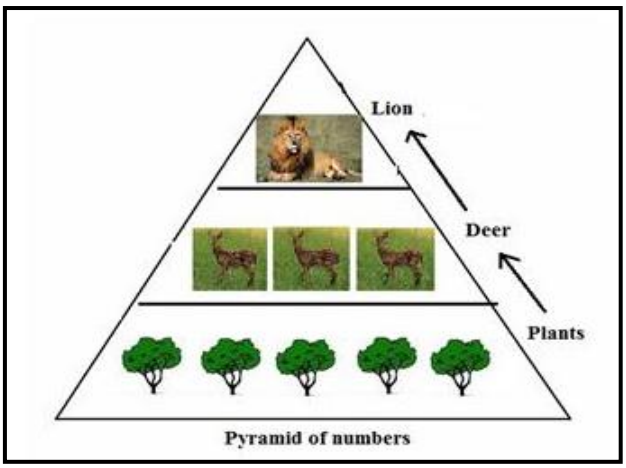


Figure 07. Pyramid of numbers

3-4-2- Pyramid of Biomass

Biomass is a measure of the total amount of living material present. Pyramid of biomass allows us to compare the mass of organisms present in each trophic level at a particular time. Biomass is a better way to measure the amount of living material in each trophic level if the organisms have different sizes.

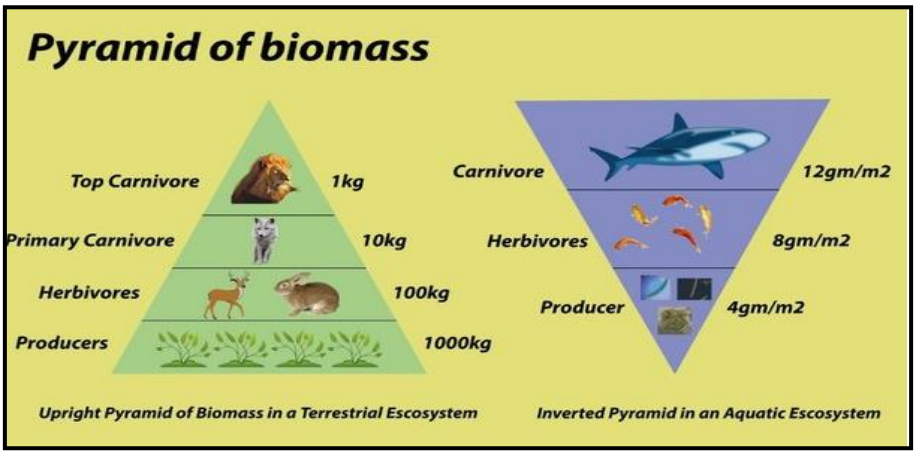


Figure 08. Pyramid of biomass

3-4-3- Pyramid of Energy

Pyramids of energy permit us to compare the amount of energy passing through each trophic level over a period of time. The energy value is calculated over the whole year, which allows for seasonal variations in all populations.

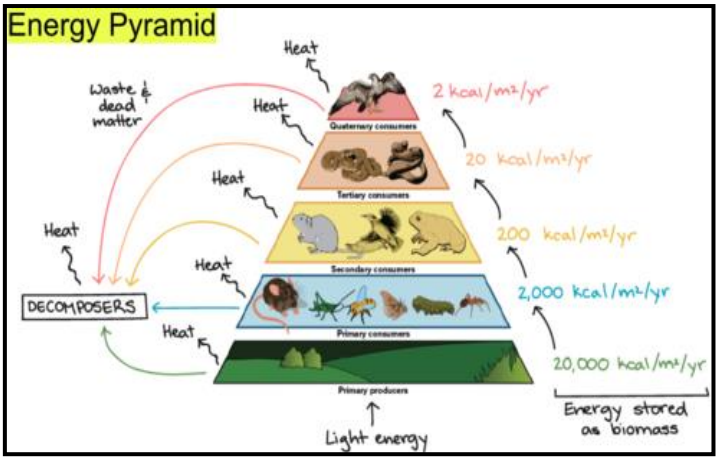


Figure 09. Pyramid of energy

4-Ecological interactions between living beings:

4-1-Concept of Interaction:

Living beings interaction is the effect that a pair of organisms living together in a community have on each other. This enables the balance of life in a specific community and other organisms to benefit from efforts and activities of every element in the ecosystem. Interactions can be:

4-1-1-Intraspecific interactions:

Interactions between individuals of the same species. They can be harmful, if they provoke competition for natural resources (Food, light, space) or reproduction. They can also be beneficial, if they favor cooperation between individuals:

- **Interaspecific competition**

A competition between members of the same species. Many animals have developed complex behaviors to minimize the potential impact of direct competition. For instance the maintenance of dominance hierarchies and territories through behavioral displays reduces fighting and the risk of injury.

Figure 10. Example of intraspecific competition

❖ **Group effect**

Groups can better defend themselves together, modify their environment and take down larger preys and more efficiently raise offspring. This positive effect provides the benefits of co-operative behaviors often outweigh the cost of increased competition.

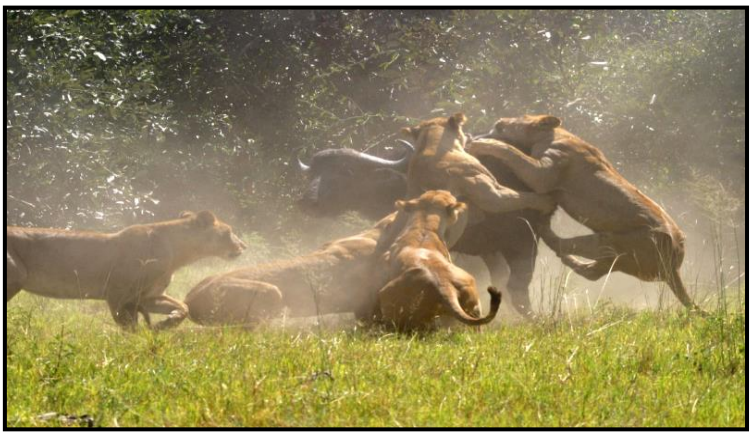


Figure 11. Example of group effect

❖ **Mass Effect**

It occurs when the environment is overpopulated and causes exacerbated competition with harmful consequences for individuals. This negative effect results in disturbances of populations, such as a drop in fertility rate, a reduction in the birth level, and an increase in mortality frequency.

Figure 12. Example of Mass effect

4-1-2-Interspecific interactions:

Interactions which are established between individuals of different species. They can be negative, neutral or positive relationships:

Table 01. Principal interspecific interactions in Ecology

SN. NO.	TYPES OF INTERATION	SPECIES 1	SPECIES 2	GENERAL NATUE OF INTERACTION	EXAMPLES
1	Amensalism	–	0	The most powerful animal or large organisms inhibits the growth of other lower organisms	Cat and Rat
2	Mutualism	+	+	Interaction favorable to both and obligatory	Between crocodile and bird
3	Commensalism	+	0	Population 1, the commensal benefits, while 2 the host is not affected	Sucker fish on shark
4	Competition	–	–	Direct inhibition of each species by the other	Birds compete with squirrels for nuts and seeds.
5	Parasitism	+	–	Population 1, the parasite, generally smaller than 2, the host	*Ascaris* and tapeworm in human digestive tract.
6	Predation	+	–	Population 1, the predator, generally larger than 2, the prey	Lion predatory on deer

Chapter 03: Biodiversity concepts

1-Biodiversity Definitions:

- The term "**Biodiversity"** was first invented by Edward Wilson in 1985, as the variety and the variability of living organisms taking in consideration the ecological complex ecosystems in which they exist.
- During the **Convention of biological diversity** (Rio De Janerio, Brazil) in 1992 and by the participation of 154 countries, the biodiversity was also defined as the variability among living organisms from all sources including inter alia, terrestrial, marine and other ecosystems besides the ecological complexes of which diversity variety includes diversity in species, between species and in ecosystems.
- Biodiversity is the variety of different forms of life on earth, including the different plants, animals, micro-organisms, the genes they contain and the ecosystem they form within an area, biome or planet.
- Relative to the range of habitats, biotic communities and ecological processes in the biosphere, biodiversity is vital in number of ways for living beings, and this by providing essential food, clean water, fuel, shelter, timber and medicine.

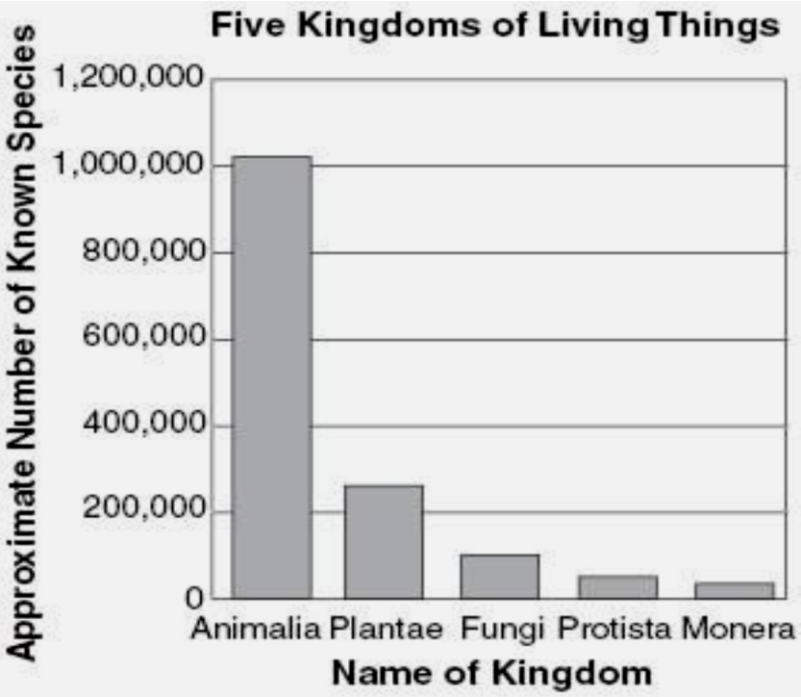


Figure 01. Biodiversity distribution on earth

2-Biodiversity types:

There are three levels of biodiversity namely; genetic diversity, species diversity and community or ecosystem diversity.

❖ **Genetic diversity:**

It describes the variation in number and types of genes and chromosomes present in different species. It also represents the genetic information contained in all of the individual plants, animals and microorganisms occurring within populations of species. Simply it is the variation of genes within organisms and populations. The genetic variation arises by mutation in **AND sequences** which helps the evolution of new species; the adaptation to changes in environmental conditions; and the improvement in agricultural productivity.

❖ **Species diversity:**

It indicates the variety in number and **richness** of different species within a region. This diversity refers to the total count of species in a defined area (Species Abundance**)** and to the relative numbers among species (Rate). The concept of species richness doesn't only inform about the extent of biodiversity in a specific site, but also provides means for comparing different ecological areas. If all the species have the same equal abundance, this means that variation is high in diversity, however if one species represents a high abundance comparing to other populations, that indicates a low diversity level (Concept of dominance).

❖ **Ecosystem diversity:**

This relates to the variety of habitats, biotic communities and ecological processes in the biosphere. It describes the assemblage and interaction of species living together at a physical environment in a given area. The ecosystem diversity is due to variability of niches, trophic levels and different ecological processes including nutrient cycling, food webs, energy flow and various related biotic interactions. The terrestrial biodiversity of our planet tends to be highest near the equator, which is the result of the warm climate and high primary productivity, while the Marine variability tends to be highest along coasts in the western pacific, and the mid-latitudinal band of oceans, where sea surface temperature is the highest.

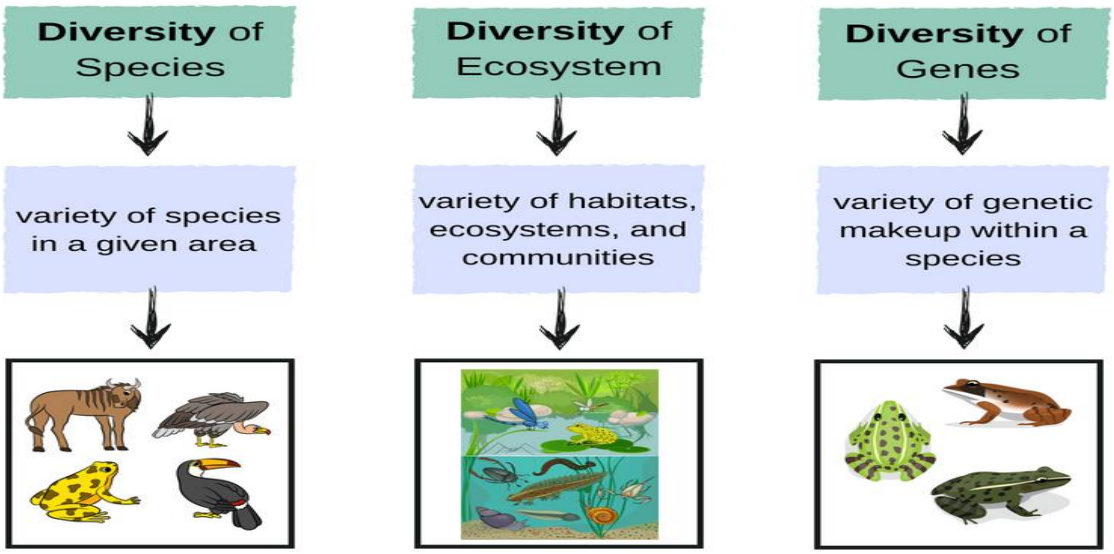


Figure 02. Biodiversity types

3-Biodiversity axes:

The study of biodiversity deals with:

- The Protection of water resources and natural species.
- The soil formation, protection and maintenance of fertility projects.
- The nutrient storage and cycling processes.
- The degradation of waste, pollution breakdown and absorption analyzes.
- The biological productivity study.
- The carbon sequestration operation and regulation of global climate.
- The control of potential pest and diseases causing species extinction.
- The detoxification of soil and sediments, stabilization of lands against erosion and pollution.

4-Biodiversity loss:

It refers to the decline or disappearance of biological diversity. Biodiversity loss happens when various species disappear completely from earth (**extinction**), or when there is a decrease in species populations in a specific area, what globally leads to reduction in biological diversity. In 2019, the United Nations (UN), in collaboration with the intergovernmental science-policy platform on biodiversity and ecosystem services (IPBES) report that out of a total of eight millions, one million species are in danger of extinction.

Year	Population	Land area converted for human use	Loss of species in ecosystems
1800	0.9 billion	7.6 %	-1.8 %
1900	1.7 billion	16.9 %	-4.9 %
2000	6.1 billion	39.3 %	-13.6 %
2100 Green model	8.7 billion	33.4 %	-11.6 %
2100 Current model	12 billion	49.1 %	-17 %

Figure 03. Biodirversity losses rhythm

4-1-Concept of species extinction:

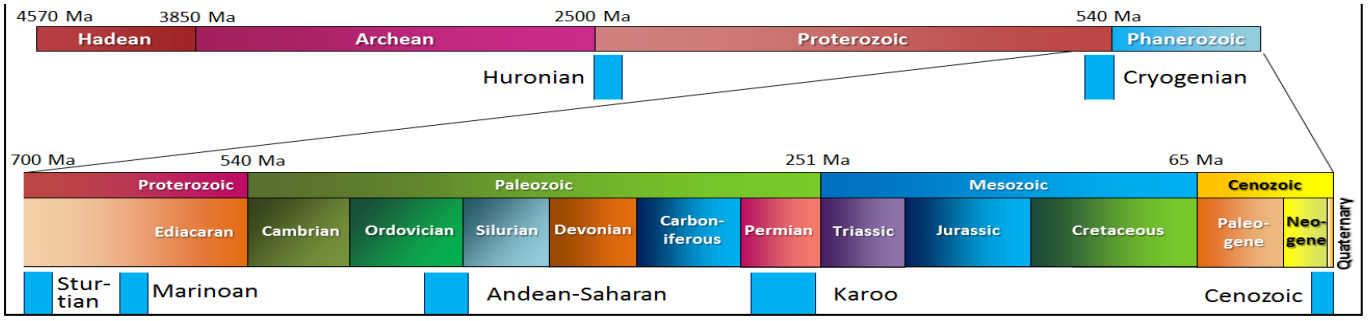
A species is said to be extinct when it no longer lives anywhere on the planet. Extinction occurs when the last members of a species die because they cannot acquire food**,** water, shelter, and necessary space to survive. The decrease in population size that typically precedes extinction can be due to environmental change, predation, diseases or extreme climatic events.

4-2- Major Five Extinction events:

Paleontologists have identified five major extinction events in geological history of sudden and dramatic losses in biodiversity (542 million years ago), with more than half of all extant species disappearing from the fossil record generally because of some extreme historical events (Intense glacial catastrophe; Sequestration of CO2; Intense volcanic activity; Asteroid impact). These five events are called mass extinctions:

Table 01: Major mass extinction events and their position in total earth geological history

Extinction Event	Age ($x10^6$ years)	Families (%)	Genera (%)	Species (%)
End Cretaceous	65.0	16–17	47–50	76 ± 5
End Triassic	200.0–220.0	22–23	48–53	80 ± 4
End Permian	245.0–251.0	51–57	82–84	95 ± 2
Late Devonian	360.0–370.0	19–22	50–57	83 ± 4
End Ordovician	435.0–444.0	26–27	57–60	85 ± 3



4-3- The 6th extinction crisis

The sixth mass extinction is driven by human activity, primarily by the unsustainable use of land, water, energy, and climate change. Currently, 40% of all land has been converted for food production; Agriculture is also responsible for 90% of global deforestation and accounts for 70% of the planet's freshwater use. Biodiversity loss is caused by several natural and anthropogenic factors, which globally leads to dangerous consequences on living being health, and harms environment, ecosystems and natural resources:

4-3-1- Causes of biodiversity loss

- Destruction of natural habitats (deforestation, agriculture, intensive mono-culture, urbanization).
- Direct exploitation such as hunting and over-fishing.
- Climate change.
- Pollution (Industrial emissions, organic fertilizers and domestic residues).
- Invasive species and genetic pollution.
- Wildfire, floods, and volcanic eruptions.
- Ocean acidification.

4-3-2- Consequences of biodiversity loss

- Extinction of species
- Loss of ecosystems stability and decline in ecosystems services (soil, water and food chains)
- Proliferation of pests (damages in crops productivity)
- Increase in CO_2 emissions.
- Increas in zoonotic disease transmission to humans.

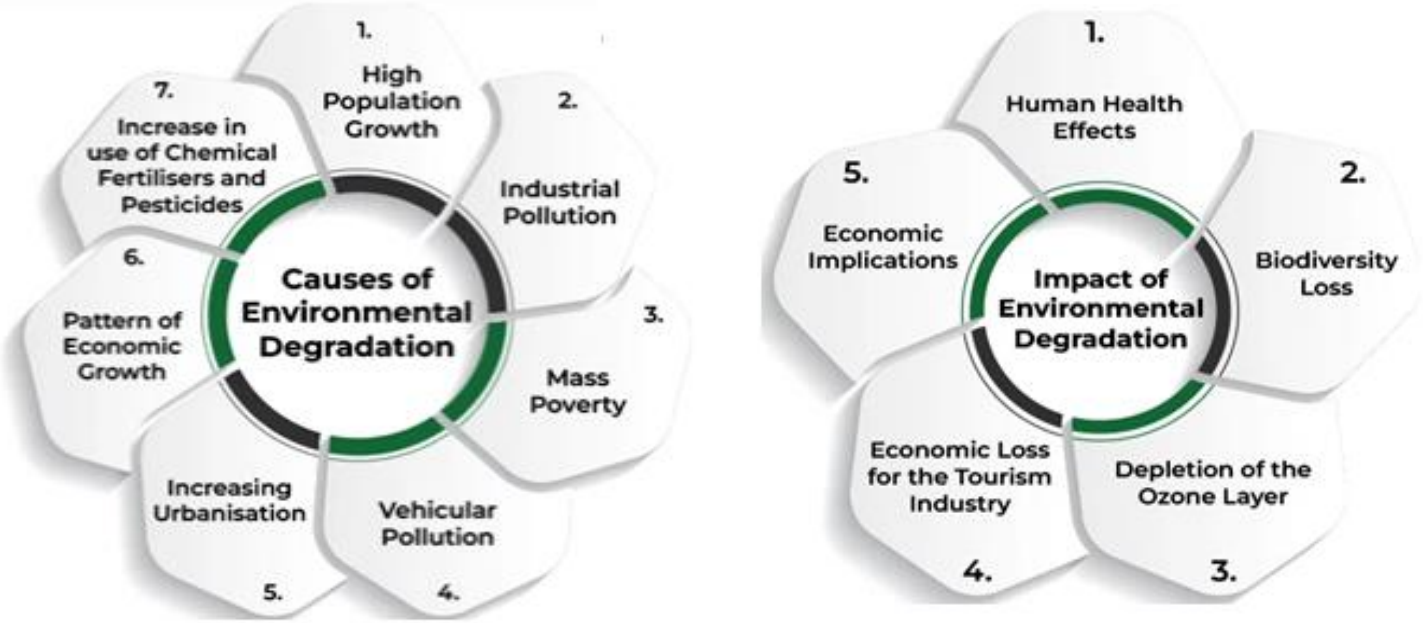


Figure 04. Causes and consequences of biodiversity loss

5-Solutions for biodiversity loss:

5-1-Concept of biodiversity conservation:

In ecology, conservation is the protection, the preservation, the management, and the restoration of wildlife and natural resources such as forests and water. Through conservation of biodiversity, survival of many species and habitats can be ensured. There are two types of conservation for natural biodiversity:

In-situ conservation

Conservation, recovery and maintenance of ecosystems, populations and species in their natural habitats or the surroundings where they have developed their distinctive properties. It means that to save a tiger, we have to save the whole forest. The protected areas where in-situ conservation takes place are:

- National Parks
- Wildlife sanctuaries
- Biosphere reserves
- Sacred groves.

Ex-situ conservation

Conservation of the components of biological diversity outside their natural habitats. In ex-situ conservation, threatened animals and plants are taken out of their natural habitat and placed in a unique and ideal setting where they can be protected and given special care. This could be realized in:

- Plant seed banks
- Botanical gardens
- Zoological parks
- Field gene banks
- Invitro methods

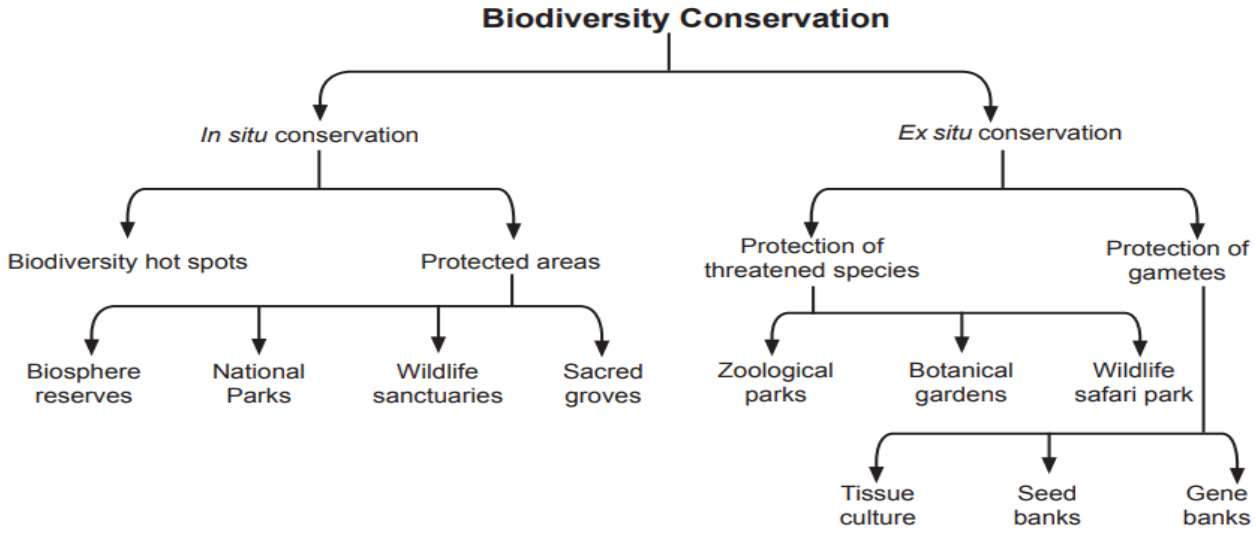


Figure 05. In-situ and Ex-situ conservation processes

5-2- Concept of sustainable development

"Sustainable development is the development that responses to all human needs (people) without compromising the ability of future generation to meet their own needs". In other words it is improving the quality of life of the present generation without excessive use or abuse of natural resources, so that they can be preserved for the next generation.

Figure 06. Sustainable development principal axes

5-2-1-Main axes of sustainable development:

The principal axes of sustainable development are: economic development, social development and environmental protection:

- **Economic growth**
  Building a strong and competitive economy, by ensuring the availability of sufficient land ecosystems and natural resources to support growth and modern coordinating development requirements.
- **Environmental protection**
  Contributing to protecting and enhancing our natural and developed environment, while helping to improve biodiversity, use natural resources wisely, minimizing waste and pollution, adapting and helping to decrease climate change, and including a global shift to low-carbon economy.
- **Social inclusion**
  Supporting strong, active and healthy communities by providing the supply of human needs as well as protecting the future generations rights (Creating a high-quality of development, with accessible local services as health, social and cultural well-being).

5-3- Habitats Restoration:

It is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed to reflect its intrinsic values and to provide goods and services that people value. The aim is to return the ecosystem to the condition it would have been in if degradation had not occurred, accounting for anticipated change. Restoration ecology is the scientific study of repairing disturbed ecosystems through human intervention.

5-3-1-Ecological restoration Goals:

Many restoration projects aim to establish ecosystems composed of a native species; other projects attempt to restore, improve, or create particular ecosystem functions, such as pollination or erosion control. Restoration projects include:

- **Revegetation**
  The establishment of vegetation on sites where it has been previously lost, often with erosion control as the primary goal.
- **Habitat enhancement**
  The process of increasing the suitability of a site as habitat for some specific species.
- **Mitigation**
  Legally providing efforts for restoration towards loss of protected species or ecosystems.

5-4-Ecosystems remediation:

Environmental remediation deals with the removal of contaminants or pollution from soil, groundwater, sediment, surface water or cleaning up after an oil spill. It's the action of improving an existing ecosystem or creating a new one with the aim of replacing another that has deteriorated or been destroyed. The major purpose of environmental remediation is to restore contaminated sites or resources to reduce the negative impact of the pollutants on human and natural health. Ecosystems remediation can be:

- **Bioremediation**
  The process of detoxification and degradation of heavy metals with the help of microorganisms (soil or aquatic ecosystems).
- **Phytoremediation**
  The method that helps to absorb the heavy metals in the polluted ecosystem by using plants and trees to remediate and clean the environment.

5-5-Natural resources recycling

Recycling and reusing residues reduce the necessity to extract and employ new materials from the Earth. That in turn decreases the harmful disruption and damage in the natural world (fewer forests cut down, rivers diverted, wild animals harmed or displaced, and less pollution of water, soil and air).

Chapter 04: Global warming

1-The climate change concept:

- Climate change refers to changes to the average weather of a specific region or the whole planet for decades or longer. Both anthropogenic and natural factors contribute to global warming, which can be estimated by changes in temperature, precipitation, wind, storms and sea level rise. These changes are driven by "The greenhouse effect", mainly caused by increased levels of carbon dioxide, and burned fossil fuels (coal, oil, and natural gas).
- In its 5th Assessment Report in 2013, the IPCC (Intergovernmental Panel on Climate Change) stated that, "Most of the observed increase in global average temperatures since the mid-twentieth century is very likely higher than 95% and mainly caused by the increase in anthropogenic greenhouse gas concentrations." In other words, most of the global warming from the past 50 years is believed to be caused by human activities.

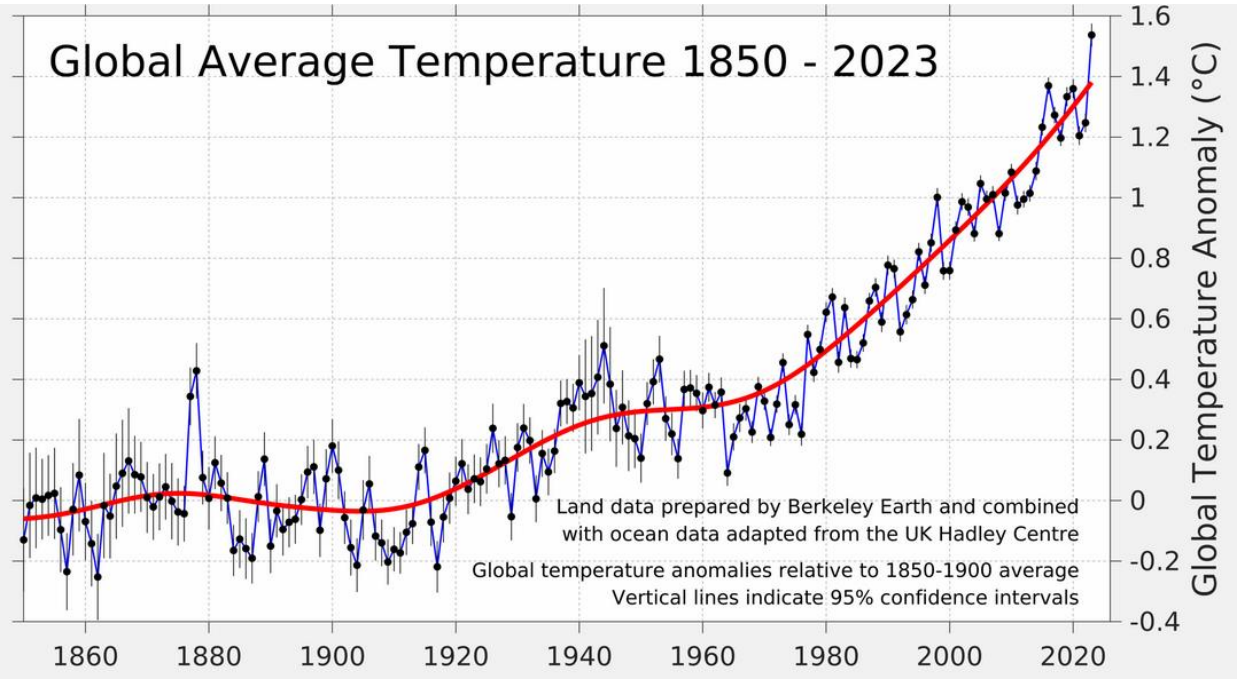


Figure 01. Average temperature anomalies on the planet since 1850

2-The greenhouse effect concept:

- In 1824, French physicist "Joseph Fourier" was the first to suggest that the Earth's atmosphere might act as an insulator, the first proposal of what was later called "The greenhouse effect".
- In 1850, Irish born physicist "John Tyndall" was the first to demonstrate that water vapor and other atmospheric gases absorbed Earth's radiant heat.

- In 1896, Swedish scientist “Svante Arrhenius” was the first to calculate the warming power of excess carbon dioxide (CO_2). From his calculations; he predicted that if human activities increased CO_2 levels in the atmosphere, a warming trend would result.
- The greenhouse effect is recently defined as the process through which heat is trapped near Earth's surface by natural substances “greenhouse gases”. This process makes Earth much warmer than it would be without these natural gases. There are two types of greenhouse effect:

2-1-Natural green house effect:

The greenhouse effect happens when the sun’s heat penetrates the atmosphere, and when it is blocked in during its reflection from the ground towards the space. Imagine Earth as a giant greenhouse where certain gases such as water vapor gas (H_2O), methane (CH_4), nitrous oxide (N_2O), ozone (O_3) and carbon dioxide (CO_2), act like the glass panes, trapping some of the sun's heat and keeping the planet warm enough for life what participates to maintain an average temperature of +15°C instead of -18°C without the greenhouse effect, and what makes of the “natural greenhouse effect” in this case a beneficial phenomenon responsible for the softness of our climate (Natural thermostat effect).

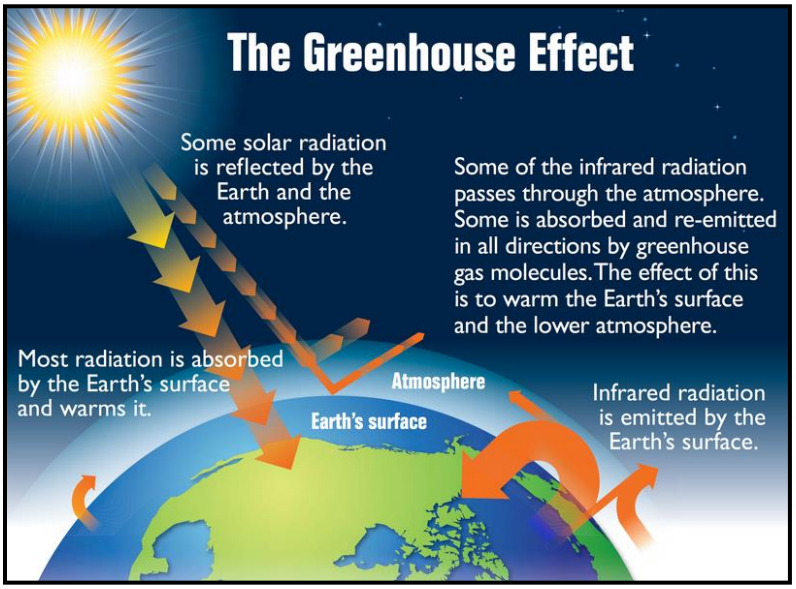


Figure 02. Natural greenhouse effect

2-2-Human green house effect:

Since the 19th century, economic and demographic growth has increased exponentially, which contributed to increase in the burning fossil fuels (coal, oil, gas….etc). The accumulation of these greenhouse gases (+85%) and particularly the carbon dioxide used by people as a convenient source for transport, electricity generation and industrial processes, participates to induce “The additional greenhouse effect”. In fact, since the industrial revolution (1850-1900), the global annual temperature has increased in total by a little more

than 1°C. Between 1880 and 1980, it increases by 0.07° C every 10 years. For the last 40 years, we've seen the global annual temperature rise by 0.18°C per decade.

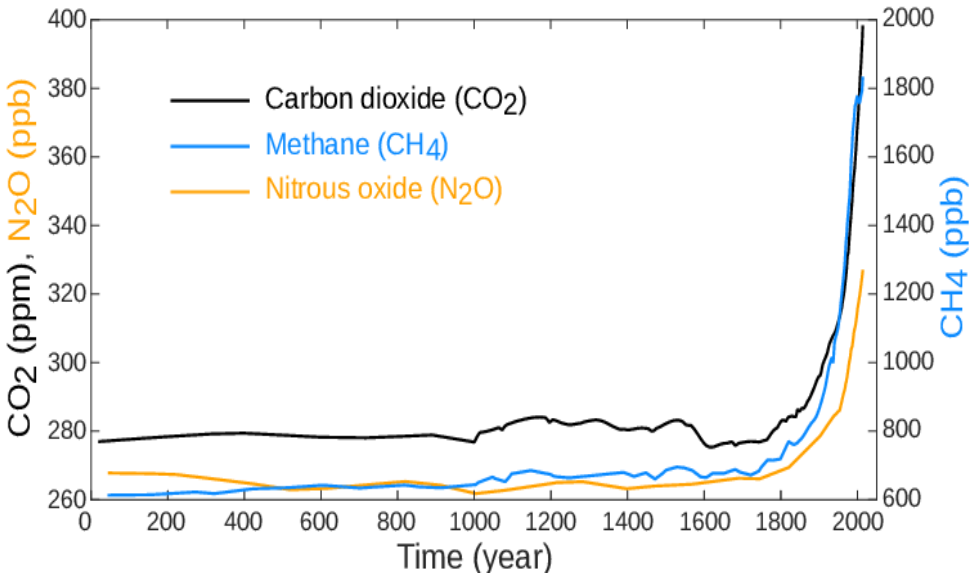


Figure 03. Rate of greenhouse gases emission

3-Signs of Climate Change:

Climate change is happening now, and the situation tends to get worse every year on our environment. There are many proofs that the Earth's climate is warming:

- Global surface temperatures have risen by 1.3°C over the last 100 years. (The worldwide for the last decade has been the warmest on record, with more frequent extreme heat events and more severe droughts seasons).
- Changing precipitation patterns (More intense precipitation, winter storms, hurricanes and more frequent and severe floods due to intense rain and spring snowmelt)
- Melting ice in the Arctic (Rising sea level around all oceans).
- Increasing ocean temperatures (Acidification and deoxygenation of the oceans due to elevated carbon dioxide in the atmosphere and changes in the global water cycle).
- More natural damages such as volcanic eruptions, wildfire and earthquakes.
- Worsening air quality (Higher temperatures increase production of ozone and pollen, as well as increasing the risk of living beings diseases).
- Deterioration in the yield of crops and agricultural production qualities.

- Loss of productivity and bio-diversity (Destruction of natural habitats and ecosystems and more animal and plant species extinction. Many parks and agricultural pests of the southern areas shifted towards northern zones, in an attempt to ensure their growth and survival).

Figure 04. Signs of the climate change effects

4-Main greenhouse gases and projections:

4-1- Main greenhouse gases:

Gases that trap heat in the atmosphere are called the greenhouse gases. Information on the table 01 provides details about emissions and removals of these gases to and from the atmosphere:

Tab 01. Principal greenhouse gases

Compound	Pre-industrial concentration (ppmv*)	Concentration in 2019 (ppmv)	Atmospheric lifetime (years)	Main human activity source	GWP**
Carbon dioxide (CO_2)	280	411	variable	Fossil fuels, cement production, land use change	1
Methane (CH_4)	0.715	1.877	12	Fossil fuels, rice paddies, waste dumps, livestock	28
Nitrous oxide (N_2O)	0.27	0.332	121	Fertilizers, combustion industrial processes	265
HFC 23 (CHF_3)	0	0.000024***	222	Electronics, refrigerants	12,400
HFC 134a (CF_3CH_2F)	0	0.000062***	13	Refrigerants	1,300
HFC 152a (CH_3CHF_2)	0	0.0000064***	1.5	Industrial processes	138
Perfluoromethane (CF_4)	0.00004	0.000079***	50,000	Aluminum production	6,630
Perfluoroethane (C_2F_6)	0	0.0000041***	10,000	Aluminum production	11,100
Sulphur hexafluoride (SF_6)	0	0.0000073***	3,200	Electrical insulation	23,500

4-2-Global worming rhythm and predictions for future climate:

Climate change rhythm through the last decades eliminates the theory of a “pause” or a “slowdown” in rising global warming around the world. Scientists use statistical tests to determine and predict future scenarios for the present situation, where climate models project the following changes:

- Even one degree can harm the planet in many ways. Climate models predict that Earth's global average temperature will rise an additional of 4° C by the end of the 21st century if greenhouse gas levels continue to rise. Heat waves are expected to become more common, severe, and longer lasting.
- Heavy rain events are expected to become 1.7 times (14%) more intense. Some storms are likely to become stronger and more frequent, increasing the chances of flooding and damage in coastal communities by the end of 2100.
- Melting ice may lead to changes in ocean circulation, too. Although Arctic Ocean will likely be ice-free by the end of the century. It is estimated that one in ten people will live in an area threatened by rising sea levels (20 and 60 cm) in the coming years. Changing salinity and higher acidity may also disrupt marine species and cause their extinction.
- Under this accelerated rate of atmospheric warming, the planet will experience a shortage of natural resources (water, biodiversity…..etc.) and an intense deterioration in the yield of agricultural lands, inducing more famine and diseases around the world.
- Climate change will affect different regions, ecosystems, and sectors of the economy in many ways, depending not only on the sensitivity of those systems to climate change, but also on their ability to adapt to risks and changing conditions.

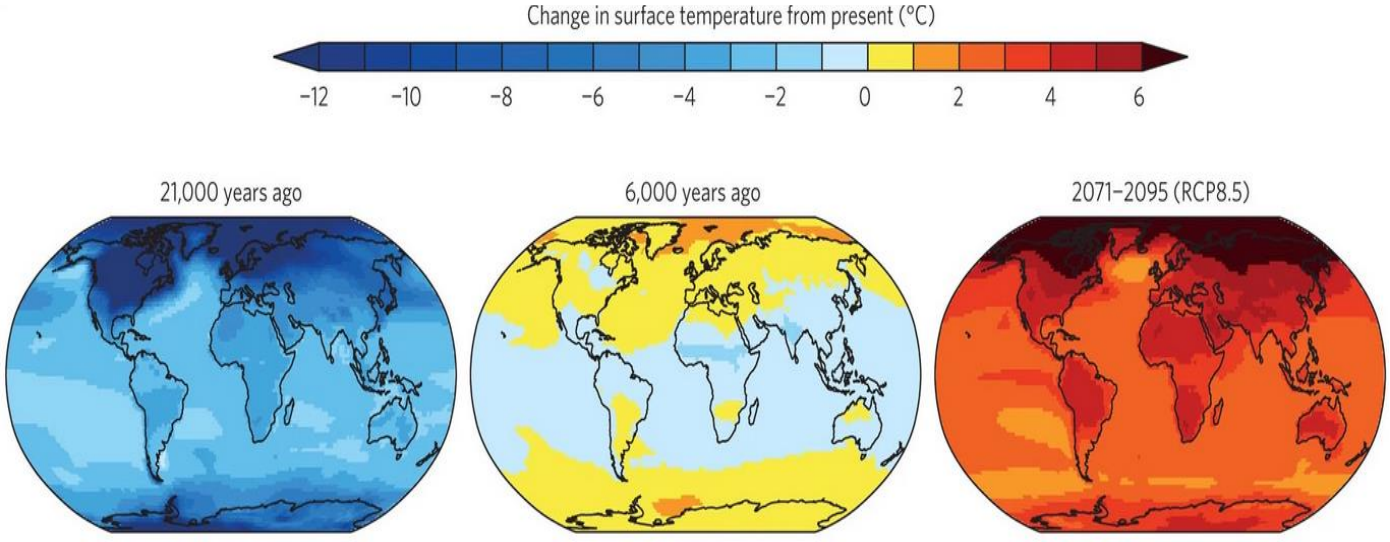


Figure: Changes in temperature rise until 2100

5-Causes, effects and solutions for global worming:

5-1-Causes of global warming:

- The burning of fossil fuels, such as coal, oil, and natural gas, for energy and transportation is a major contributor to global warming.
- Deforestation, especially in tropical regions, reduces the number of trees that can absorb carbon dioxide from the atmosphere, leading to increased greenhouse gas levels.
- Agricultural activities, including livestock farming and rice cultivation, release methane; a potent greenhouse gas, that contribute to global warming.

5-2-Impacts of global warming on ecosystems:

- Global warming impacts the availability and distribution of food sources, causing disruptions in ecosystems and affecting the balance of predator-prey relationships.
- Rising sea temperatures lead to coral bleaching, and the diverse marine life that depends on these habitats.
- Changes in temperature and precipitation patterns affect the growth and distribution of forests, leading to shifts in vegetation and potential loss of forest ecosystems.
- Rising greenhouse gases had a harmful effect on the ozone shield causing an important degradation of the global atmosphere quality around the earth. These gases also participate to other natural damages as acid rains.

5-3-Solutions for climate change:

- Renewable energy: Transition by implementing solar, wind, and hydroelectric power to reduce reliance on fossil fuels and lower carbon emissions.
- Energy efficiency measures: Promoting energy-efficient technologies and practices to decrease energy consumption and emissions (Mitigation processes)
- Afforestation: Planting trees to absorb carbon dioxide and restore forest ecosystems.
- Individual responsibility: Recognizing the impact of personal actions and making environmentally conscious choices to reduce carbon footprint and support sustainability efforts and changing individual habits: We can all make a difference by reducing our carbon footprint through simple changes in our daily lives, such as using public transportation, and conserving more energy.
- Advocacy and education: Raising awareness and promoting education on climate change to mobilize communities and inspire collective action.
- Community engagement: Initiatives and community-based projects to address climate challenges and contribute to resilience-building efforts to reduce the effect of greenhouse gases such as carbon capture projects....etc.