Biodiversity, Classification & conservation

Classification of living organisms

the process of arranging organisms into distinct groups (or categories) based on morphological & physiological similarities

Classification groups (taxons)

Dumb King Philip Can Order for German students

- Domains
- Kingdoms
- Phyla (sing. phylum)
- Classes (sing. class)
- Orders (sing. order)
- Families (sing. family)
- Genus
- Species

Homo sapiens
Plasmodium malariae
Vibrio cholerae

GENUS + SPECIES

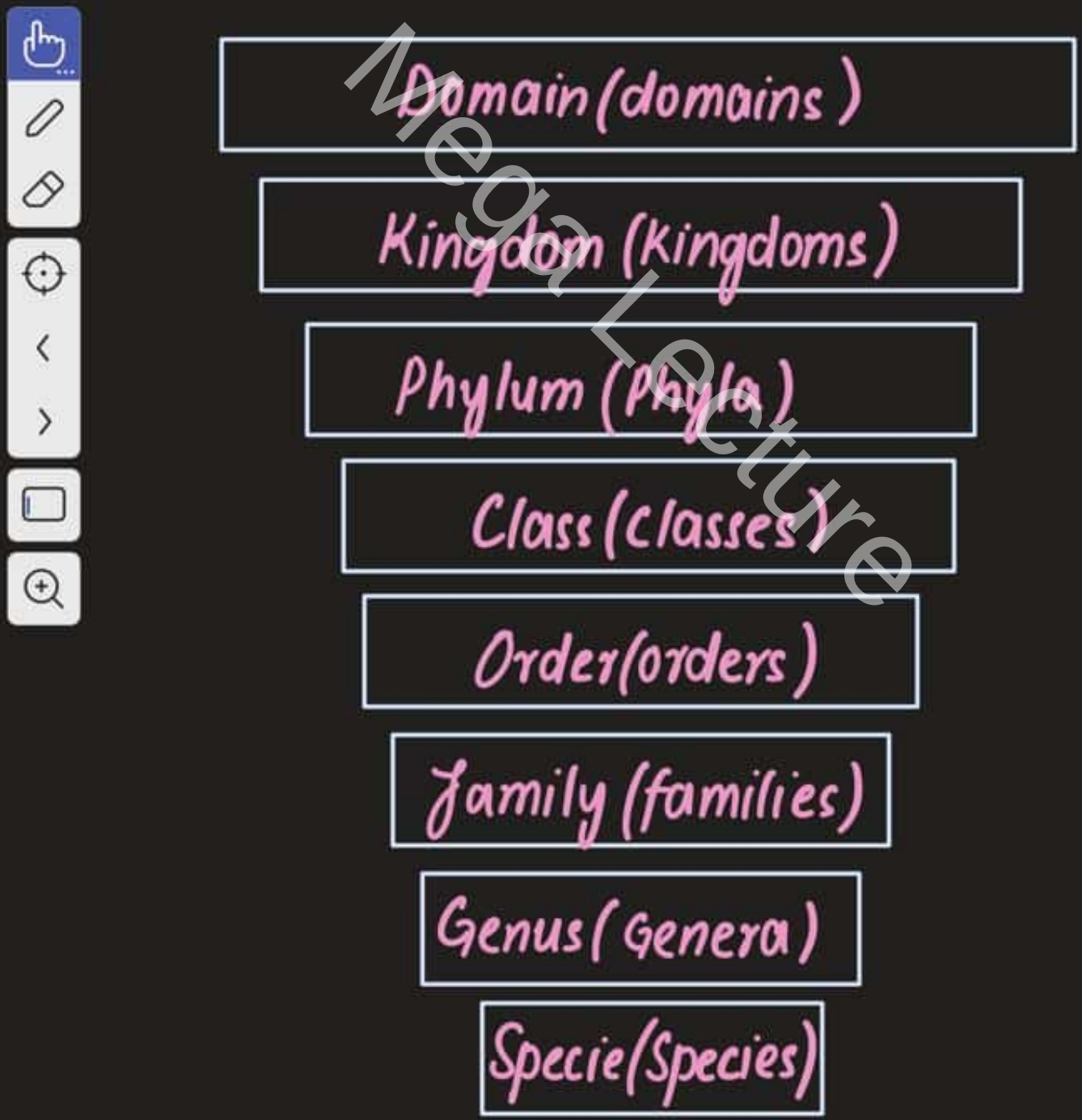
Binomial Nomenclature

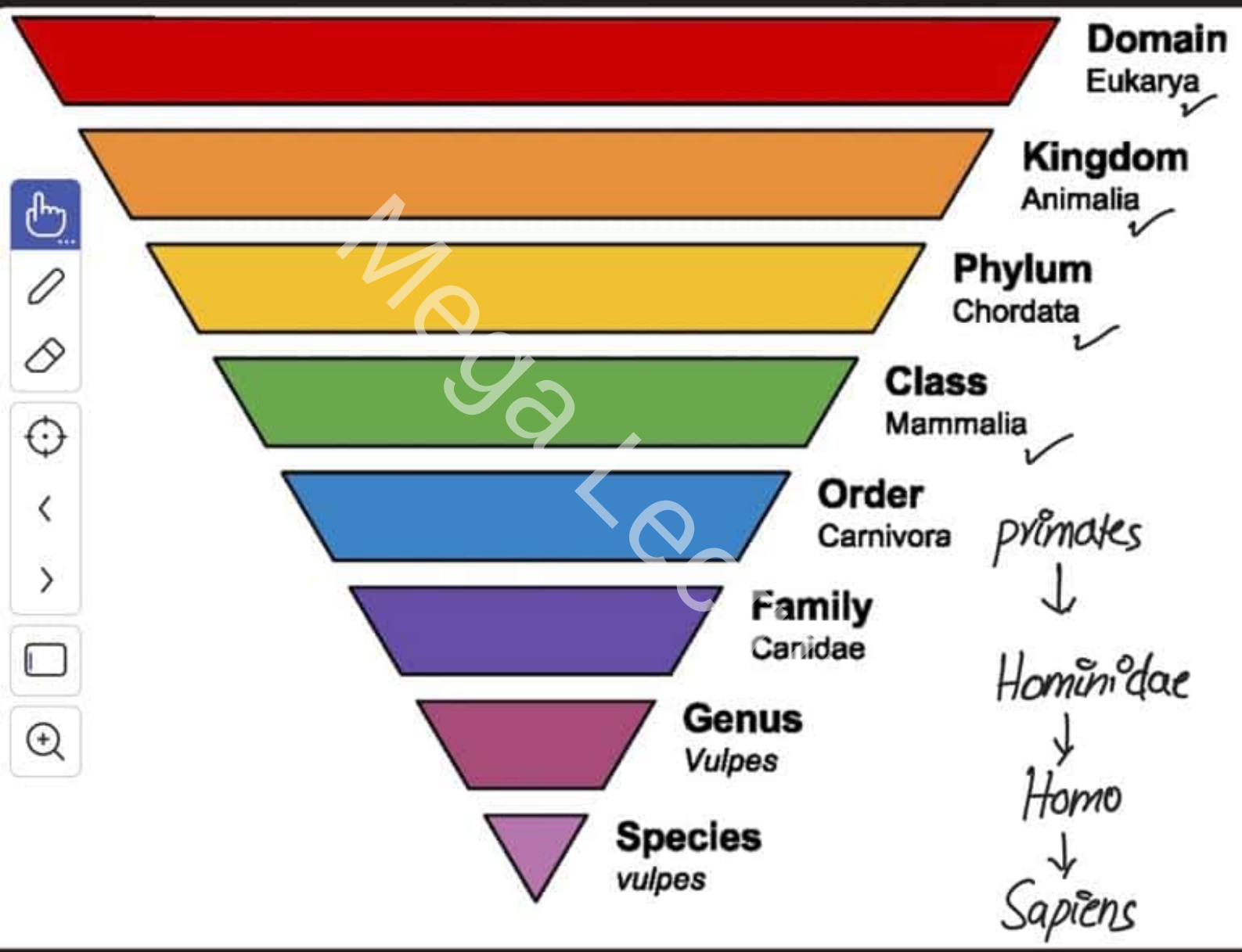
Classification

* The process of arranging organisms into different groups is known as **classification**.
* Classifying organisms makes it easier to understand them and their key features.
* **Taxonomy** is the study and practice of classification which involves placing organisms in a series of taxonomic groups

* These taxonomic units form a hierarchy as shown below:

Domain → Kingdom → Phylum → Class → Order → Family → Genus → Species





* The domain is at the top of this hierarchal system.

* As we move from domain to species:

The morphological & the physiological similarities b/w the organisms increase.

* The number of organisms in each taxon decrease.

* All the living organisms are currently classified into a 3 domain & 5 kingdom classification.

Domains & Kingdoms

3 domains

- BACTERIA
- ARCHAE
- EUKARYA

5 kingdoms

- Prokaryotes
- Protochists (Euk.)
- Fungi (Euk.)
- Plantae (Euk.)
- Animalia (Euk.)

Domains

BACTERIA

ARCHAE

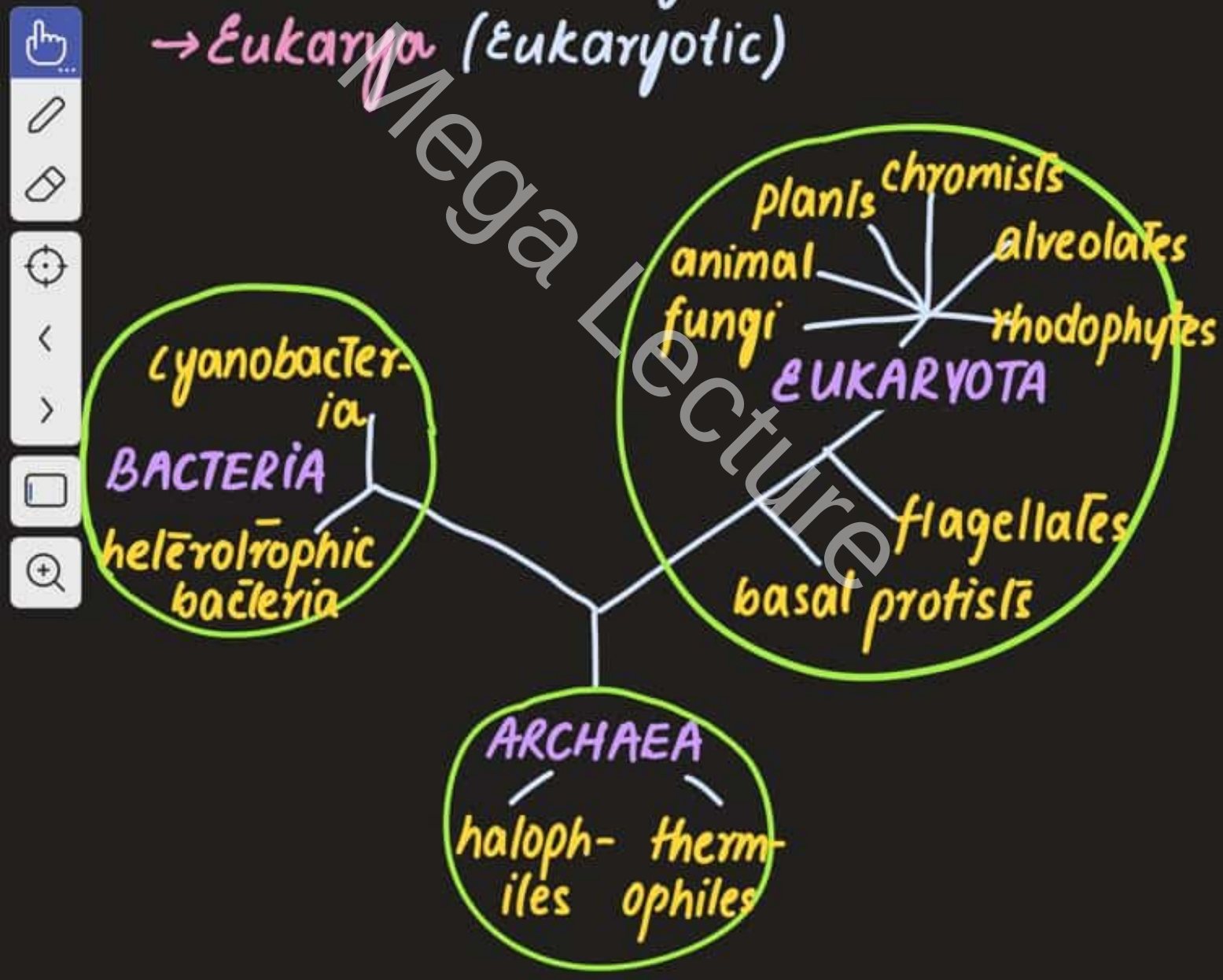
EUKARYA

* survive in extremes of environment
* prokaryotic
* circular DNA which is bound to histones
* do NOT have a peptidoglycan cell wall
* 70S ribosomes are larger than bacterial 70S ribosomes
* protein synthesis ?

Archae
- Thermophiles
- Halophiles
- Methanogens

* Living organisms are classified into the following 3 domains:

→ Archaea (Prokaryotic)
→ Bacteria (Prokaryotic)
→ Eukarya (Eukaryotic)



ARCHAEA

* Archaea are prokaryotic organisms which survive in extremes of environment.

* Archaea can be classified into the following 3 categories:

→ Thermophiles: survive in extremely hot climates like hot springs and volcanoes.

→ Halophiles: survive in extremely salty environment such as the Dead Sea.

→ Methanogens: are responsible for producing methane by reducing carbon.

BACTERIA

* Bacteria are prokaryotic organisms which are distinct from Archaea.

* Bacteria have typical prokaryotic features.

Why are Archaea classified into a different domain when compared with bacteria?

* Archaea have a cell wall which is not made of peptidoglycan.

* The circular DNA of Archaea is associated with histone proteins.

* The 70S ribosomes in Archaea are larger than bacterial ribosomes but smaller than the eukaryotic 80S ribosomes. These ribosomes have a greater similarity to eukaryotic ribosomes.

* The protein synthesis machinery of Archaea has more similarity to eukaryotes. For e.g. transcription in Archaea and the tRNAs used in translation are similar to that in eukaryotes.

EUKARYA

Characteristic features:

* cells with a nucleus and membrane-bound organelles.
* DNA in the nucleus is arranged as linear chromosomes with histone proteins.
* ribosomes (80s) in the cytosol are larger than in prokaryotes. chloroplasts and mitochondria have 70s ribosomes, like those in prokaryotes.

* Chloroplasts and mitochondrial DNA is circular as in prokaryotes.

* A great diversity of forms: there are unicellular, colonial and multicellular organisms.

* Cell division is by mitosis.

* many different ways of reproducing: asexually and sexually.

Kingdoms

a. Prokaryotes
b. Protoctists
c. Fungi
d. Plantae
e. Animalia

} eukaryotic

1. Cellular organisation
2. Cellular features
   - true nucleus?
   - ribosomes?
   - membrane bound organelles?
   - DNA?
3. Cell Wall
4. Mode of nutrition
   - heterotrophic
   - autotrophic
5. Motility
6. Mode of division / reproduction
7. Examples

List of kingdoms :

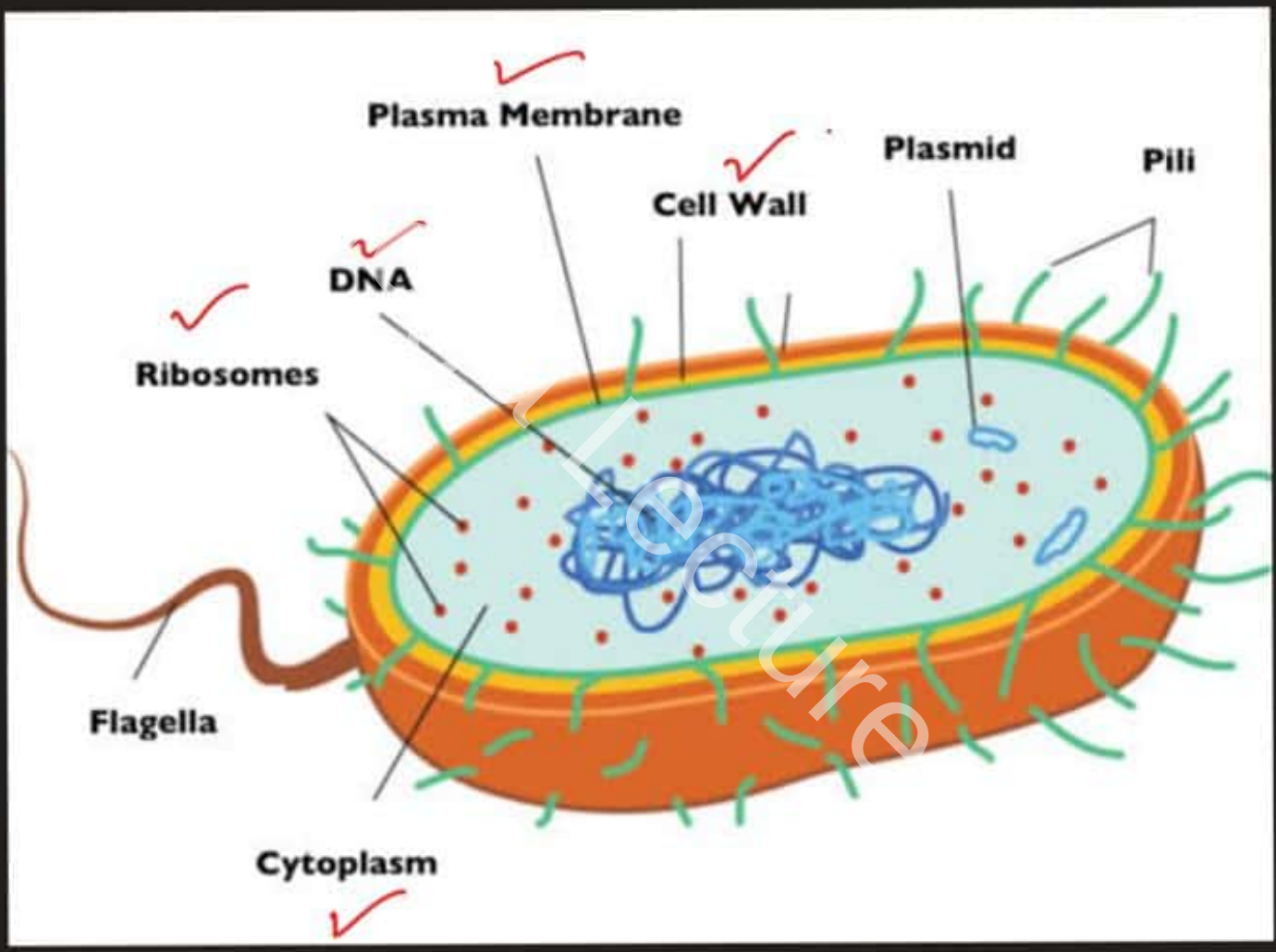
1. Prokaryotes
2. Protoctista
3. Fungi
4. Plantae
5. Animalia

Prokaryotic Kingdom

* The prokaryotic kingdom has the following features:

- they are unicellular organisms.
- most prokaryotes have a peptidoglycan cell wall.
- they are devoid of a true nucleus which implies that the genetic material is not membrane-bound.
- they do not have membrane-bound organelles.

- the circular DNA is not bound to histone proteins.
- they may contain circular rings of DNA called plasmids.
- they contain 70s ribosomes.
- they may or may not be motile depending on the presence of a flagellum.
- they may be autotrophic or heterotrophic
- they divide by binary fission.
- few examples of prokaryotic organisms include cyanobacteria, Archaea bacteria, streptococcus and staphylococcus.

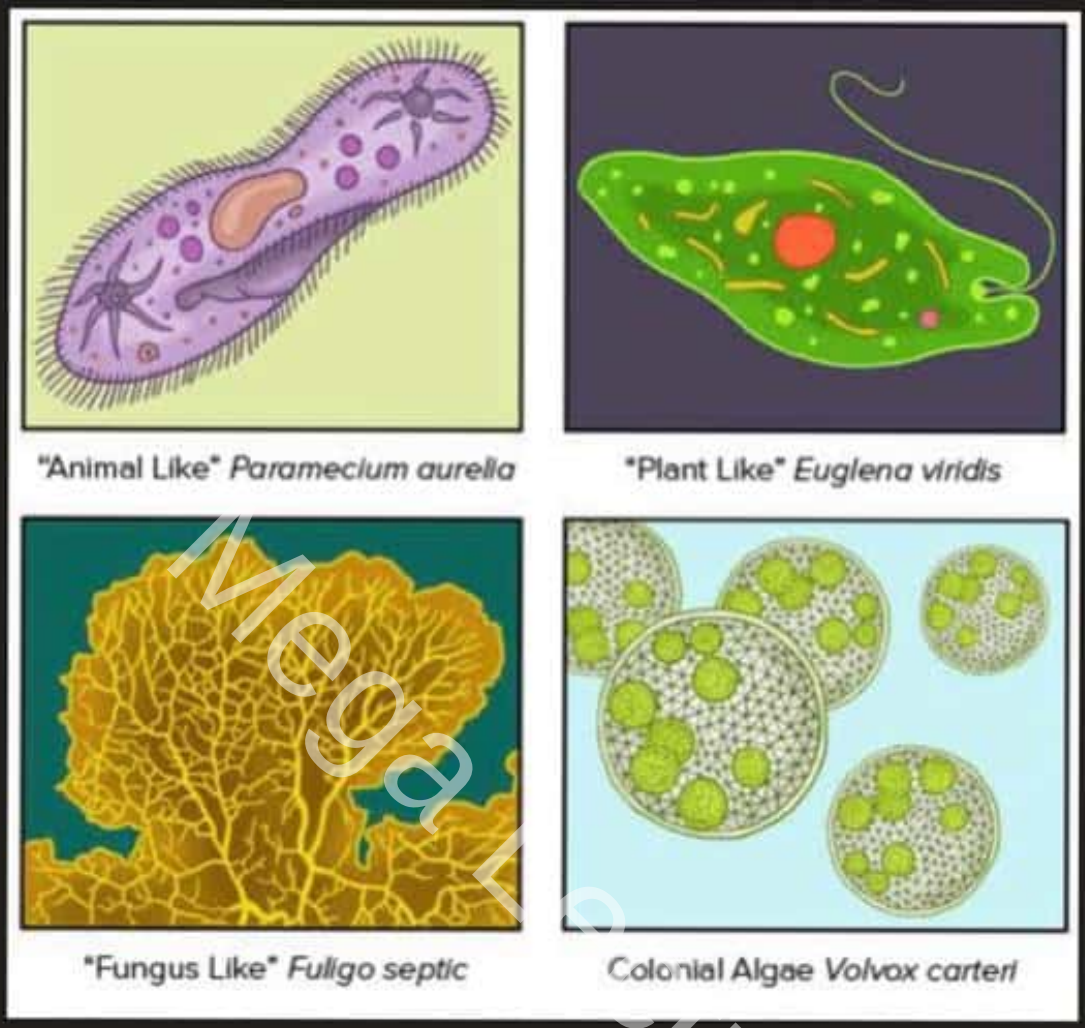


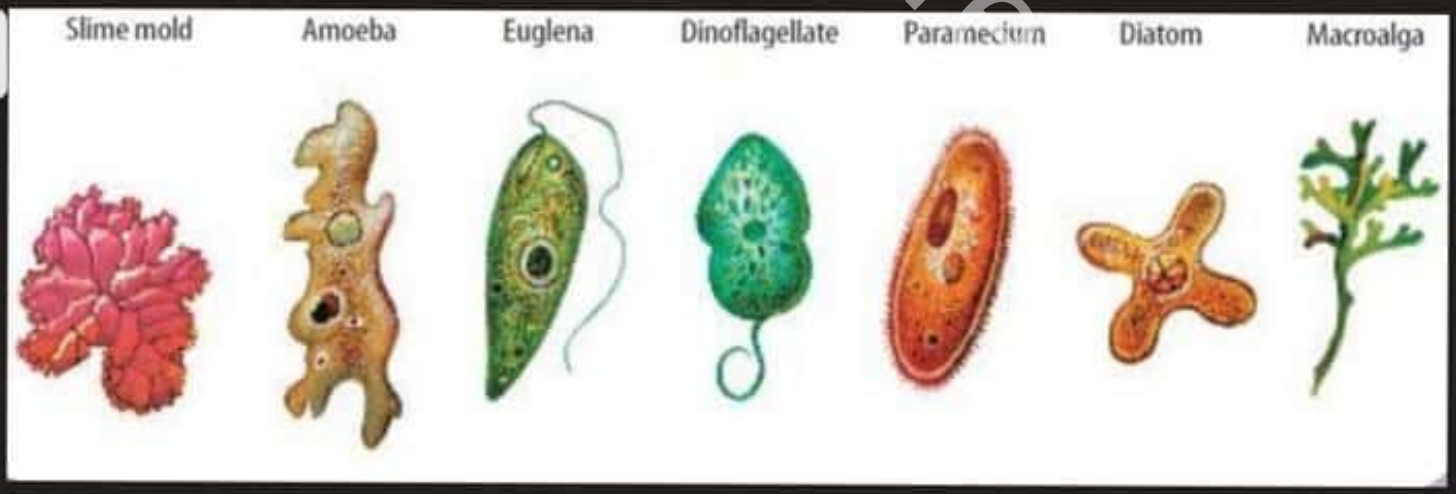
Protoctista

* Protoctists are eukaryotic organisms that cannot be classified into the kingdoms fungi, animalia or plantae.

- they may be unicellular or multicellular.
- they have a true nucleus and membrane-bound organelles.
- they have linear DNA associated with histone proteins.
- they contain 80s ribosomes.
- they may or may not be motile.

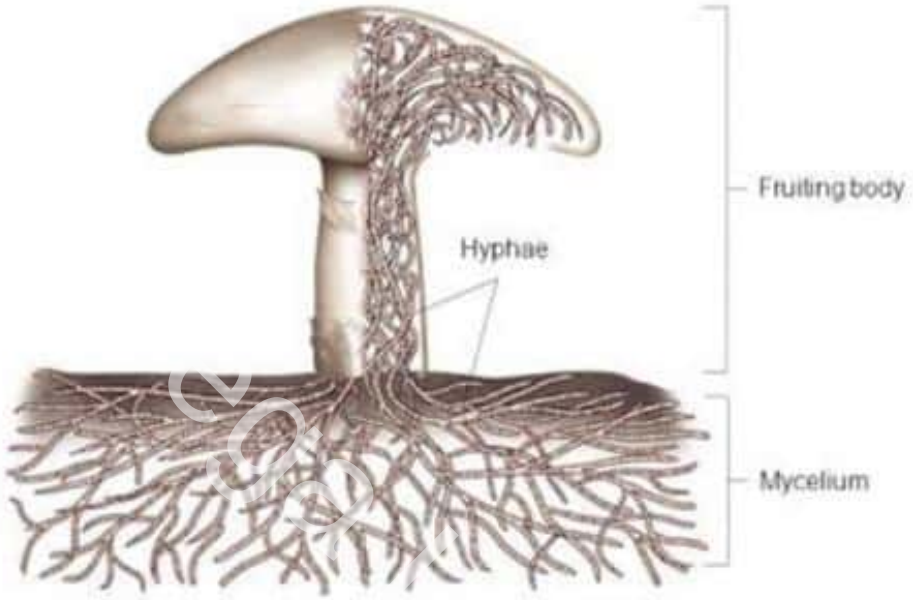
- They may be autotrophic or heterotrophic
- they may or may not have a cell wall.
  - Examples:
    - → algae are plant-like protoctists
    - → protozoa are animal-like protoctists.
    - → slimy moulds are fungi-like protoctists.

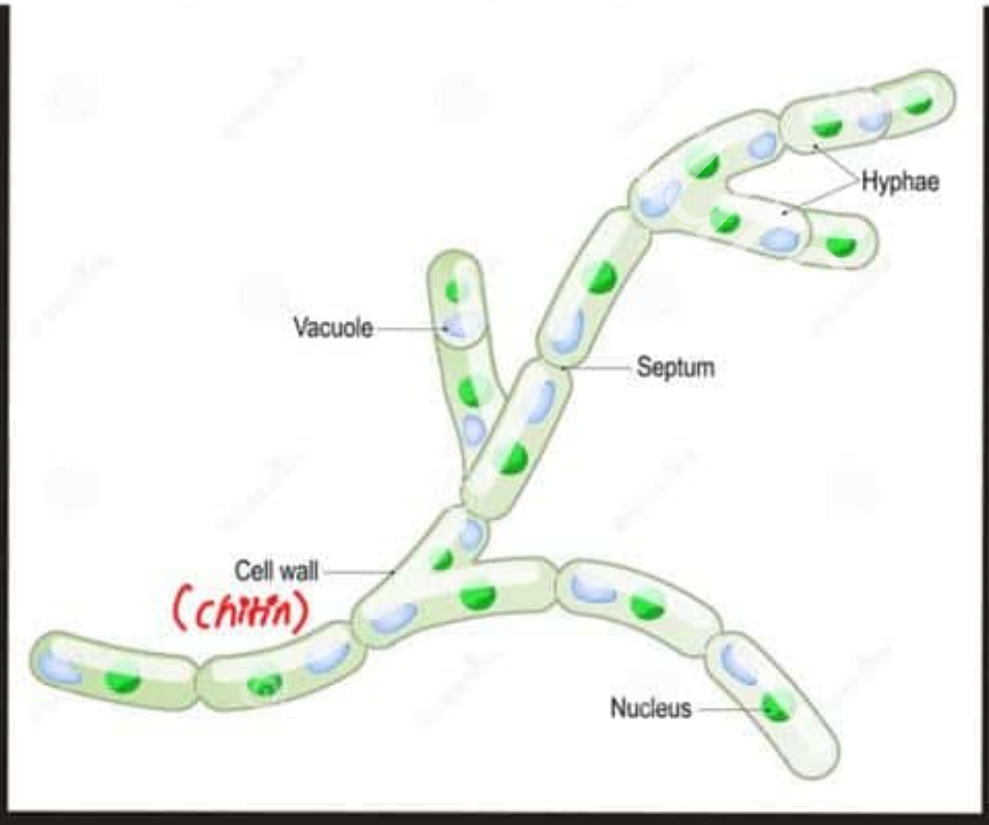


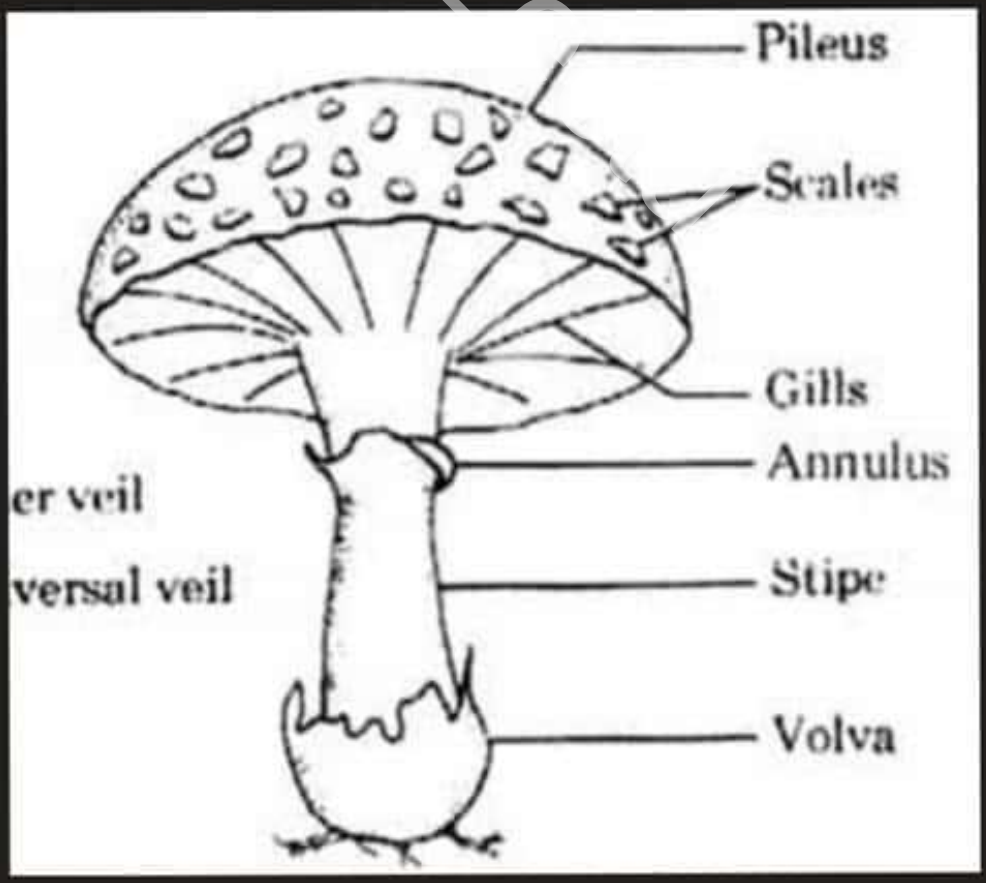


Fungi

Fungi Structure

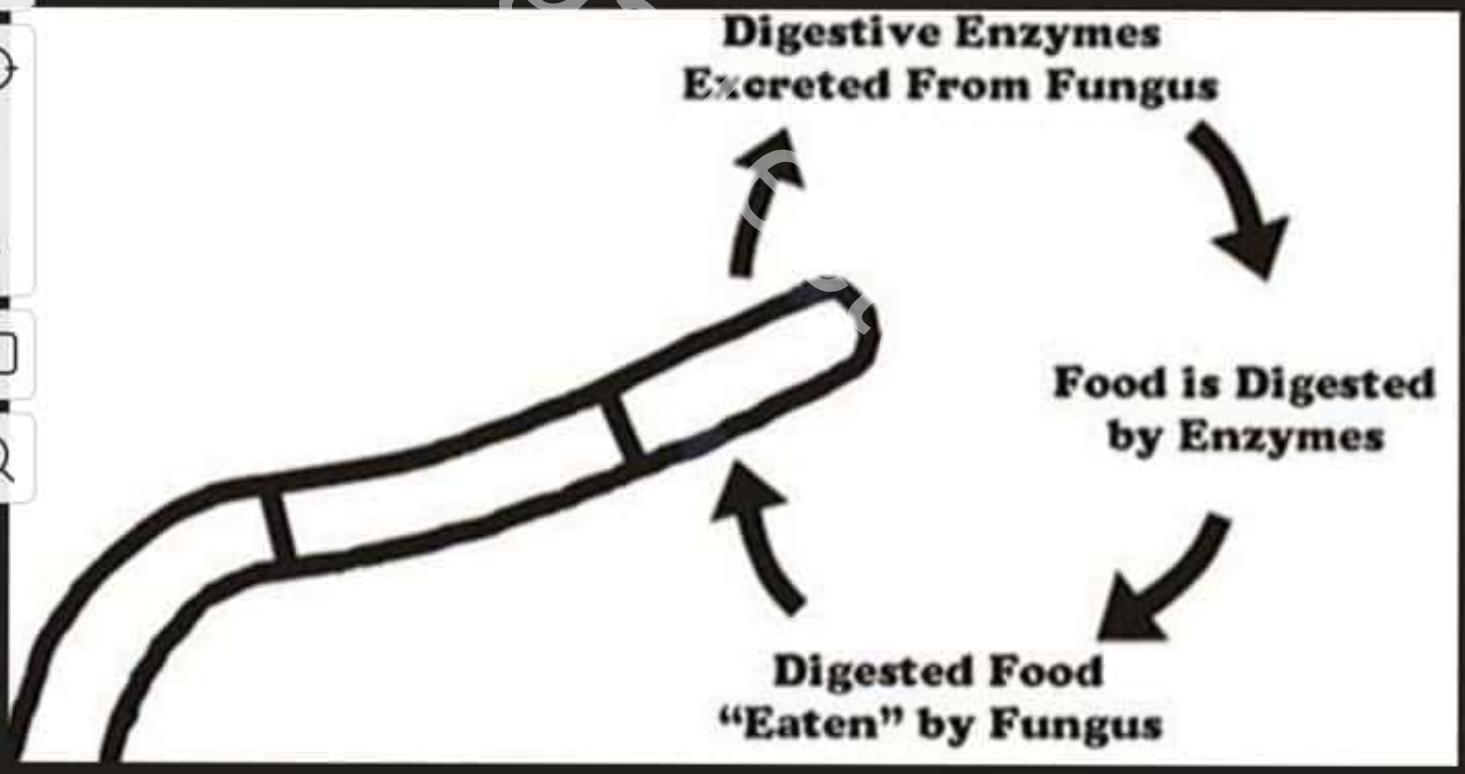






- Most fungi are multicellular exceptyeast.
- Jungal bodies are made up of long threads called hyphae.
- Network of hyphae is called mycelium.
- They have cell walls made up of chitin.
- All fungi are heterotrophic which means that they derive their energy by using organic compounds synthesized by other organisms.
- Jungi are always immotile bcz they are devoid of cilia or flagella.

- They reproduce by production of spores.
- They have an extracellular mode of digestion. They secrete digestive enzymes into external medium and absorb digested food material.



Previously,

* Classification → taxonomy
* Domains
* Kingdoms → Prokaryotes
  → Protoctists
  → Fungi

Kingdoms

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b. Protoctists
c. Fungi
d. Plantae
e. Animalia

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Plantae

- Plantae are photosynthetic eukaryotic organisms.
- They are multicellular and differentiated to form tissues and organs.
- They contain chloroplasts and are therefore photosynthetic (hence autotrophic)
- The plant cells often have a large permanent vacuole.
- Plant cell wall is made up of cellulose.
- Plant cells are generally immotile except for a few
- Reproduce sexually / asexually

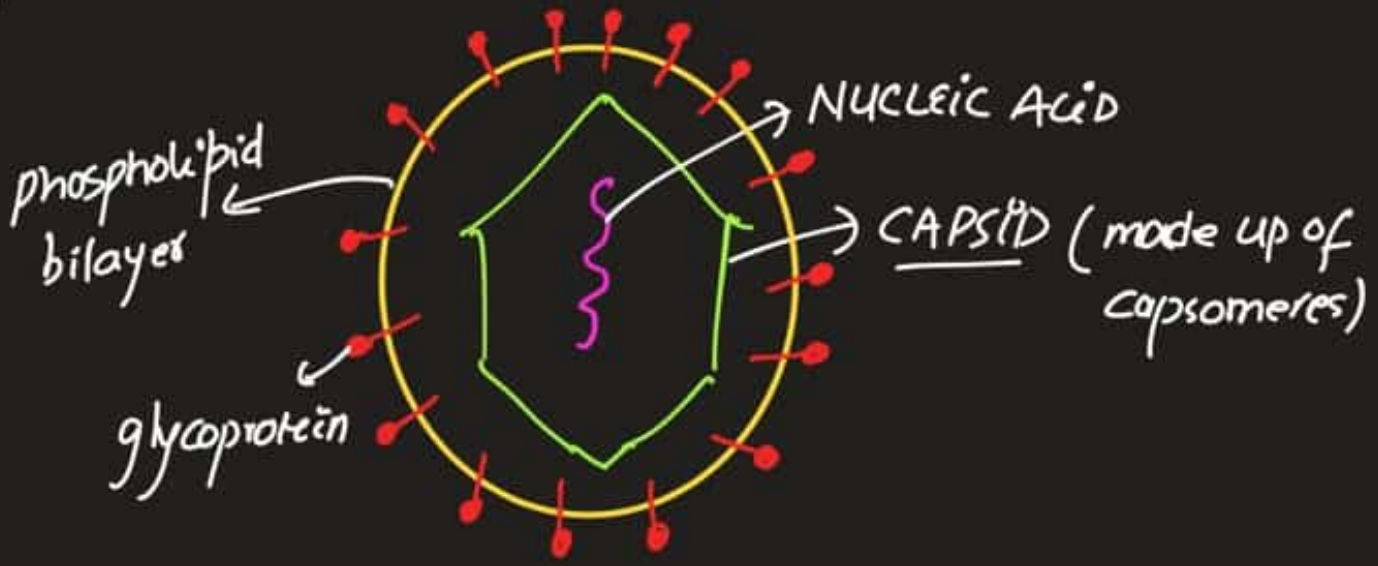
Animalia

- They are multicellular and differentialēd into tissues and organs.
- Animal cells do not contain chloroplasts and are therefore non-photosynthetic.
- They have a helērolrōphic mode of nutrition.
- They are motile.
- Animal cells do not have a cell wall.
- Animal cells communicate via nervous system.
- Reproduce sexually

Viruses

1. particles made up of proteins and nucleic acids
2. Can be classified on the basis of the nucleic acid they possess:

- DNA
  - ssDNA
  - ds DNA
- RNA
  - ssRNA
  - ds RNA



Viruses

* Viruses are particles that are made up of proteins and nucleic acids.

* There are different ways of classifying viruses some of which include:

  - Naked & enveloped viruses.
  - DNA & RNA viruses.

* Structure of a naked virus include:

- a protein coat made up of small protein sub-units called capsomeres. This protein coat is known as the capsid.

- nucleic acid which could be one of the following:

→ Single-stranded DNA virus, for e.g. canine parvovirus.

→ Double-stranded DNA such as varicella-zoster virus

→ Single-stranded RNA virus such as morbillivirus

→ Double-stranded RNA virus such as HIV.

* Enveloped viruses have an additional glyco-protein coat external to the capsid.

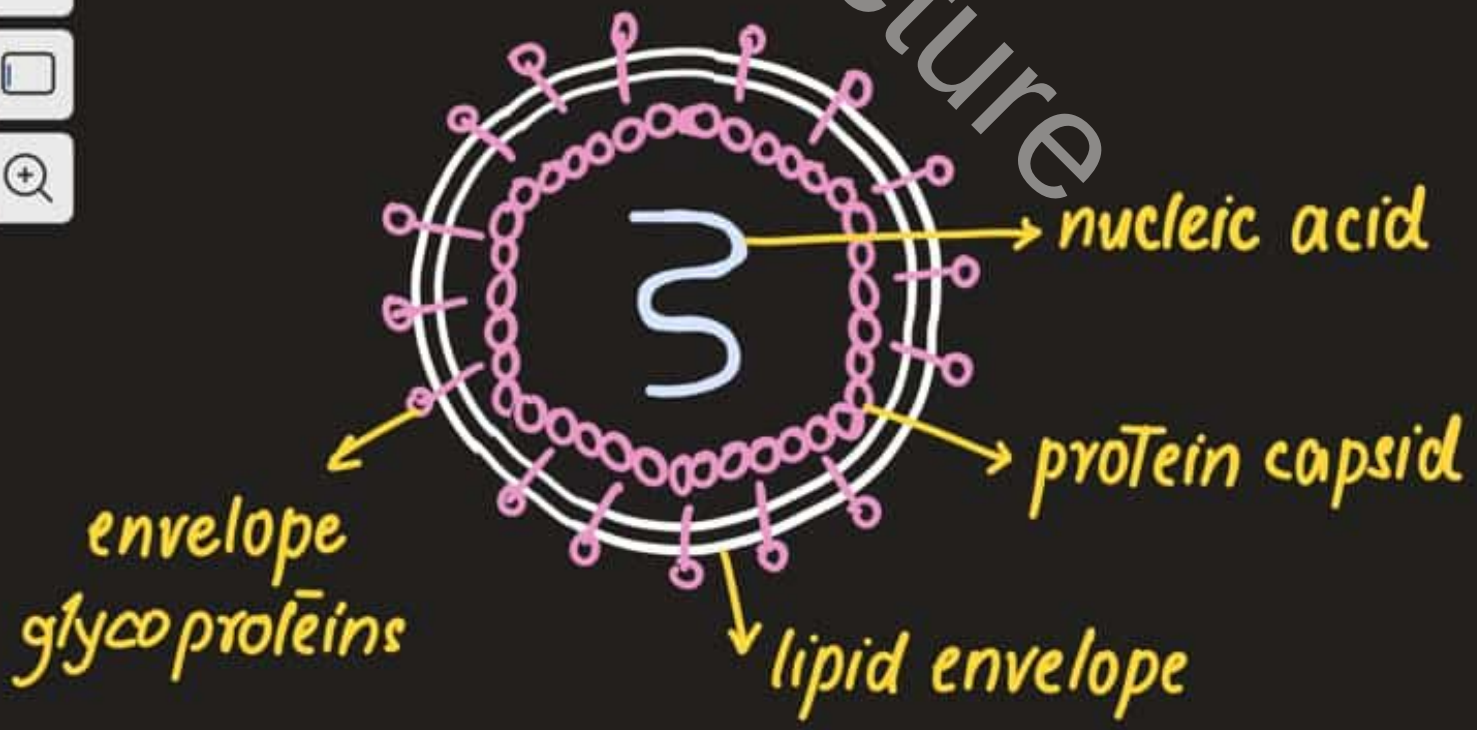
* Viruses are not classified within 3 domain, 5 kingdom classification.

* Many scientists believe that viruses are at the borderline b/w living & non-living organisms.

* A virus can only survive within the host cell by taking over the protein machinery of the host cell.

* Viruses are NOT classified as living organisms because:

- they are devoid of protoplasm (cell membrane & cytoplasm)
- they do not respire
- they have no metabolism.



Endangerment & Extinction

Endangered Species

* numbers are so low that they cannot be maintained by normal rates of reproduction
* danger of becoming extinct

Critically endangered

* numbers fall below 10% of the original population

Extinct species

* no organisms in the natural or artificial habitat

Endangerment and Extinction

* Species are said To be **endangered** if their numbers are so low that they cannot be maintained by normal rates of reproduction and are at the danger of becoming extinct.

* Species are said To be **critically endangered** if their numbers fall **below 10%** of their original population.

* Species are said To be **extinct** if there are no organisms in the artificial or natural habitats.

Reasons for endangerment of species

1. Habitat loss
2. Climatic changes
3. Pollution
   - Air pollution
   - Ind. & domestic pollution
   - Marine pollution
4. Overexploitation & unsustainable use of resources
5. Food shortages
6. Diseases
7. Invasion by alien species

Reasons for endangerment of species

Habitat loss

- This is one of the most significant reasons for endangerment of both terrestrial and marine organisms. Human activities such as deforestation and reclamation of land are a few examples of habitat loss.

Climatic Changes

- Changes such as global warming and natural disasters are responsible for affecting a large number of different species. For e.g. coral reefs are affected due to a rise in ocean temperatures.

Pollution

* It has significantly contributed to reduction in numbers of a diverse group of species.

Pollution may be classified as:

Air Pollution:

→ It involves emission of oxides of nitrogen, oxides of sulfur and CO_2.

→ These harmful emissions contribute to acid rain and global warming.

Industrial and Domestic Pollution :

→ It involves the release of harmful chemical into the atmosphere such as the polychlorinated biphenyls (PCBs)

- PCBs are responsible for reducing the fertility and weakening the immune system in certain birds and mammals.

Marine Pollution :

→ It involves disposal of non-biodegradable plastic into nearby rivers and lakes. These plastic bags are mistaken as jelly fish by turtles that ingest them.

Overexploitation & unsustainable use of resources

*It includes overfishing and cutting of valuable trees (teak) which led to endangerment of a considerable no. of species.

Food shortages:

*It may be due to disruption in the food chain and food web.

Disease:

*For e.g. viral infections.

Reduction in Breeding Sites of Organisms

Invasion of alien species

It involves introduction of an organism to an ecosystem where it was originally absent. These alien species are responsible for:

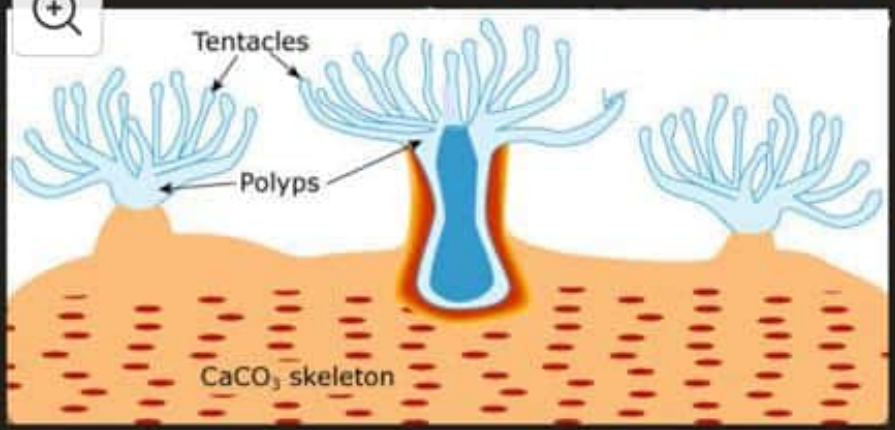
- Pushing the native organisms to endangerment or extinction (discussed in detail later).

Examples of endangered species

1. African elephants
2. Coral reefs
3. Polar bears
4. White-backed vultures

African elephants

1. Habitat loss
2. Hunting
3. Poaching



Coral reefs

1. Global warming
2. Acid rain
3. Overfishing
4. Tourism
5. Reclamation of land

Polar bears

1. global warming
2. Food shortage
3. Diseases

White backed vultures

1. diclofenac in carcasses causing kidney damage

African Elephants

African elephants have declined in numbers from 5 to 10 million to half a million over the last century.

The reasons for endangerment of African elephants include:

- **Habitat loss** due to deforestation. African elephants survive in Savannah habitats.
- **Deforestation** due to land requirements for housing, growth of crops and grazing of livestock has significantly contributed

To the reduction in numbers of elephants.

- **Hunting** for their ivory tusks and meat. Some are killed because they were considered as pests.
- **Poaching** which is illegal hunting of African elephants.

Poaching involves the use of automated weapons and airplanes to hunt down larger elephants. Killing of these animals disrupts the social structure of younger animals.

Coral Reefs

* Coral reefs make up one of the largest marine ecosystems.

* Corals are animals that use $CaCO_3$ from the sea to grow their skeleton.

* Symbiotic algae grow within the polyps of coral reefs where they provide nutrition to the corals in exchange for mineral ions.

* These algae are also responsible for providing colour to the corals.

* Coral reefs provide a habitat to 25% of the known fish species.

The reasons for endangerment of coral reefs include:

- Acid rain which lowers the pH of lakes & rivers. The drop in pH damages the $CaCO_3$ skeleton of corals.
- The rise in the temperature of the ocean due to global warming causes the algae to leave the polyps. This causes the whitening of the corals termed as "coral

bleaching'.

- Tourism
- Overfishing
- Reclamation of land

Polar Bears

* The reasons for the endangerment of polar bears include:

- Reduction in the Arctic ice sheets due to global warming.
- Reduced availability of food due to endangerment of seals.
- Diseases
- Polar bears have to travel long distances in search of food.

White-backed Vultures

* The carcasses these vultures fed on were treated with a painkiller Diclofenac that caused kidney damage in vultures.

Previously,

* Classification → taxonomy
* Domains
* Kingdoms
* Endangered & Extinct species
* Reasons for endangerment
* Examples of endangered species

Need to maintain biodiversity

① Ecological reasons

a. stability of an ecosystem
b. conservation of gene pool

② Human reasons

a. medicines
b. agriculture
c. tourism
d. religious
e. ethical

③ Commercial reasons

a. conserving wild relatives to produce hybrids with higher yields
b. conservation of microorganisms for enzymes and antibiotics

④ Aesthetic/socioeconomic reasons

a. creative individuals derive inspiration from nature
b. ecotourism boosts economy

The need to maintain biodiversity

* Biodiversity needs to be maintained for the following reasons :

- Ecological Reasons
- Human Reasons
- Social and Commercial Reasons
- Aesthetic / Economic Reasons.

Ecological Reasons :

* Biodiversity needs to be maintained to ensure stability of an ecosystem.

* All the organisms in an ecosystem interact in many different ways and if one of the organisms disappear it can affect the whole community.

* The maintenance of biodiversity ensures that the gene pool of the various species within an ecosystem is conserved.

Human Reasons :

* To provide possible medicines.
* For use in agriculture either as potential food supplies or to be crossed with existing agricultural species to improve features such as yield and disease resistance.
* To encourage tourism in some countries
* From an ethical point of view if human activity has been largely responsible for decline in biodiversity hence humans have an obligation to reverse this decline.

*Equally important is to try and maintain the current levels of biodiversity for future generations.

*Some people worship nature. Thus conservation of species could be due to religious reasons.

Commercial Reasons:

* Many crops are threatened by climate changes and habitat destruction.

* These plants do not have as much genetic diversity as their wild relatives because it has been lost by selective breeding.

* Crossing crop plants of different varieties may produce hybrids that are resistant to diseases and climatic changes

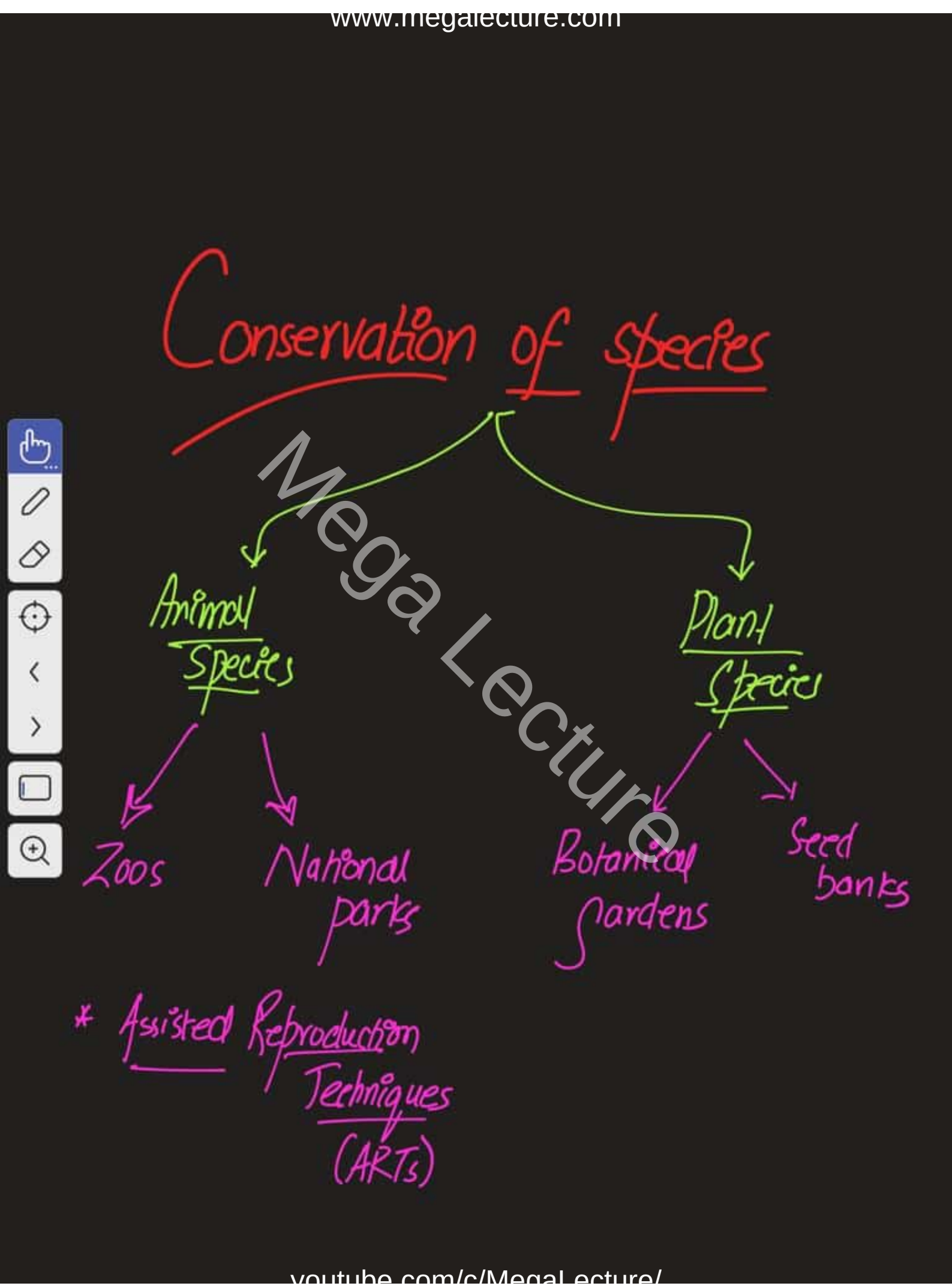
These crop plants have a better yield and therefore will have a greater commercial value.

* Certain micro-organisms are a source of useful products such as enzymes & anti-biotics.

Thermophilus aquaticus is the source of heat-stable DNA Polymerase known as Taq Polymerase. This enzyme is used in the polymerase chain reaction To produce large quantities of the DNA.

Aesthetic / Socioeconomic reasons

* Many people gain pleasure from studying or just appreciating the natural world which continues to provide an inspiration for the artists, photographers, viewers and other creative people.
* Wildlife is the source of income for many countries, as eco-tourism has increased in popularity.
* This form of tourism provides employment and contributes to the economy of the nation.



Conservation of endangered animal species

Conservation of animal species:

* Animal species can be conserved using the following methods:

- Zoos
- National Parks
- Assisted Reproduction Techniques

Zoos

* Zoos provide a source where endangered species of animals can be captivated and bred. This is known as captive breeding.

* Captive breeding is carried out To increase their numbers.

* They are protected from the predators and diseases.

* Captivated animals are fed well in the captivity.

Captive Breeding: Advantages

* It is possible to monitor the health of the mother and foetus during pregnancy.

* The sperms and oocytes can be collected and stored in frozen form in sperm banks and frozen zoos. A frozen zoo is a collection of frozen sperms, oocytes & embryos.

* Frozen sperms and oocytes can be used for assisted reproduction techniques, such as artificial insemination, IVF, ZIFT, GIFT and surrogacy.

*Animals can be transferred to other countries where environmental conditions are more conducive for breeding.

It allows the keeping of breeding records and the genetic similarity b/w captivated organisms.

Captive Breeding: Challenges

* Although some species of animals may breed successfully in captivity others may find it difficult to breed in artificial habitat. Reasons for this may include:

→ they are no longer living in their natural habitat.

→ they may have stress and behavioral changes which may arise due to the change in environment.

→ female organisms may have disruption in their menstrual cycle due to the stress in captivity.

→ organisms may not prefer the chosen mate for breeding.

* Problems associated with releasing captive bred animals may include:

- Reduced availability of food in the wild.
- Increased susceptibility to diseases.
- They are at risk of predation by other animal species.
- At times animals find it difficult to move around in their natural habitat once they have been bred in captivity for a long time.

National Parks

* Many countries have designated areas often with a legislation to ensure protection of endangered species and maintain important habitats. How they work include:

- Patrolling of parks by wardens, rangers and volunteers.
- Restricted human access - footpaths maintained to avoid interference with habitat.

- Apart from conventional farming, agricultural activities are controlled.
- Mining and industrial activities are limited and controlled.
- Visitor centres can be established to educate the general public.
- 24 hours of surveillance of nests/breeding sites.

Assisted Reproductive Techniques

* Assisted Reproduction Techniques include methods to assist fertility in organisms with reduced fertility / no. of organisms or increase the. Methods include;
  - Artificial insemination
  - In Vitro fertilisation (IVF)
  - Intra-cytoplasmic sperm injections (ICSI)
  - ZIFT (Zygote intra-fallopian transfer)
  - GIFT (gamete intra-fallopian transfer)
  - Surrogacy.

But before we discuss ARTs ....

Frozen sperms and oocytes

* Spermatozoa may be collected from different organisms and stored in frozen form.

* Semen is collected from male organism and checked for sperm activity before dilution in a fluid containing a buffer solution (albumen)

* These sperm are then distributed in small tubes known as straws and stored

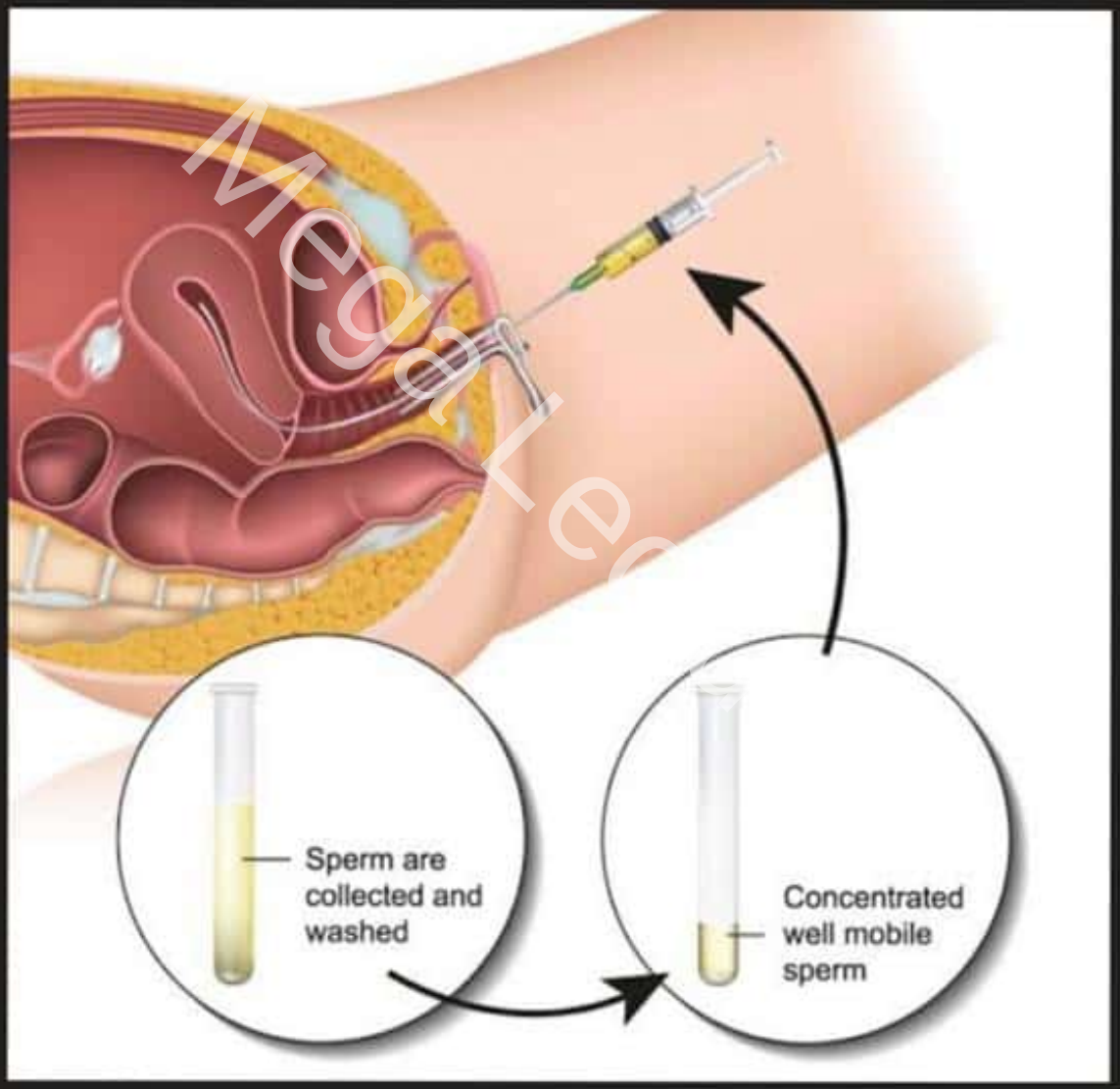
in liquid nitrogen at -196°C.

* Such a collection of sperm in frozen form is called the **sperm bank**.

* Storing oocytes is more difficult than sperm because they contain significant amount of cytoplasm.

* Water being the main component of cytoplasm forms ice crystals, which damage the intracellular organelles, when the oocytes are stored in frozen form.

Artificial Insemination



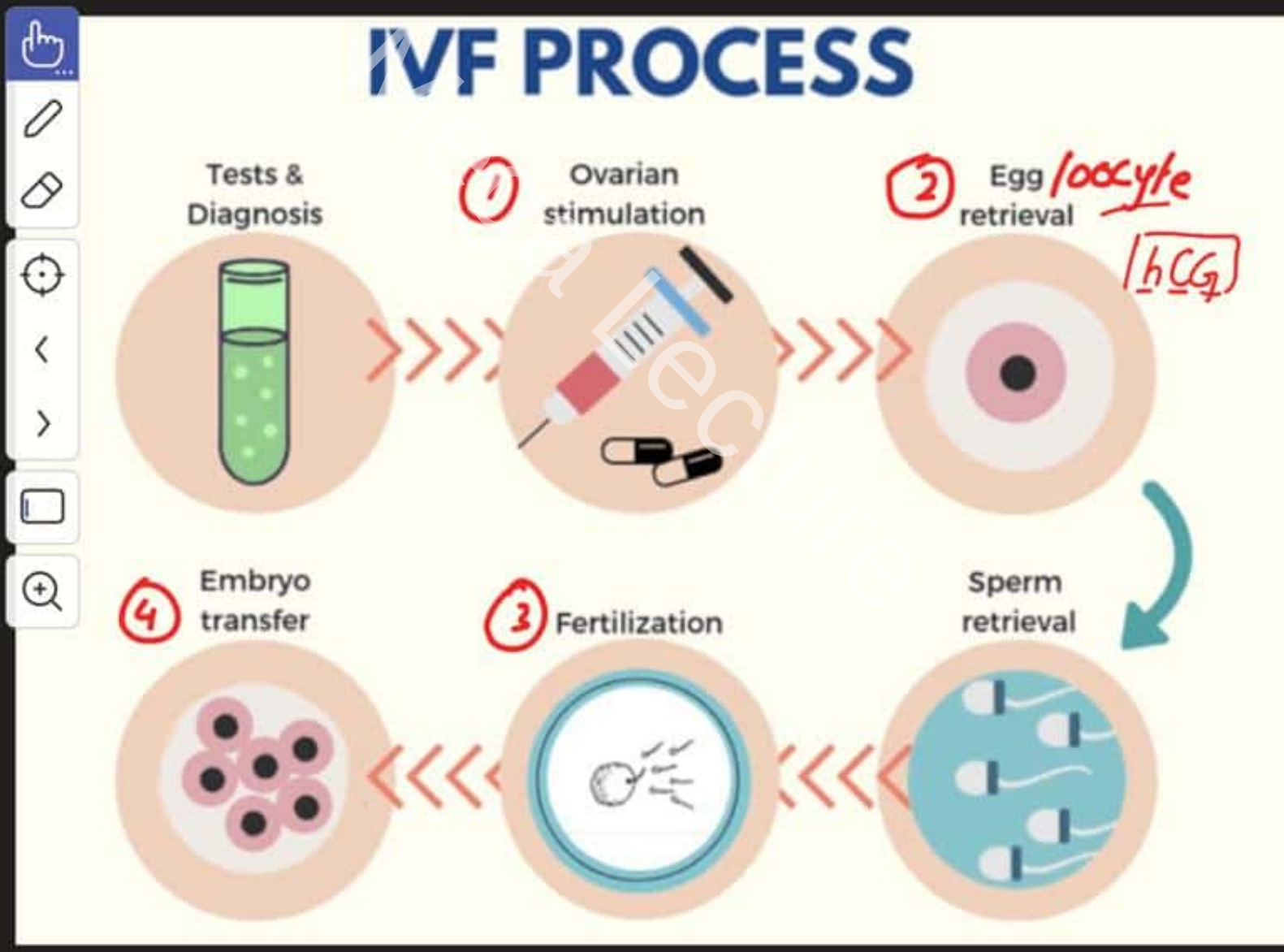
Artificial Insemination

+ It involves the transfer of sperms using a catheter into the uterus of a female organism.

+ Fertilisation therefore occurs in-utero leading to the formation of the zygote.

+ Occasionally the embryo formed in utero following mitotic division of the zygote is flushed out and transferred in the uterus of another organism.

In Vitro Fertilisation



In-Vitro fertilisation (IVF)

* IVF refers to the fertilisation in a glass tube outside the female reproductive tract.

* IVF involves the removal of the oocytes from the ovary and the sperm from the testes.

* Before the removal of the oocyte, the female organism is treated with hormones to allow maturation of multiple follicles simultaneously.

* This phenomenon is termed as **superovulation**

The oocytes are extracted from the ovary prior to ovulation using an ultrasound guided catheter.

The oocytes and sperm are mixed in a glass tube to form zygotes which are then transferred to the nutrient medium to allow the formation of multiple embryos.

* 2-3 embryos are thereafter transferred into the female reproductive tract.

Stages of IVF:

- Ovarian stimulation
- Oocyte Retrieval
- Fertilisation
- Embryo Transfer

OVARIAN STIMULATION

* Treatment normally starts on the third day of menstruation.

* Involves administration of hormones which will have an action similar To FSH.

* Stimulate the development of multiple follicles in the ovaries.

* 10 days of injection are usually necessary

OOCYTE RETRIEVAL

* Development of follicles is monitored by serum oestrogen levels.

* When the development of follicles is judged to be adequate, the hormone Human Chorionic Gonadotropin (hCG) is given.

* hCG has a similar effect to Leutinizing hormone.

* Ovulation is expected about 42 hours after injection.

* A needle is used to remove the oocytes directly from the ovaries before ovulation takes place.

FERTILISATION

The oocytes are stripped of any surrounding cells and are incubated with sperm (approximately 75000 : 1 for about 18 hrs.

* Where sperm counts are low, it is also possible to inject sperm directly into the oocyte.

* The fertilised egg is now placed in a special growth medium and left for 48 hours.

* It reaches the 6-8 cell stage in 48 hours.

EMBRYO TRANSFER

* Embryos which are growing successfully are transferred to the patient's uterus through a thin plastic catheter.

* Often multiple embryos will be transferred to improve the chances of implantation & pregnancy.

* During the next few weeks, the woman is administered progesterone, which helps the uterine lining to thicken and become suitable for implantation.

SUCCESS IN IVF

* The chance for a successful pregnancy varies from clinic to clinic. Success rates could be as high as 20-30%.

* Many factors influence the success rate:
  - Age of patient
  - Quality of eggs & sperm

* The main complication of IVF is the possibility of multiple births.

* This occurs due to the practice of transferring more than one embryo to the uterus at the same time.

* There is no significant increased risk of birth defects from the procedure but it remains controversial.

* Some embryos are frozen in liquid nitrogen and can be preserved for a very long time.

* If the patient fails to conceive, the frozen embryos can then be used.

* They can also be used in case the couple wishes to become pregnant again after a successful pregnancy.

Biodiversity classification & conservation

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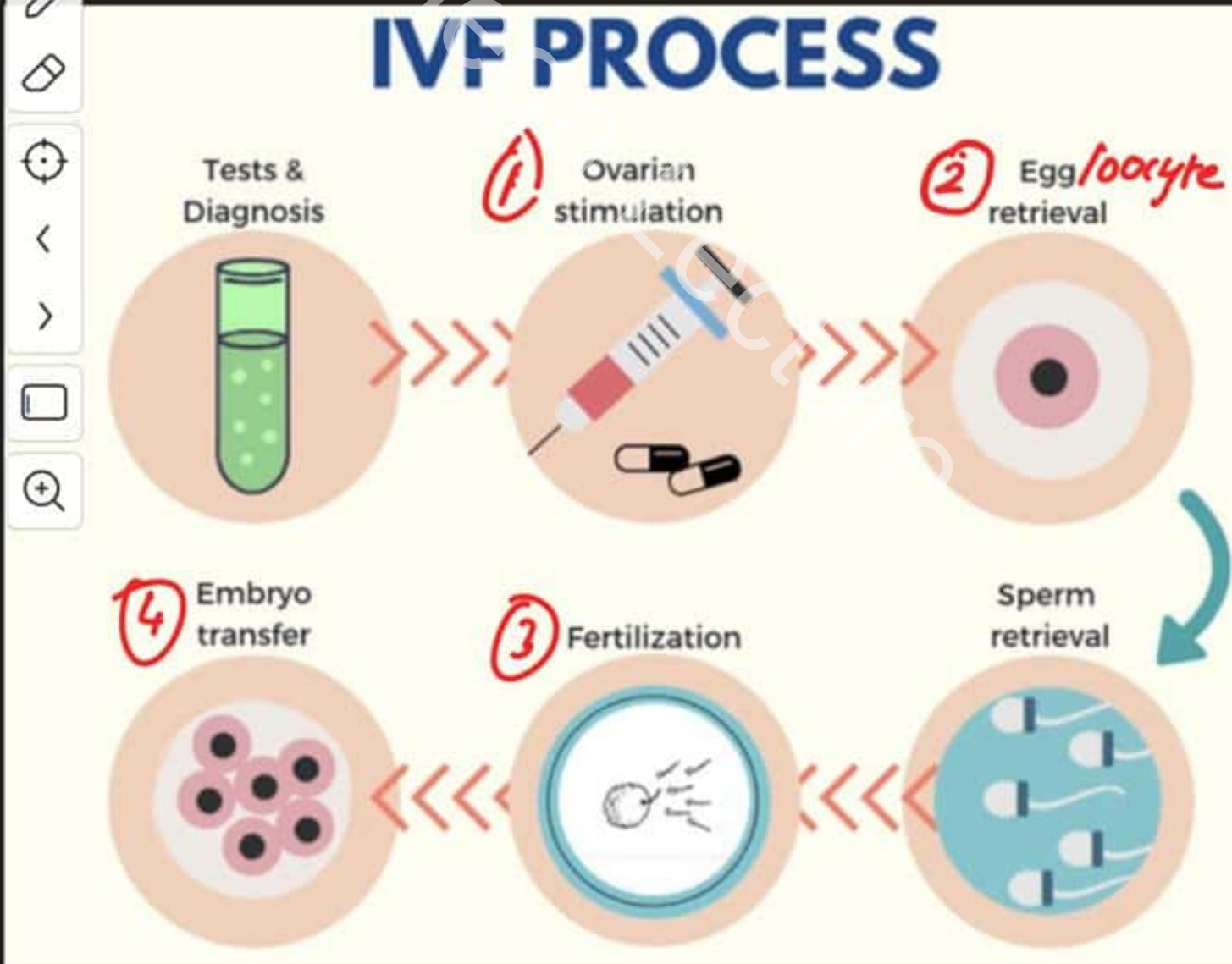
Assisted Reproductive Techniques

* Assisted Reproduction Techniques include methods to assist fertility in organisms with reduced fertility or Increase the no. of organisms. Methods include;
  - Artificial insemination
  - In Vitro fertilisation
  - Intra-cytoplasmic sperm injections (ICSI)
  - ZIFT (Zygote intra-fallopian transfer)
  - GIFT (gamete intra-fallopian transfer)
  - Surrogacy.

Stages of IVF:

- Ovarian stimulation
- Oocyte Retrieval
- Fertilisation
- Embryo Transfer



Ethical Implications of IVF

* Bypassing the natural method of conception and making pregnancy into a technological/ medical process.
* Expensive so unavailable to many people.
* Fertilising more embryos than will be needed and then discarding unwanted embryos.
* Freezing and long-term storage of embryos with unknown potential effects.

* Potential to create embryos for research, or to grow tissues and organs for transplant.

* Potential to select and modify embryos, permit selection of embryos that do not contain lethal alleles.

* Possible for single people and same sex couples to have children.

* Legal and ethical considerations of surrogacy or third party involved.

* Pregnancy possible even after menopause via IVF and subsequent implantation.

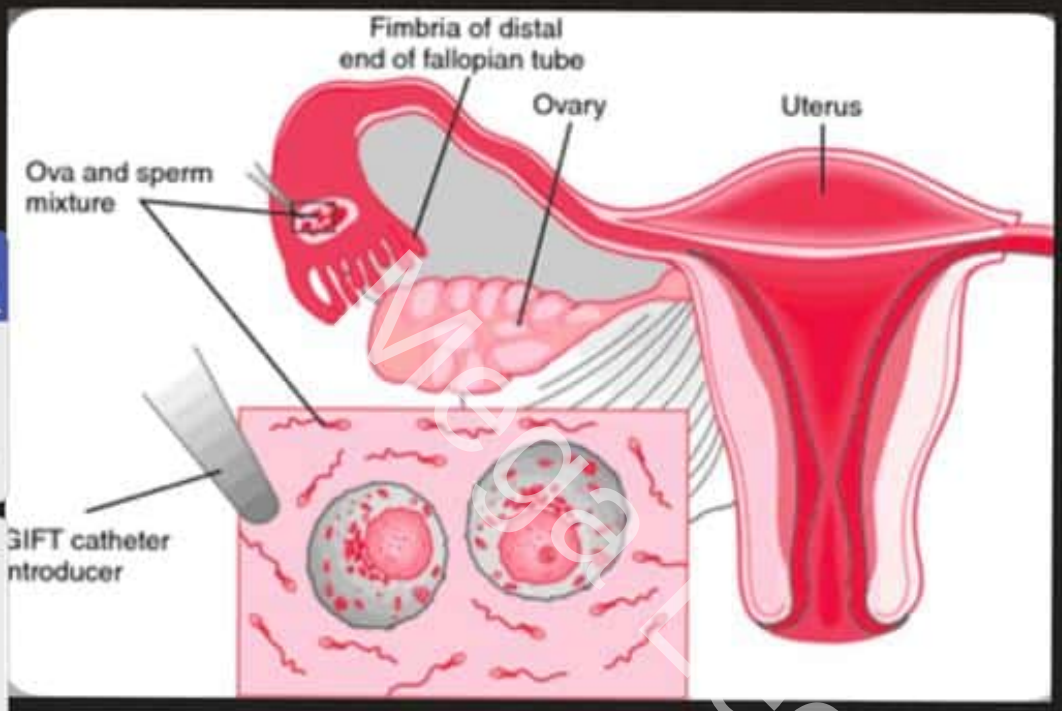
* Religious groups consider infertility as a sign from God and IVF as usurping the role of God.

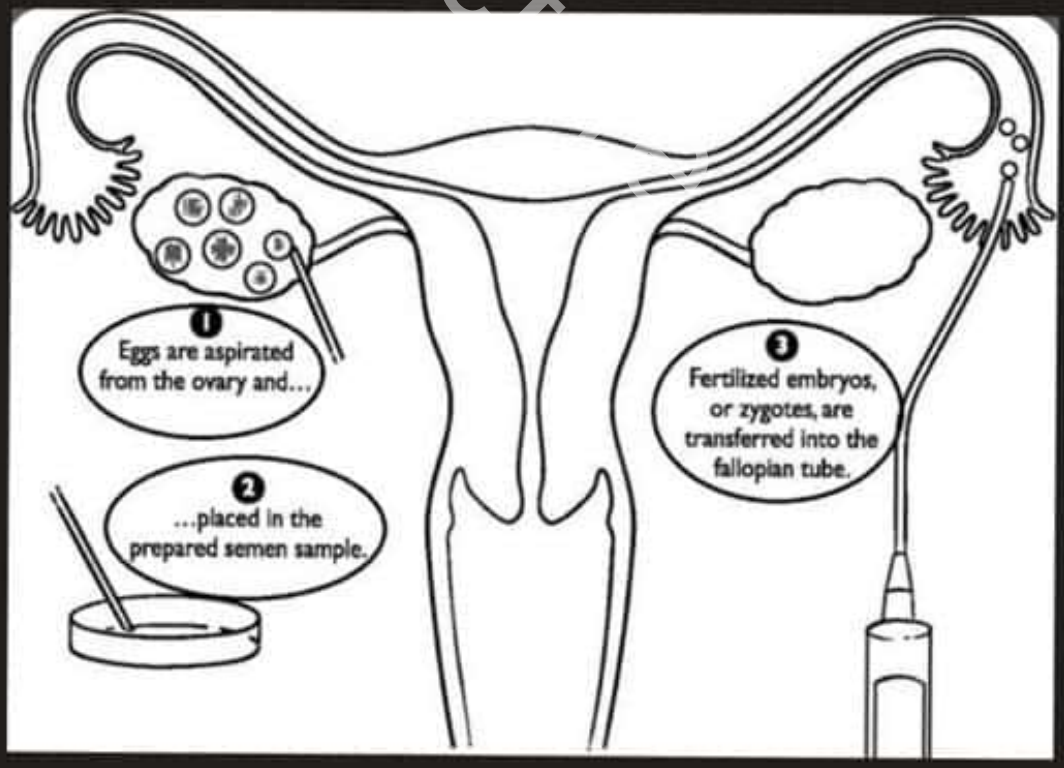
Intra-Cytoplasmic Sperm Injection (ICSI)

* ICSI is a technique which involves fusion of a visibly healthy sperm (shape & motility) with an oocyte to form a zygote outside the female reproductive tract.

* The disadvantage of the ICSI is that the genotype of the sperm can be abnormal leading to the formation of a zygote with chromosomal or gene abnormalities.

GIFT & ZIFT





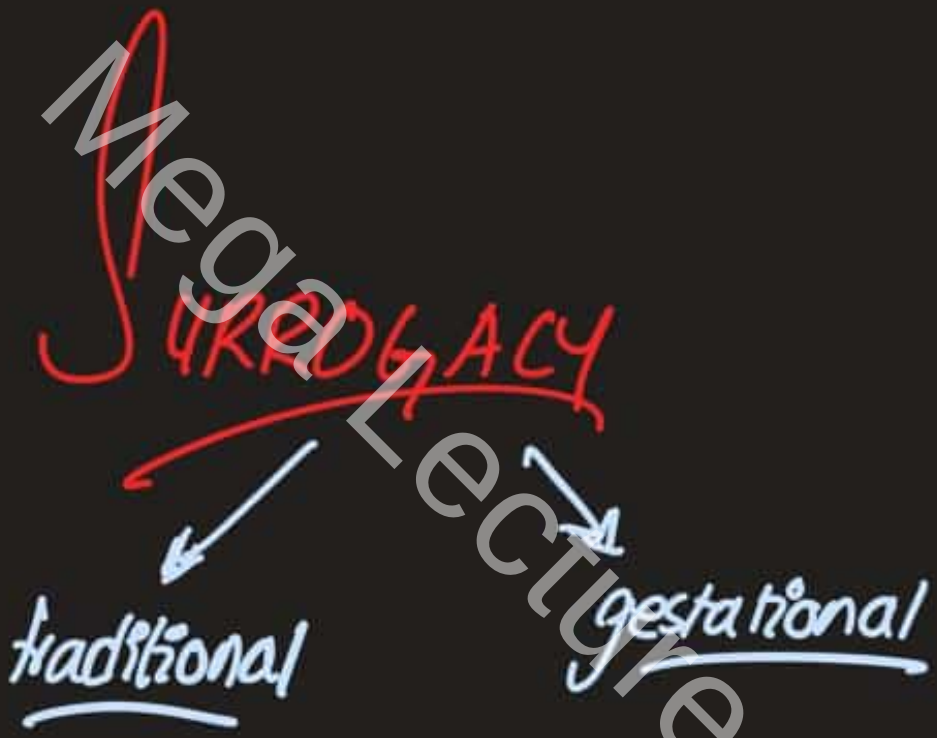
GIFT & ZIFT

* Zygote intra-fallopian transfer (ZIFT)

* Gamete intra-fallopian transfer (GIFT)

* Gamete intra-fallopian transfer involves the transfer of sperms & the oocytes into the fallopian tube of the female reproductive tract.

* Zygote intra-fallopian transfer involves the formation of zygote in vitro & then transferring it to the fallopian tube of the female reproductive tract.

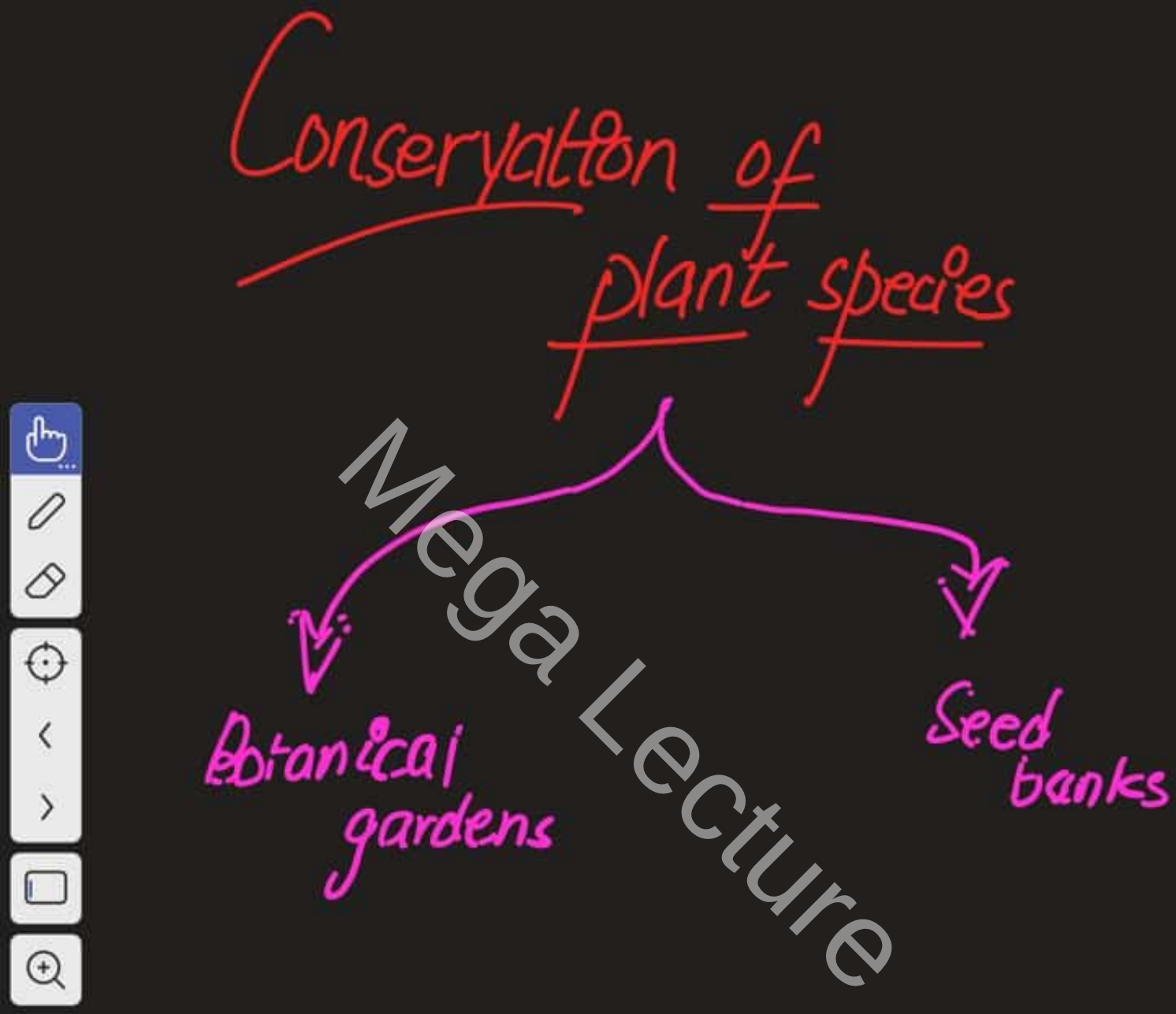


Surrogacy

* At times, the health of the female organism which donates the oocyte is not good enough to bear a normal pregnancy.

* In such cases, the embryos are usually transferred to the uterus of an unrelated female organism. This is surrogacy.

It is advantageous because it helps in the conservation of endangered female organisms which cannot bear normal pregnancy.



CONSERVATION OF PLANT SPECIES

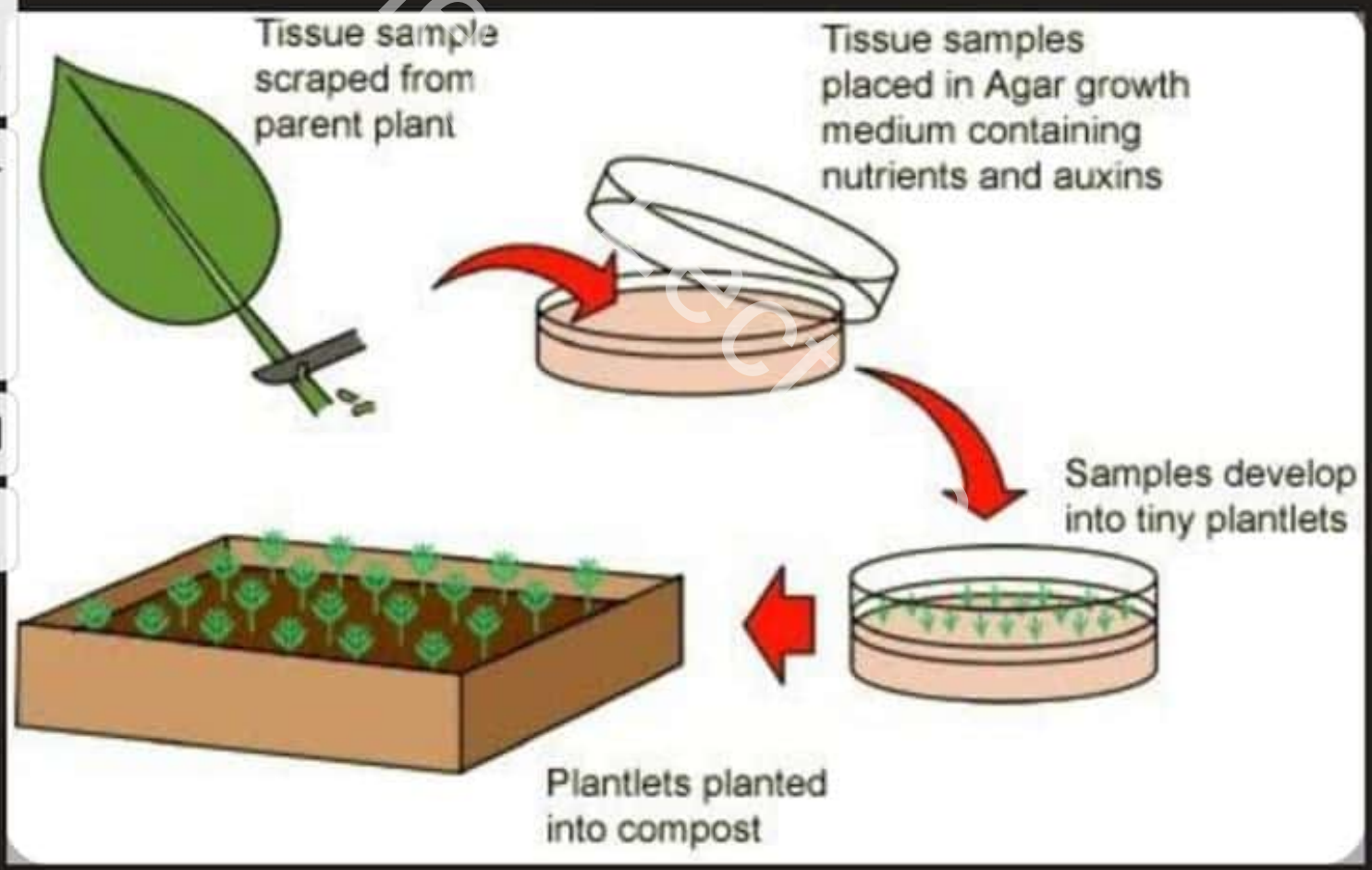
- Botanic Garden
- Seed Bank

Botanic Gardens :

- Botanic gardens, just like zoos, enable conservation of plant species by growing them from seeds, cuttings, tissue cullūres & cloning
- Tissue cullūre involves growth of a tissue sample in an agar medium under sterile conditions.

* Tissue samples develop into tiny plantlets

* Plantlets planted into soil



Role of Botanic Gardens:

The protection of endangered plant species which are threatened by climatic changes and human activities.

- Research methods of reproduction and growth so that species cultivated in Botanic gardens can be grown in appropriate conditions to be propagated.
- Research conservation methods so plants can be introduced to new habitats if their original habitat has been destroyed.
- Reintroducing plants to the habitats where they have become extinct.
- Educating the general public regarding the ecological & economic value of plant species.

Seed Banks

*Seed Banks are an effective way of conserving the gene pool of organisms of different species.

* A seed bank is a collection of seeds of plants (that are endangered or extinct) in conditions that are not suitable for germination.

* These conditions include an atmosphere low in moisture and oxygen, and low temperature.

* Orthodox seeds can be stored for a long time period following dehydration.

* Recalcitrant seeds cannot be stored for a long time period due to the dehydration of the seed. Examples of such seeds include rubber and coconut plant seeds.

* These seeds are usually grown in botanic gardens before they expire. Plants that grow from these seeds are used as a source of collecting new seeds.

Q.

6 (a) The sea otter, *Enhydra lutris*, is a marine mammal that lives on the coasts of the North Pacific ocean.

Fig. 6.1 shows a sea otter.

Fig. 6.1

Table 6.1 shows part of the classification of the sea otter.

Table 6.1

taxonomic group	name
phylum	Chordata
..... Class	Mammalia
order	Carnivora
..... family	Mustelidae
genus	*Enhydra* ✓
species	*lutris* ✓

Complete Table 6.1 by adding the correct taxonomic groups in the **two** spaces provided. [2]

(c) Seaweeds, such as kelp, are large algae that can grow to be over 30 metres in length. In the ocean along the coasts of California, USA, there are very dense areas of kelp called kelp forests. Kelp forests are very productive and diverse ecosystems.

Fig. 6.2 shows a kelp forest.

Fig. 6.2

The sea otter is a keystone species in kelp forests along the coasts of California. This means that sea otters have a larger than expected effect on other organisms in these kelp forests. The loss of the sea otter would cause major changes to the kelp forest ecosystem and a reduction in biodiversity.

Fig. 6.3 shows part of a food web in a kelp forest. The arrows show the direction of energy flow.

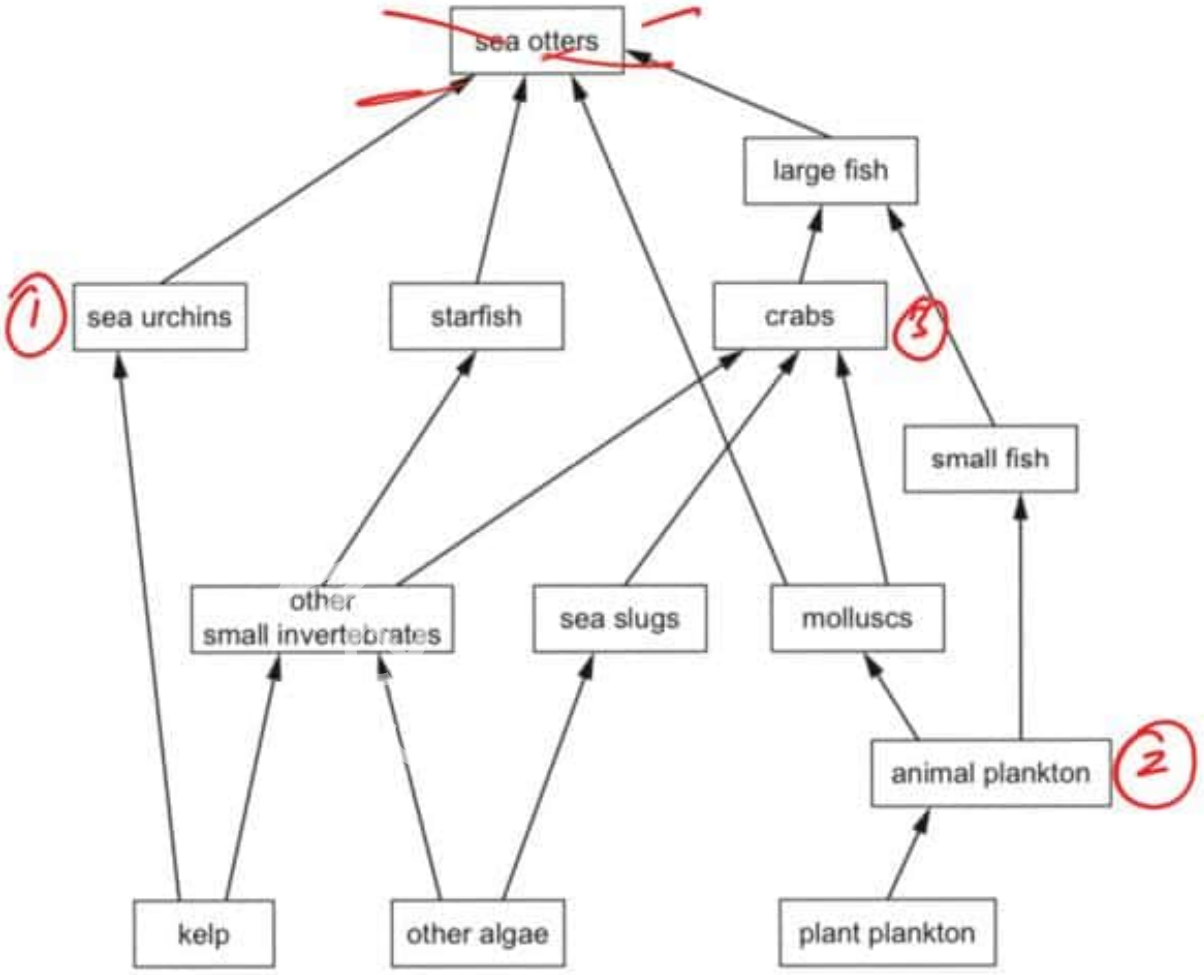


Fig. 6.3

Using Fig. 6.3, suggest **and** explain what would happen to the numbers of sea urchins, animal plankton and crabs if sea otters in this kelp forest became extinct.

sea urchins numbers will increase b/c the predators (sea-otter) become extinct

animal plankton numbers will decrease b/c the no. of molluscs increase

crabs numbers will decrease b/c the large fish increase in numbers.

[3]

Q.

8 (a) Most organisms are classified according to a taxonomic hierarchy.

The hierarchy is shown in Fig. 8.1 but the group names are not in the correct order.

1 – kingdom

2 – order

3 – genus

4 – family

5 – domain

6 – class

7 – species

8 – phylum

Fig. 8.1

Complete Table 8.1 by writing the numbers in the correct order.

Table 8.1

5	1	8	6	2	4	3	7

[2]

(b) Members of the Eukarya domain share similar features but will also have several differences.

Complete Table 8.2 by stating the differences between the kingdoms Fungi and Plantae.

Table 8.2

	Fungi	Plantae
type of nutrition	heterotrophic	autotrophic
storage polysaccharide	glycogen	starch
main component of cell wall	chitin	cellulose

[3]

(c) Name the domain that contains organisms with a peptidoglycan cell wall.

Bacteria [1]

(d) Viruses are not included in the three domain classification.

Outline how viruses are classified.

* Viruses are classified on the basis of the nucleic acid into DNA or RNA viruses
* The DNA/RNA may be single stranded or double stranded

[2]

Q.

8 Palm oil is a vegetable oil that is used very widely in food products. The oil is extracted from the fruit of the oil palm tree.

(a) Oil palm trees have a higher oil yield than that of other oil-producing plants.

Fig. 8.1 shows the oil yield of four crop plants.

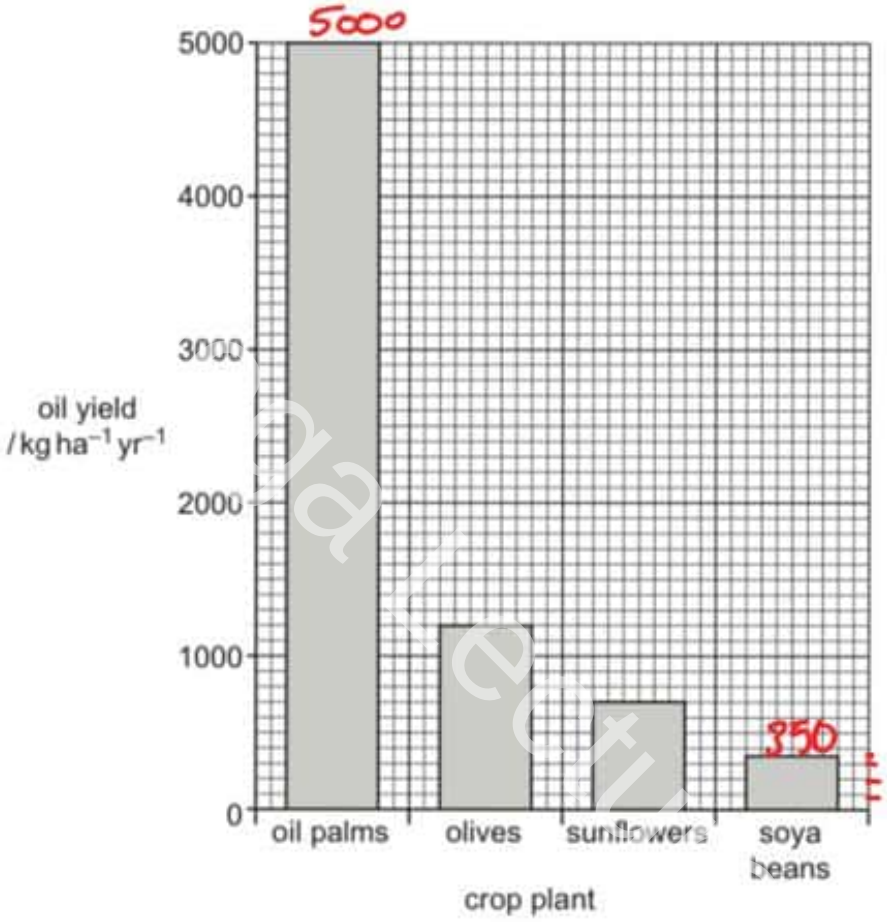


Fig. 8.1

Calculate how many hectares of soya bean plants would be needed to produce the **same** yield of oil as one hectare of oil palm trees.

Show your working and write your answer to **one** decimal place.

No. of hectares of soyabean required = $\frac{5000}{350}$ = 14.3

answer 14.3 hectares [2]

(b) Oil palm plantations in Malaysia and Indonesia have been created by cutting down rainforests. This reduces biodiversity.

Outline reasons why it is important to maintain biodiversity.

* to maintain the stability of the ecosystem & to conserve the gene pool
* aesthetic reasons
* species for medicinal purpose
* ecotourism
* moral/ethical reasons

[5]

(c) Palm oil companies are now being asked to produce palm oil in a sustainable way. This means that no more deforestation should take place.

Suggest ways in which individual consumers can encourage manufacturers to use palm oil from sustainable sources.

* to stop buying unsustainable palm oil products
* to raise awareness amongst masses regarding the use of sustainal palm oil sources

[2]

Q.

9 **(a)** Compare the characteristic features of members of the kingdoms Fungi and Animalia. [7]

(b) Discuss the methods used in breeding programmes for endangered mammal species **and** outline the problems that may occur with these programmes. [8]

[Total: 15]

a) *Similarities
- eukaryotic cells (1)
- linear DNA bound to histones
- cells have a true nucleus
- 80S ribosomes
- membrane bound organelles (1)
- heterotrophic (1)
- glycogen as storage polysacch. (1)

*Differences

FUNGI	ANIMALIA
① Multicellular with yeast being unicellular	① Multicellular organised into tissues and organs
② hyphae/mycelium	② devoid of hyphae
③ cell wall made of chitin	③ Dont possess a cell wall
④ Reproduce via spores	④ Reproduction via gametes

Q.

9 (a) Viruses are not included in the three domain classification system as they have different features from most organisms.

Describe the features of viruses. [8]

1) viruses are acellular
2) viruses are particles made up of proteins and nucleic acids
3) Nucleic acid may be DNA or RNA
4) DNA/RNA may be single stranded or double stranded
5) Protein coat → capsid
6) Capsid is made up of capsomers
7) Some viruses have an external glycoprotein membrane envelope
8) Viruses survive & replicate inside the host cells
9) Viruses are parasitic
10) Viruses have no cytoplasm

Biodiversity, classification & conservation

Previously,

* Classification → taxonomy
* Domains
* Kingdoms
* Endangered & Extinct species
* Reasons for endangerment
* Examples of endangered species
* Conservation of animal species
* Assisted Reproductive techniques
* Conservation of plant species

Definitions

* **Biodiversity** implies diversity in;
  1. Species (diversity) → species richness, species evenness
  2. Genetic (diversity)
  3. Ecosystem / habitat (diversity)

* **Species** are a group of organisms with similar morphological and physiological features which can interbreed to produce fertile offsprings. All organisms of the same species are reproductively isolated.

* **Ecosystem** is a relatively self-contained interacting community of living organisms (biotic) and the environment in which they live (abiotic) and with which they interact.

* Habitat
* Niche
* Population
* Community
* Species richness
* species evenness
* species distribution
* species abundance

Definitions

Biodiversity refers to :

- Species diversity (discussed later)
- Genetic diversity (discussed later)
- Ecosystem diversity (discussed later)

Habitat :

It refers to the place where an organism lives.

Niche :

It refers to the functional role of an organism in an ecosystem.

Population :

Population is a group of organisms of the same species occupying a given area at a given time.

Species :

It is a group of organisms having similar physiological and morphological features which can interbreed to produce fertile offsprings. All the organisms of the same species are reproductively isolated.

Community :

It refers to all the organisms of different populations occupying a given area at a given time.

Ecosystem :

It is a relatively self-contained, interacting community of living (biotic) organisms and the environment (abiotic) in which they live and with which they interact.

Biotic → living

Abiotic → non-living

- Species diversity
- Genetic diversity
- Ecosystem diversity

Species Diversity:

* It refers to the different types of species (richness) and the relative abundance (evenness) of each species within an ecosystem.

* Species richness:

It refers to the different type of species within an ecosystem.

* Species evenness:

It refers to the relative abundance of each species within an ecosystem.

Additional terms ....

* **Species distribution :**

It refers to the spread of an organism within an ecosystem.

* **Species abundance :**

It is the total number of organisms of a particular species in an ecosystem.

Measuring species diversity

Simpson's Index of Diversity (D)

$$D = 1 - \sum \left(\frac{n}{N}\right)^2$$

* values range bw 0 and 1
* greater the value of D → greater is the species diversity
* no units

n → no. of organisms of a species

N → total no. of organisms of all the species

Q. How can we measure species diversity?

* Species diversity can be measured using the Simpson's index of diversity (D)

The Simpson's Index of diversity can be calculated using the following expression:

$$D = 1 - \sum \left(\frac{n}{N}\right)^2$$

Where,

n = no. of organisms of particular species

N = total no. of organisms of all the species

* The value of D ranges from 0-1. The closer the value to 1, the greater is the species diversity of an ecosystem. The greater the diversity, the more stable is the ecosystem.

* Low value of D may result due to;

- Less number of different species within an ecosystem.
- Dominance by one or more species within an ecosystem.

Genetic Diversity:

* Genetic diversity is the diversity of alleles within the genes in the genome of a single species.

* Genetic diversity can be assessed by finding out what proportion of genes have different alleles and how many alleles there are per gene.

* Genetic Diversity is important in providing populations with the ability to adapt to changes in biotic and abiotic factors, such as

competition with other species (Biotic), new strains (biotic) of disease, changes in temperature (abiotic), rainfall & humidity (abiotic).

Ecosystem Diversity:

* An ecosystem is a relatively self-contained unit in which biotic and abiotic factors interact.

* Biotic factors are all the living organisms within an ecosystem.

* Abiotic factors are all the non-living components of an ecosystem, such as external temperature, availability of water & oxygen, humidity and rainfall.

* Examples of ecosystems include:

- Tropical rainforest
- Sandy desert
- Coral Reefs

Q.

(b) Table 8.1 shows the results of the sampling of field **A**.

Table 8.1

	species	number of individuals (n)
1	*Scabiosa columbaria*	13
2	*Centaurea centaurium*	15
3	*Primula veris*	26
4	*Trifolium pratense*	36
5	*Leucanthemum vulgare*	11
6	*Silybum marianum*	5
7	*Anacamptis morio*	8
	total number of individuals (N)	N= 114

Simpson's Index of Diversity (D) is a value of the species diversity in an area.

The formula for this is:

$$D = 1 - \left(\Sigma\left(\frac{n}{N}\right)^2\right)$$

Σ = sum of
n = number of individuals of a species
N = number of individuals of all species

(i) Complete Table 8.2 for *Primula veris*.

Table 8.2

species	n	$\frac{n}{N}$	$\left[\frac{n}{N}\right]^2$
Scabiosa columbaria	13	0.11	0.01
Centaurea centaurium	15	0.13	0.02
Primula veris	26	0·23	0·05
Trifolium pratense	36	0.32	0.10
Leucanthemum vulgare	11	0.10	0.01
Silybum marianum	5	0.04	0.00
Anacamptis morio	8	0.07	0.00

$\Sigma = 0{\cdot}19$ [1]

(ii) Use the data in Table 8.2 to calculate Simpson's Index of Diversity (D) for field **A**.

Show your working and write your answer to **two** decimal places.

$D = 1 - \left(\Sigma\left(\frac{n}{N}\right)^2\right) = 1 - 0{\cdot}19 = 0{\cdot}81$

$D =$ 0·81 [2]

(iii) The value of D for field **B** was 0.45.

Comment on the values of D for both fields.

field A has a higher species diversity than field B

[1]

Q.

8 (a) Explain what is meant by the term *biodiversity*.

* Biodiversity implies species diversity, genetic diversity and ecosystem / habitat diversity. Species diversity involves the no. of different type of species and the relative abundance of the species in an ecosystem. [3]

(b) Simpson's Index of Diversity (D) is a method of assessing biodiversity.

The formula for Simpson's Index of Diversity is:

$$D = 1 - \left(\Sigma\left(\frac{n}{N}\right)^2\right)$$

n = number of individuals of each species present in the sample
N = total number of all individuals of all species

(i) In an investigation of biodiversity in a pond, samples of pond animals were removed using sampling nets. The species of each animal was identified and the number of individuals of each species was recorded.

Table 8.1 shows the results of the investigation.

Calculate Simpson's Index of Diversity by completing Table 8.1 in the spaces provided. Record your values to three decimal places.

Write the value for Simpson's Index of Diversity on the dotted line. Record your value to three decimal places.

Table 8.1

species	number	$\frac{n}{N}$	$\left(\frac{n}{N}\right)^2$
Rana temporaria	10	0.042	0.002
Leucorrhinia dubia	35	0.148	0.022
Hydrometra stagnorum	50	0.212	0.045
Lymnaea stagnalis	44	0.186	0.035
Gammarus pulex	97	0.411	0.169
total	236		$\Sigma = 0.273$

$D = 1 - 0.273$
$= 0.727$

Simpson's Index of Diversity (D) = 0.727 [3]

(ii) Explain what this value for Simpson's Index of Diversity shows about the diversity of the pond.

* D = 0.727 is a value closer to 1
* which indicates high species diversity

[2]

Q.

8 Table 8.1 shows the total number of plant species, the total number of insect species and the number of habitats in three areas, **A**, **B** and **C**.

Table 8.1

area	total number of plant species	total number of insect species	number of habitats
A	6	5	1
B	15	23	4
C	362	70	12

(a) Identify the area with the highest biodiversity.

Give reasons for your choice of area.

area C

reasons

* highest different no. of plant and insect species
* highest no. of different habitats

[3]

(b) Identify the area that is likely to be affected the most if the environment changes.

Give a reason for your choice of area.

area A

reason increase or decrease in one species will affect the entire community.

[1]

(c) State **one** reason why it is important to conserve biodiversity in **all** three areas.

* medicinal value of species

[1]

Q.

7 (a) Define the term *ecosystem*. (1)

* relatively self contained interacting community (2) of living organisms and the environment (3) in which they live and with which they interact.

[3]

(b) State the term used to describe:

the functional role of a species within an ecosystem

niche

a reproductively isolated group of organisms that interbreed to produce fertile offspring

species

physical factors in the environment such as temperature and soil pH.

abiotic

[3]

Biodiversity, classification & conservation

Previously,

* Biodiversity – definition
* Species, Generic & ecosystem diversity
* Simpson's Index of diversity (D)

Sampling

* The process of taking samples to determine species frequency, distribution, density, abundance and/or percentage cover within an ecosystem.

→ There are two ways to sample organisms

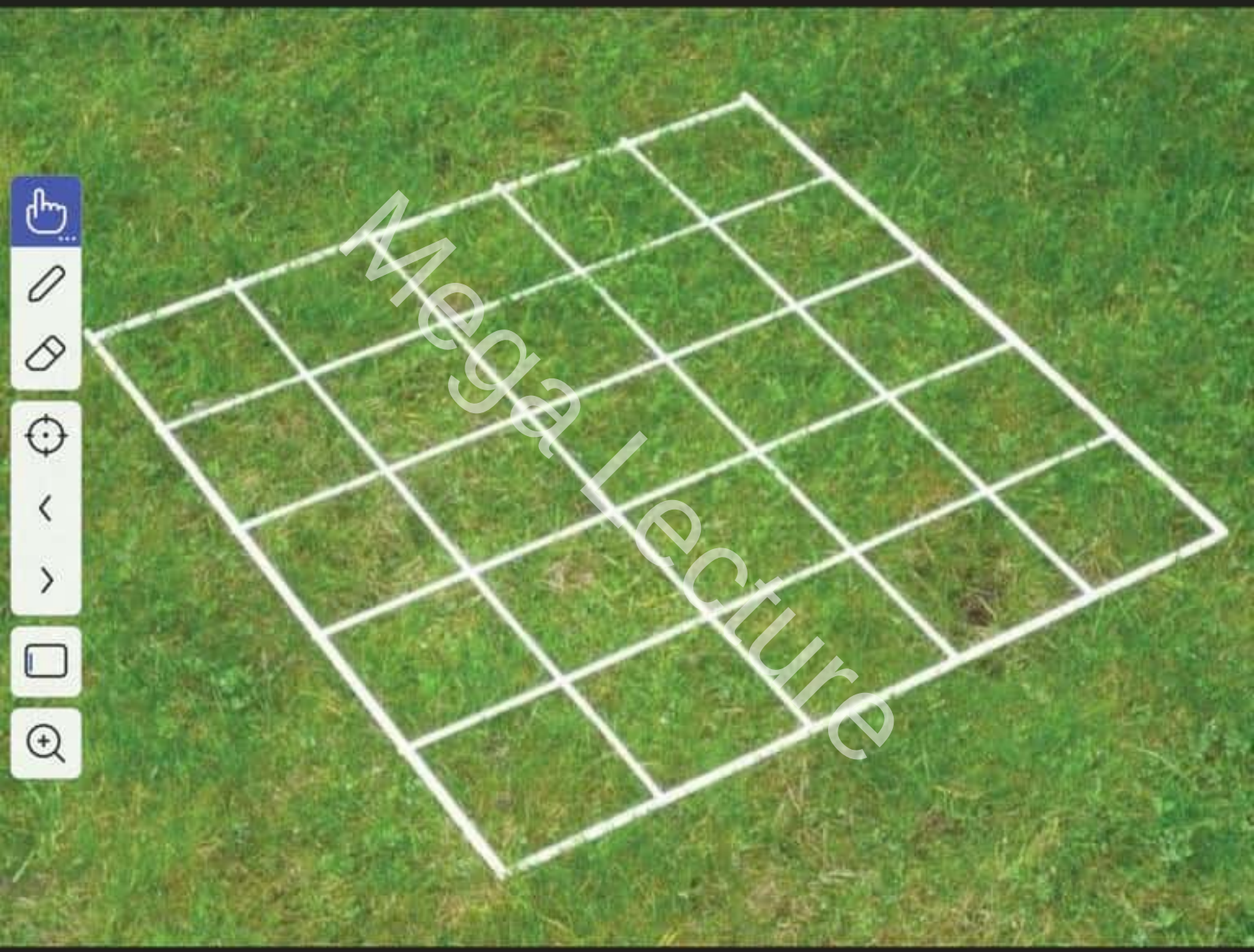
Random sampling

Systematic sampling

Before we discuss the sampling techniques...

Quadrat { frame that is used to mark off an area of land or water }

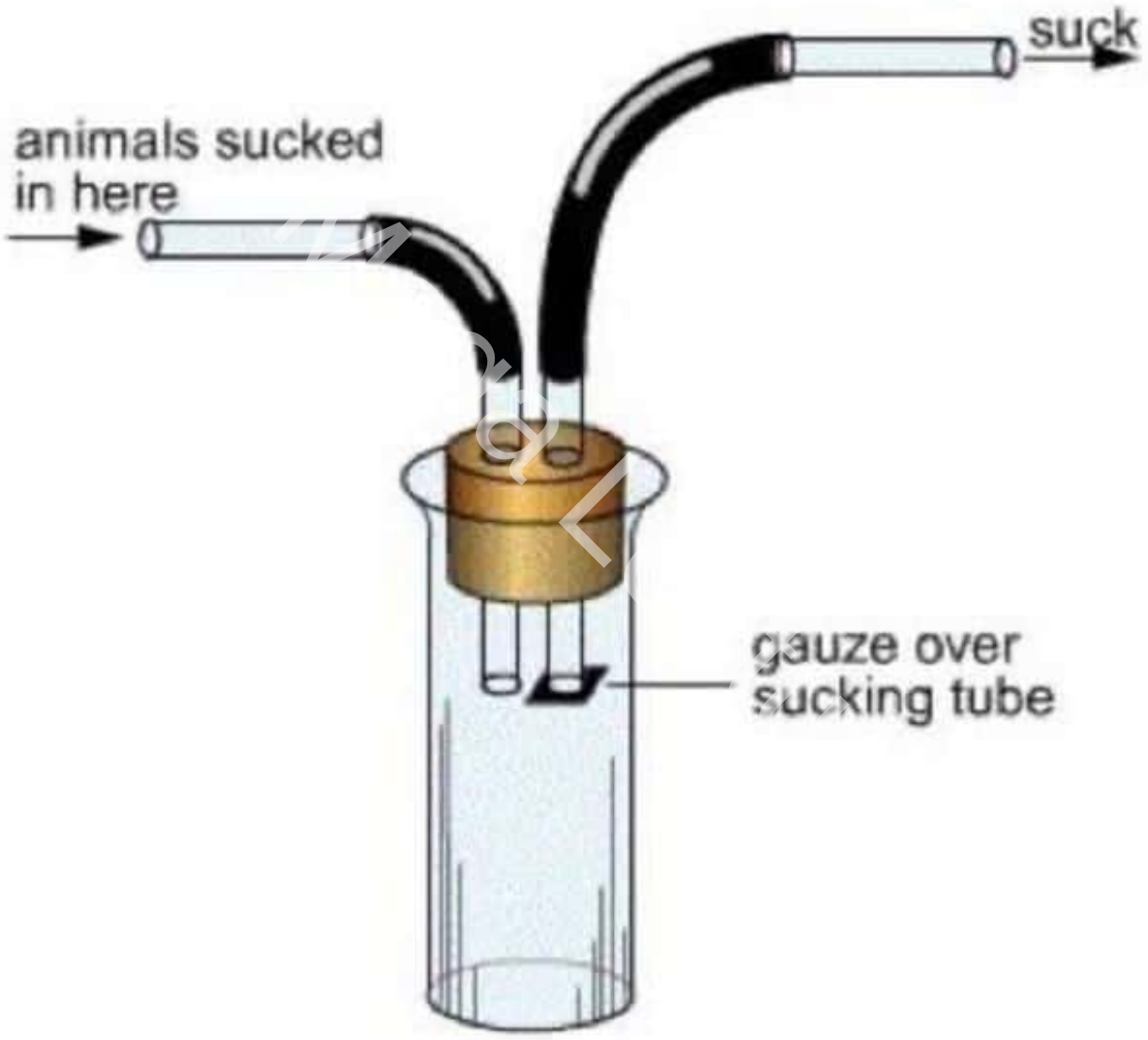
Quadrat



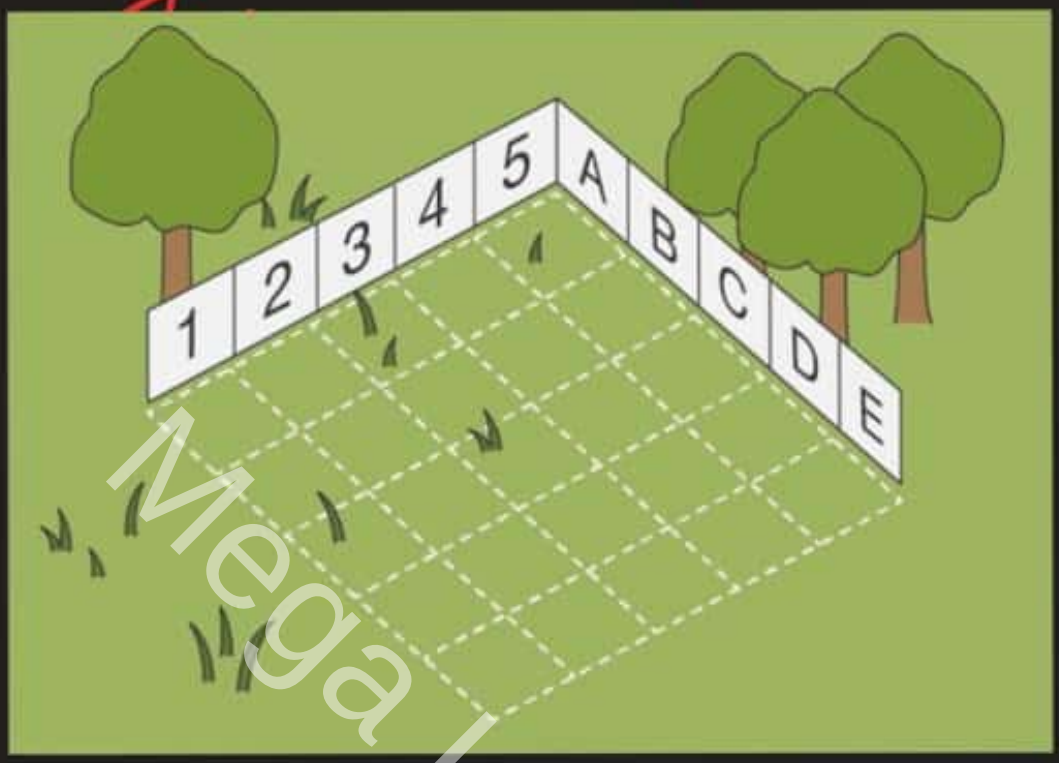
Net

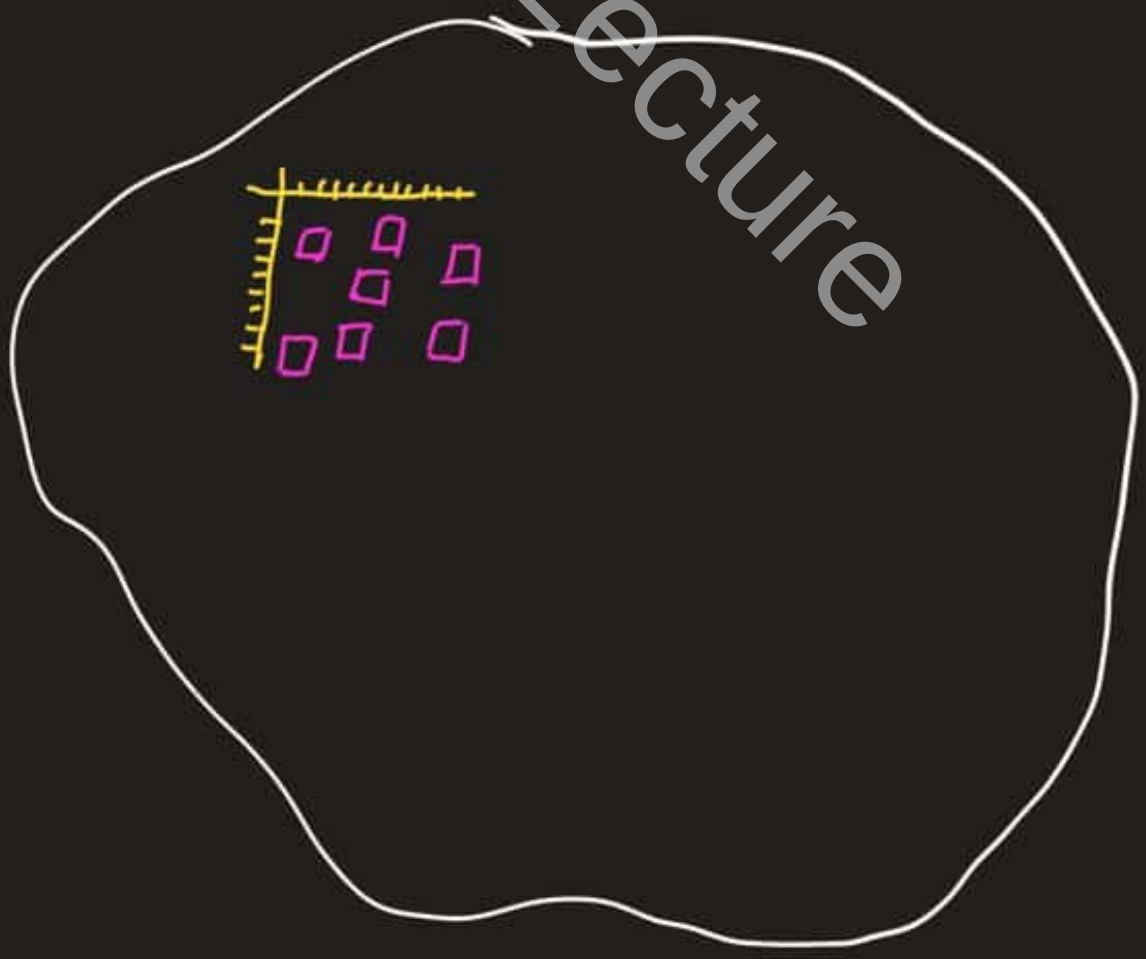
Trap

Pooter



Random Sampling





① Random (unbiased) Sampling

Random sampling is carried out if the physical conditions within an ecosystem are uniform and/or there is no clear pattern of distribution of organisms.

Random sampling is carried out using the following procedure:

1) Mark off an area of the ecosystem using a measuring tape.

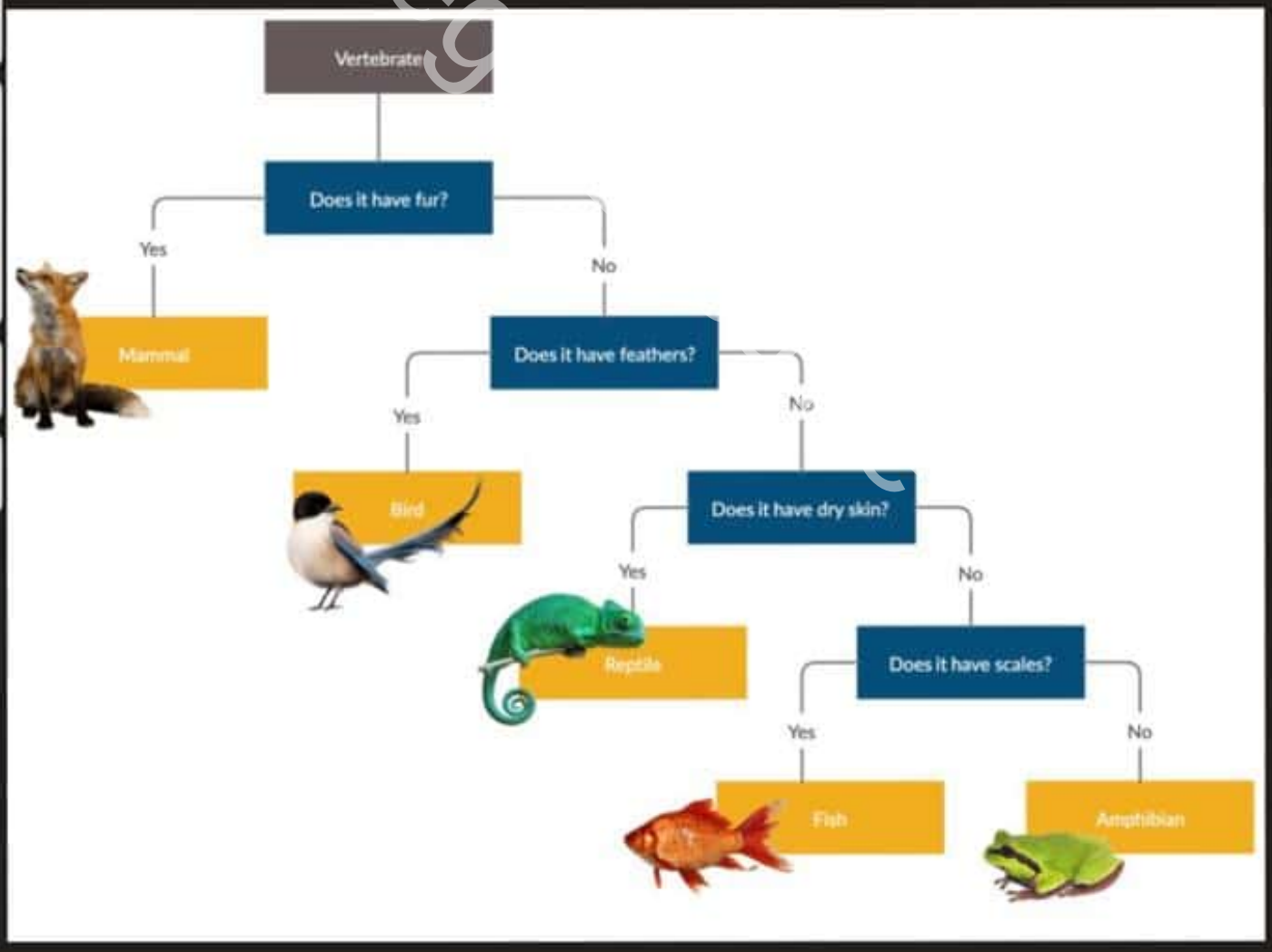
2) Determine the size and the no. of quad. sats to be used e.g. 25 quadrats each with

an area of $1m^2$.

3) Place the quadrats randomly at the coordinates generated by a mobile app or a random number generator.

4) Collect the organisms within each quadrat using nets / traps / pooter.

5) Identify the organisms using dichotomous keys (each qs has two responses → yes or no).



6) Determine the species frequency / density / abundance / percentage cover.

* Species frequency = $\frac{\text{No. of quadrats with the species}}{\text{total no. of quadrats}} \times 100$

* Species density = $\frac{\text{total no. of organisms in all quadrats}}{\text{total area of all quadrats}}$

* percentage cover is used for grassland or other immotile species which grow in a specific manner. Braun-Blanquet scale is used to

quantify percentage cover.

score	% cover
+	<1%
1	1-4%
2	5-25%
3	26-50%
4	51-75%
5	>75%

4) Mark off a separate area within the same ecosystem and repeat sampling using the same number and size of the quadrats {reliability}.

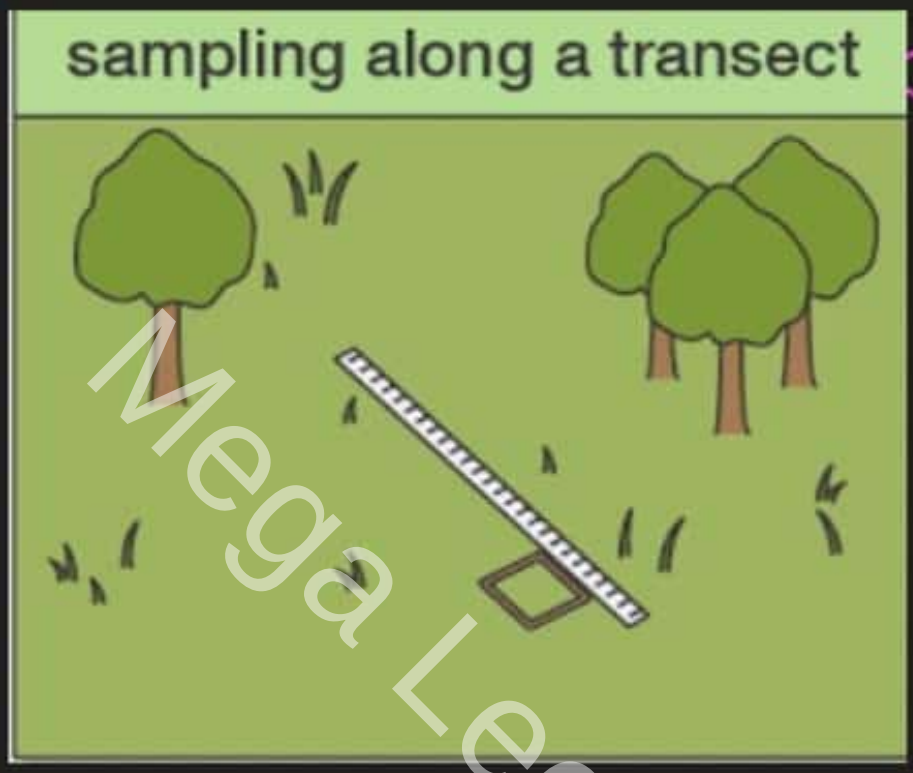
8) Safety precautions:

a) Stay with the group to avoid getting lost.

b) Wear protective clothing & gloves to avoid allergies.

) Wear mask to avoid inhalation of pollen.

Systematic Sampling



- line transect
- belt transect
  - interrupted
  - continuous

② Systēmic Sampling

* Systēmic sampling is carried out if physical conditions (such as rainfall, soil pH, soil water) within an ecosystēm change.

* Systēmic sampling is carried out using the following procedure:

1) Randomly select a starting point and lay down the measuring tāpe along the line till the marshy area.

2) Sampling organism along the line is known as a Transect.

3) Transect is of two types:

a) Line Transect

b) Belt Transect

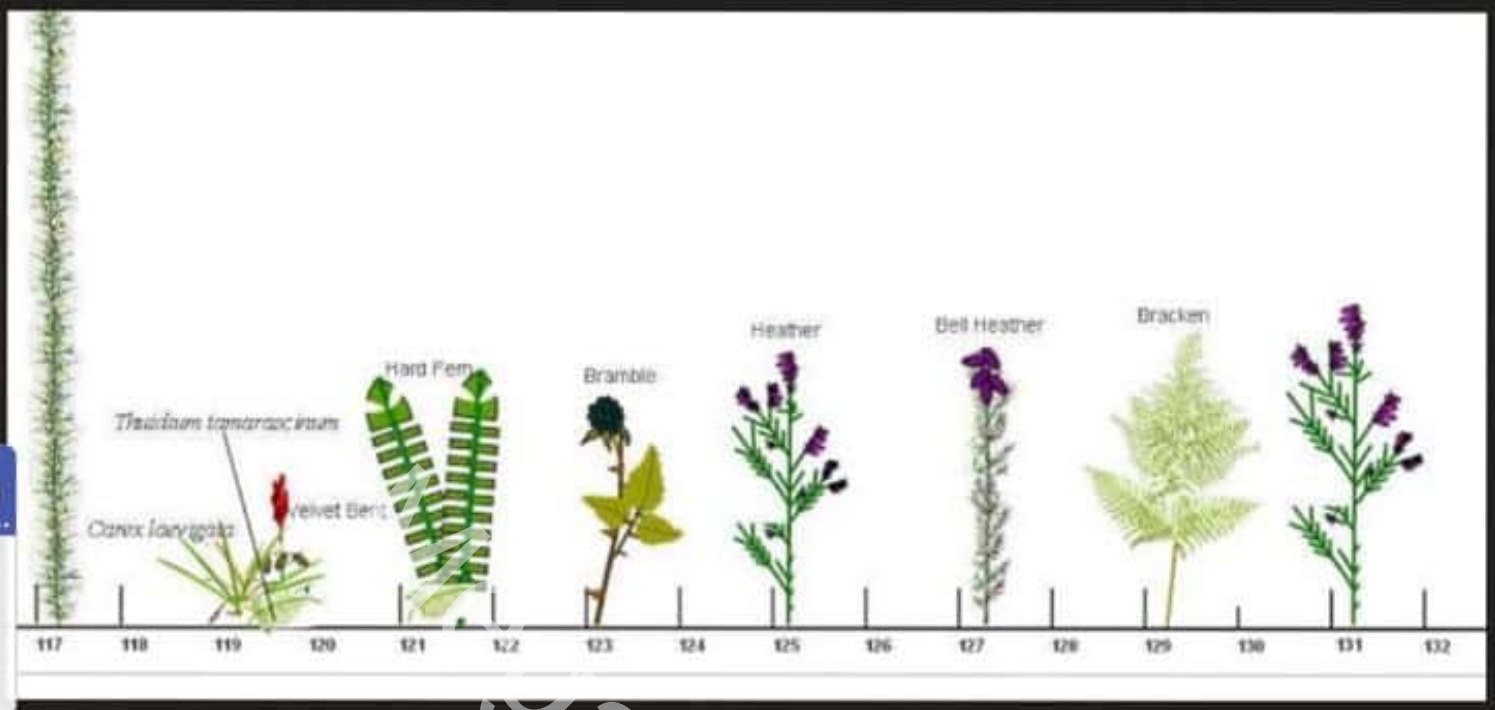
4) Line Transect involves sampling organisms along a line at regular intervals. The organisms sampled are represented qualitatively using diagrams.

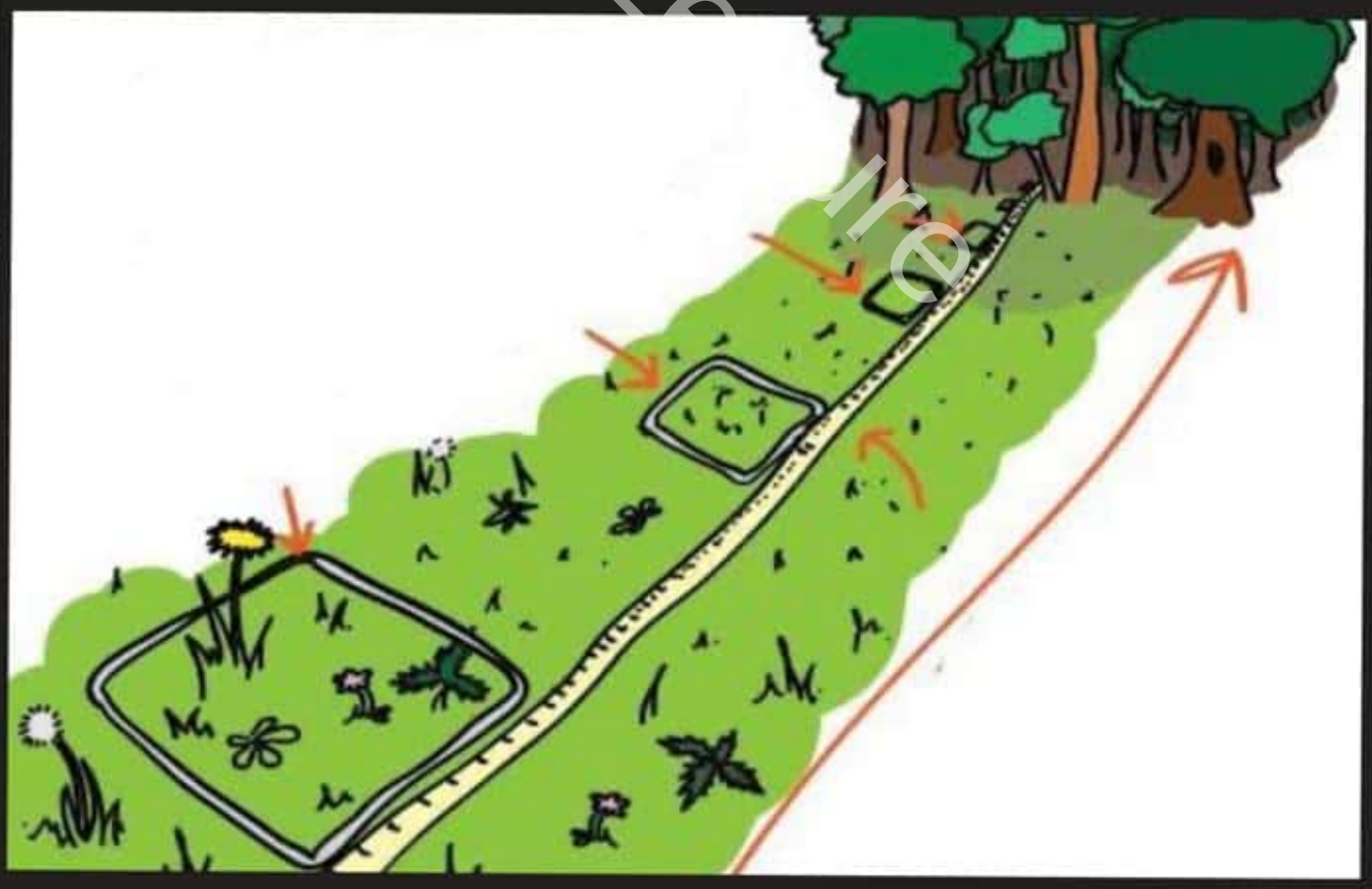
5) Belt Transect (interrupted) involves sampling organisms along a line by placing quadrats at regular intervals. The results obtained are quantitative and represented using bar charts or kite diagrams.

6) Organisms are collected via traps/nets/pooter and identified using dicholomous keys.

7) Determine species frequency/density/distribution.

8) Repeat sampling at different times of the year.





9) Select a different starting point and repeat transect to ensure reliability.

10) Safety precautions:

a) Stay with the group to avoid getting lost.

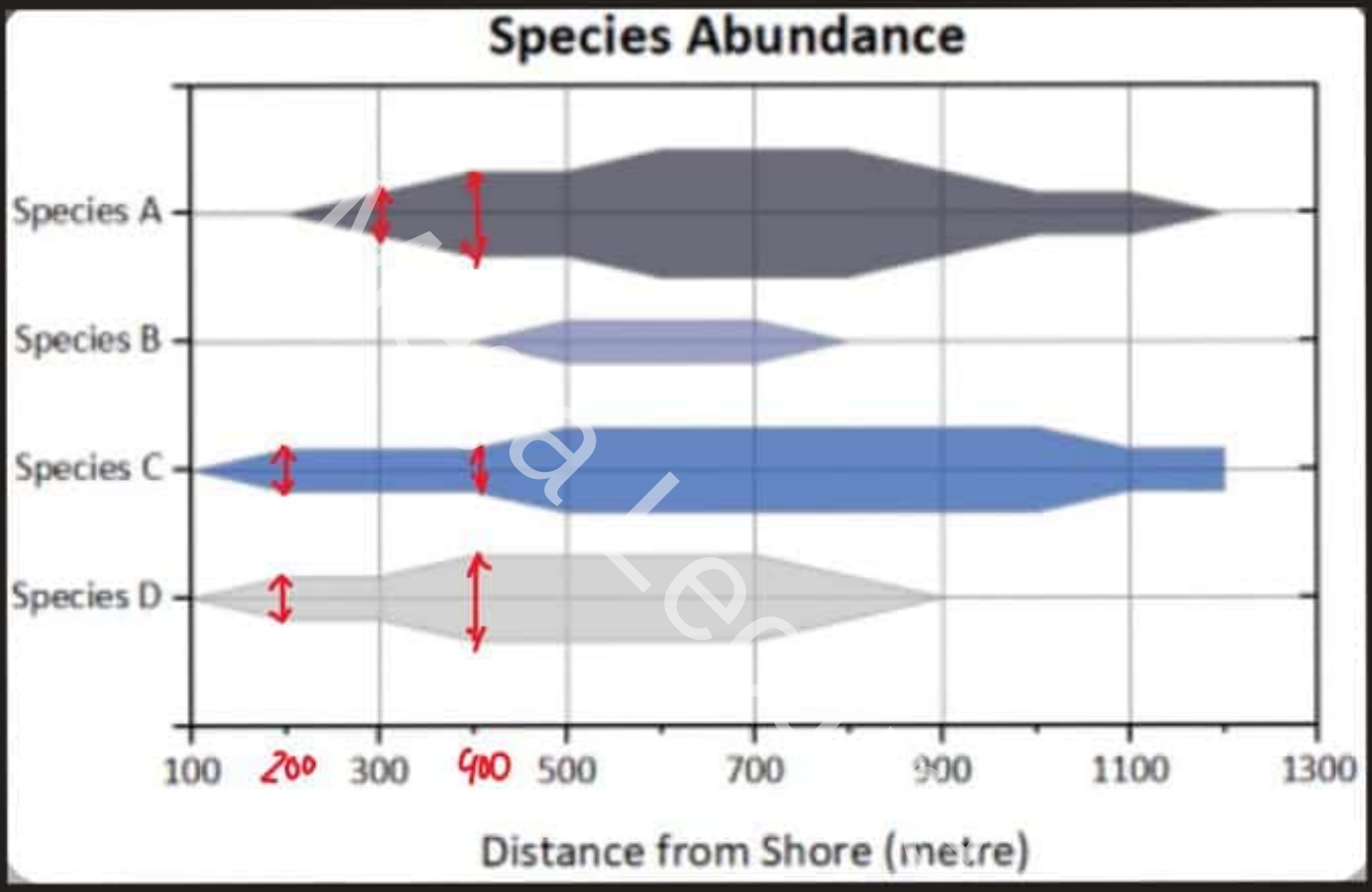
b) Wear protective clothing & gloves to avoid allergies.

c) Wear mask to avoid inhalation of pollen.

* Differences b/w line and belt transect :

Line Transect	Belt Transect
• Refers to sampling organisms at regular intervals along a line.	• Refers to sampling organisms at regular intervals along a line by placing quadrats.
• Offers qualitative data.	• Offers quantitative data.
• Data of a line transect is represented using a diagram.	• Data of a belt transect is represented using a kite diagram or bar chart.

Kite diagram

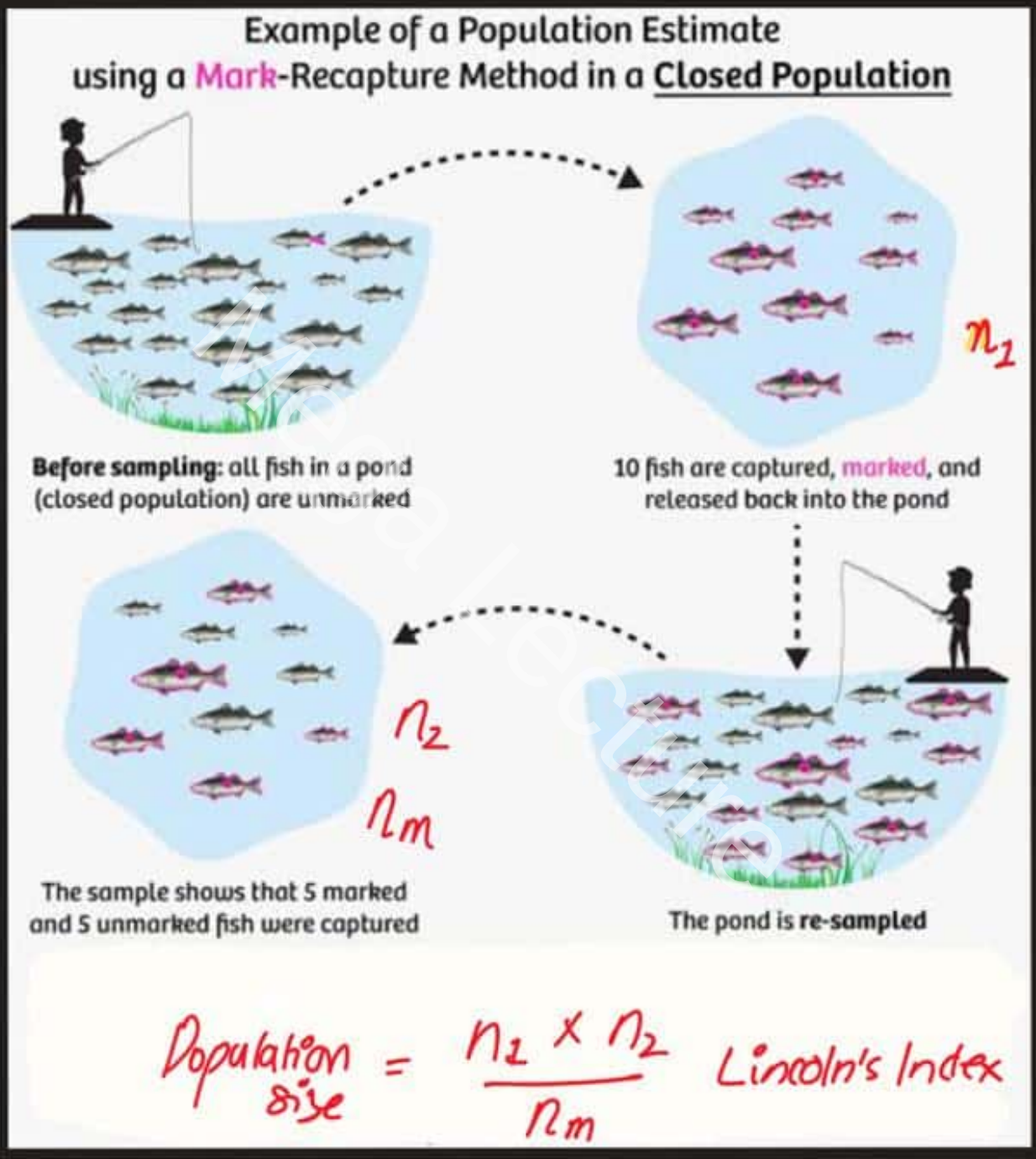


Estimating population size (N)

(for small mobile organisms)

Mark-release-recapture method

Mark-release-recapture method



Estimating Population Size (N) of Mobile Organisms 'mark-release-recapture method'

* The population size of mobile organisms can be determined using the mark-release-recapture method.

→ The method involves the following steps:

1) Collect a sample of organisms using nets or traps and mark them with a non-toxic paint in such a way that it doesn't harm the organisms.

2) Count the organisms (n_1)

3) Release the organisms and allow sufficient time To mix with their population.

4) Recaplūre a second sample of organisms and count them (n_2).

5) Count how many of The recaptured organisms are marked (n_m).

6) Population size can therefore be determined using the expression:

$$N = \frac{n_1 \times n_2}{n_m}$$ Lincoln's Index

Assumptions for the validity of this method:

1) Paint does not affect mobility of organisms.

2) Paint does not affect survival of organisms

3) No migration of organisms.

The number of voles collected in a particular ecosystem were 247. All of these voles were marked with a non-toxic paint and released.

A second sample was collected the next day. The total no. of voles caught in the second sample were 259. Sixteen of these voles were marked. Estimate the population size.

Ans: $N = \frac{247 \times 259}{16}$

$N = 3998$

Biodiversity, classification & conservation

Previously,

* Biodiversity - definition
* Species, genetic & ecosystem diversity
* Simpson's index of diversity (D)
* Sampling → random
  → systematic
* Mark-release-recapture method

Q.

8 (a) Describe a method that could be used to estimate the population size of a mobile animal, such as a brown rat.

* mark-release-recapture method
* capture the brown rats using traps
* count the no. of rats (n_1) and mark them with a nontoxic paint
* Release the rats into the ecosystem and allow sufficient time to mix with their population
* recapture a second sample (n_2) of rats
* Count the no. of marked rats (n_m) in the second sample
* Population size = $\frac{n_1 \times n_2}{n_m}$ [5]

Q.

8 (a) Sampling is used to find out the variety of species in an ecosystem and the size of the population of each species.

A study was carried out to investigate the biodiversity of two fields, **A** and **B**.

Field **A** had **not** been used for growing crops for 10 years. Field **B** had been used for growing crops until one year before the study. Random sampling was carried out.

Describe how random sampling could be carried out on plant species in the two fields.

* Mark off a region using measuring tape
* Determine the co-ordinates using the random number generator
* Place 25 quadrats each with an area of $1m^2$ at the co-ordinates generated
* determine the species frequency and abundance
* determine the % cover using the Braun-Blanquet scale
* Carry the procedure in the same way in both the fields. [4]

Q.

8 (a) Sampling can be used to find the distribution and abundance of species in an area.

Students sampled a rocky shore from a high tide area to a low tide area. They decided to use a belt transect.

Describe how you would carry out a belt transect to assess the distribution and abundance of organisms in an area.

* lay a measuring tape along a line
* the line should extend from high tide to low tide area
* Quadrats are placed at regular intervals along the line (interrupted belt transect)
* determine the species frequency and species abundance
* determine the % cover using the Braun-Blanquet scale

[5]

Q.

7 The passage below outlines one method used by a student to estimate the population size of an animal species.

Complete the passage by using the most appropriate scientific term or terms.

A student estimated the population size of an animal species using the mark-release-recapture technique. This can only be used for mobile animals such as mice.

The student caught a sample of mice using humane traps. The student then marked the mice in a way that did not harm them. For example, the mark did not make them more visible to potential predators. The student released the marked mice and left enough time for them to randomly mix with the population.

The student then caught a second sample of mice and noted the numbers of marked and unmarked mice.

The student estimated the population size by multiplying the number of mice in the first sample by the number in the second sample, then dividing by the number of marked mice in the second sample.

[6]

10 (a) Describe how random sampling can be used to assess the distribution and abundance of plants in an area. [6]

(b) Describe named examples of threats to the biodiversity of aquatic ecosystems and terrestrial ecosystems. [9]

[Total: 15]

CORRELATION

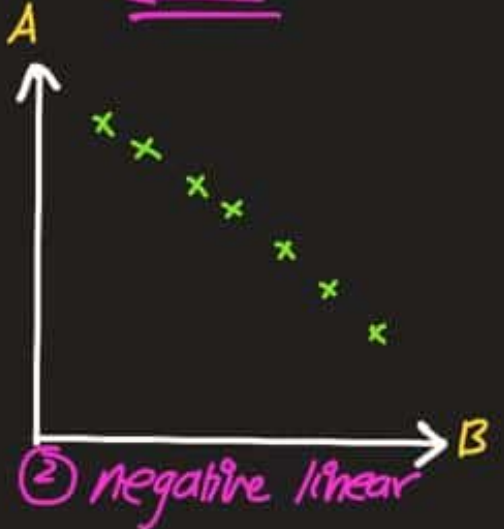
* is used to determine an association between two variables
* Correlation does NOT establish causal relationship.

CORRELATION

* determining an association bw two variables.

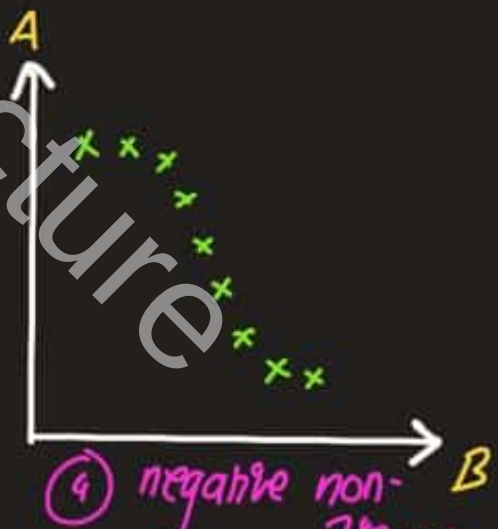
SCATTER PLOTS

① positive linear

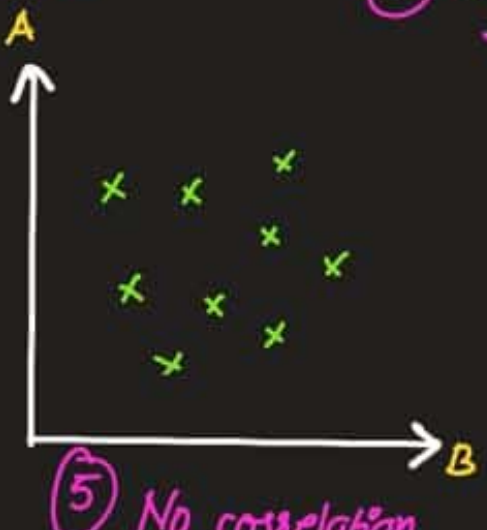


② negative linear

③ positive non-linear



④ negative non-linear



⑤ No correlation

CORRELATION

* Correlation is used to determine an association b/w two variables.

* Correlation can be linear or non-linear.

* A scatter plot can be used to determine the correlation is linear or non-linear.

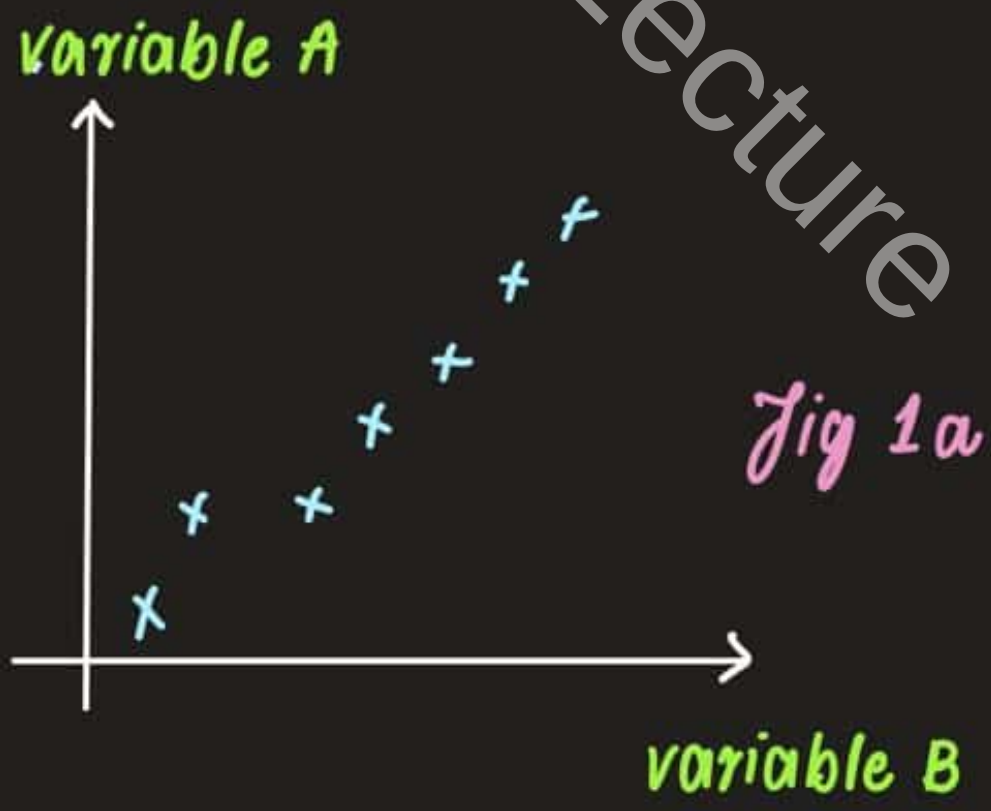


Fig 1a

Fig 1b

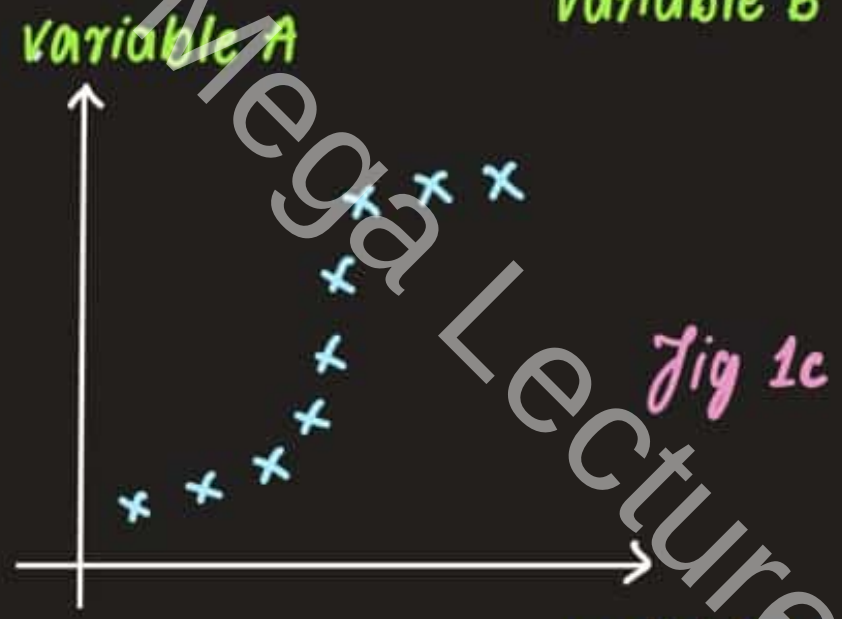


Fig 1c

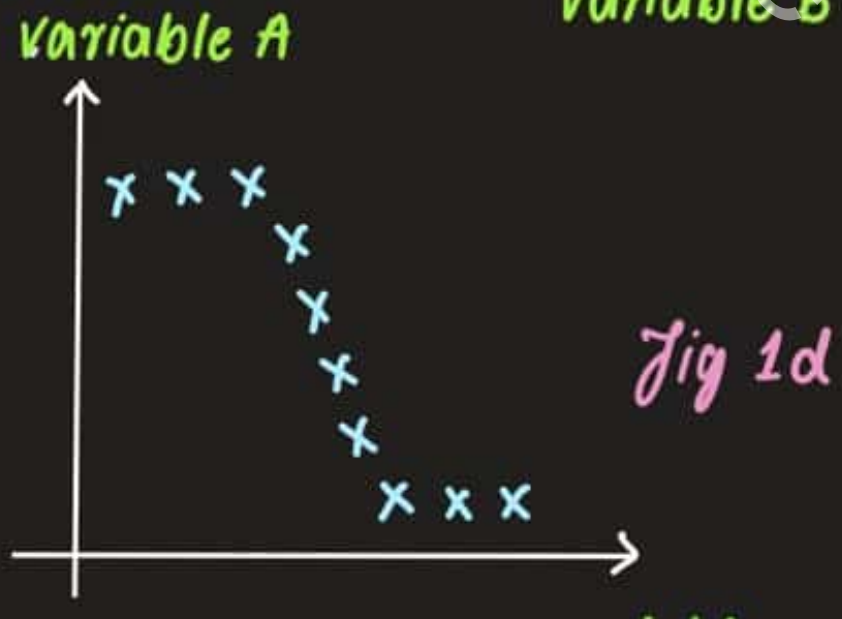


Fig 1d

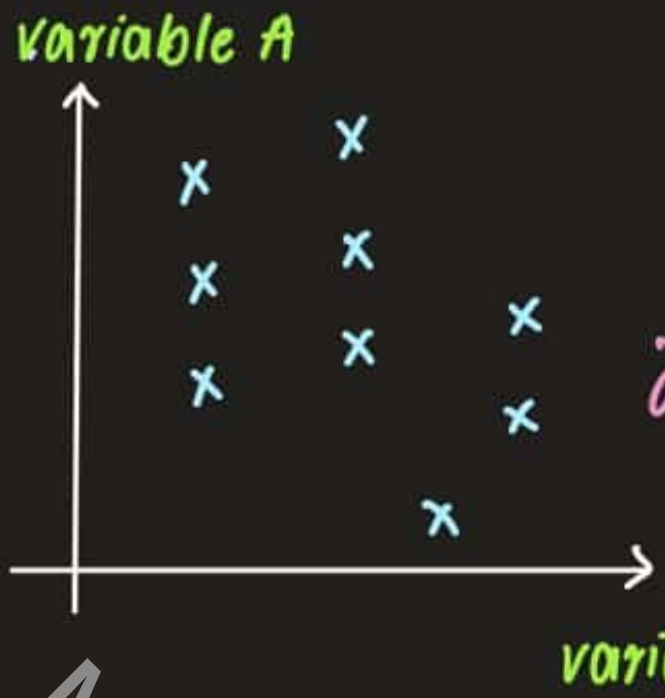


Fig 1e

* Fig 1a and 1b show linear correlation b/w variable A and B.

1a → positive linear correlation

1b → negative linear correlation

* Fig 1c and 1d show non-linear correlation b/w variable A and B.

1c → positive non-linear correlation

1d → negative non-linear correlation

* Fig 1e shows no correlation b/w variables A and B.

* The scatter plot can be drawn using the data obtained from quadrats in random sampling or systematic sampling (belt transect)

* The strength of correlation b/w two variables can be determined using a quantitative parameter known as correlation coefficient.

- There are two types of correlation coefficients
  a) Pearson's linear correlation coefficient (r)
  b) Spearman's rank correlation coefficient (r_s)

- Correlation never establishes a causal relationship.

Q.

8 (a) Sampling can be used to find the distribution and abundance of species in an area.

Students sampled a rocky shore from a high tide area to a low tide area. They decided to use a belt transect.

Describe how you would carry out a belt transect to assess the distribution and abundance of organisms in an area.

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..... [5]

(b) The results of an ecological investigation may suggest that there is a relationship between two variables, for example the abundance of a plant species and light intensity.

Scattergraphs can be drawn between the two variables.

(i) Fig. 8.1 shows three scattergraphs, **A**, **B** and **C**.

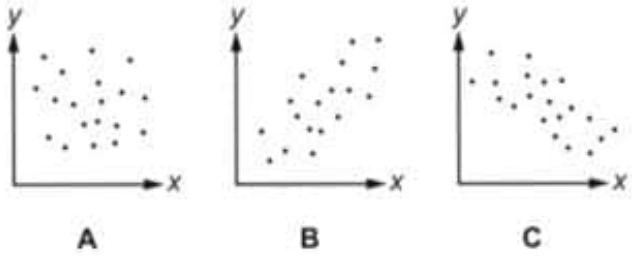

Fig. 8.1

State which scattergraphs show a relationship between the two variables, *x* and *y*.

..... B and C ..... [1]

(ii) Name a statistical test you would carry out to assess the strength of any relationship between two variables.

..... Pearson's linear correlation coefficient [1]

Pearson's Coefficient :

- Pearson's correlation coefficient (r) is used if:

1) The data is normally distributed.
2) There are atleast 5 pairs of data sets.
3) The scatter plot shows linear correlation.
4) The data is continuous.

- The value of r can be calculated using the expression:

$$r = \frac{\Sigma xy - n\bar{x}\bar{y}}{n S_x S_y}$$

$n \rightarrow$ pairs of data (no. of quadrats)

$\bar{x} \rightarrow$ mean of variable x

$\bar{y} \rightarrow$ mean of variable y

$S_x \rightarrow$ standard deviation of x

$S_y \rightarrow$ standard deviation of y

* values of r range between

$$-1 \leq r \leq +1$$

- -1 = perfect negative
- $+1$ = perfect positive
- 0 = no correlation.

* Step 1 → make a null hypothesis
* Step 2 → calculate the value of r
* Step 3 → determine the degrees of freedom $(n-2)$
* Step 4 → use Pearson's table like χ^2/t-table To accept or reject the null hypothesis

Example Quadrat	No. of individuals of species P(x)	No. of individuals of species Q (y)
1	10	21
2	9	20
3	11	22
4	7	17
5	8	16
6	14	23
7	10	20
8	12	24
9	12	22
10	9	19

mean of $x = 10.2$

mean of $y = 20.4$

SD of $x = 2.10$

SD of $y = 2.55$

$\Sigma(xy) = 2124$

$$r = \frac{\Sigma xy - n\bar{x}\bar{y}}{n S_x S_y}$$

$$r = \frac{2124 - 10(10.2)(20.4)}{10\,(2.10)(2.55)}$$

$$= 0.81$$

- Degree of freedom = $(n-2) = (10-2) = 8$
- The null hypothesis is rejected because the calculated value of Pearson's is greater than the critical value therefore there is a strong positive linear correlation b/w species P and species Q.

Q.

(c) In another experiment 10 subjects were each given a different concentration of caffeine. The reaction time was measured 5 times for each subject and a mean calculated.

Table 1.2 shows the results.

Table 1.2

subject	1	2	3	4	5	6	7	8	9	10
concentration of caffeine / mg dm^{-3}	0	40	60	80	100	120	140	160	180	200
mean reaction time / ms	355	343	340	321	300	305	288	252	242	204

Fig. 1.1 shows the graph produced by a computer programme for the data.

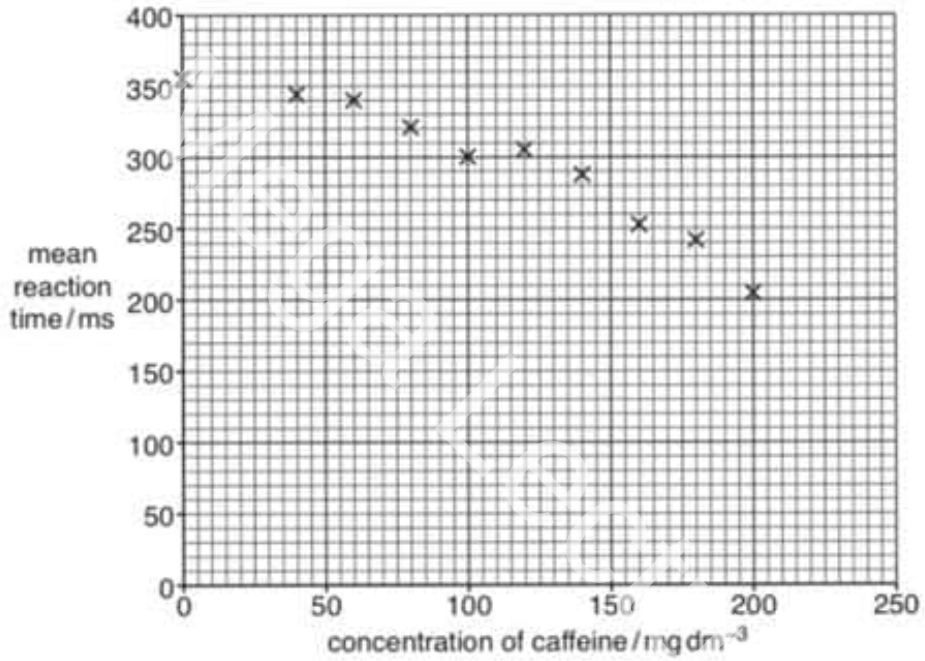

Fig. 1.1

Based on this graph the student decided to use a statistical test to find the strength of the correlation between the concentration of caffeine and the mean reaction time.

(i) State why Pearson's linear correlation test is suitable for the data.

scatter graph shows linear correlation

[1]

(ii) The results of the statistical test gave Pearson's linear correlation, $r = -0.722$.

State what this value indicates about the relationship between the concentration of caffeine and the mean reaction time.

strong negative linear correlation

[1]

Table 1.3 shows part of a table of critical values for Pearson's linear correlation test (r).

Table 1.3

number of pairs of data (n)	probability level (p)			
	0.10	**0.05**	**0.02**	**0.01**
1	0.988	0.997	0.9995	0.9999
2	0.900	0.950	0.980	0.990
3	0.805	0.878	0.934	0.959
4	0.729	0.811	0.882	0.917
5	0.669	0.754	0.833	0.874
6	0.622	0.707	0.789	0.834
7	0.582	0.666	0.750	0.798
8	0.549	0.632	0.716	0.765
9	0.521	0.602	0.685	0.735
10	0.497	0.576	0.658	0.708

(iii) Describe how the student calculated the degrees of freedom.

$df = n - 2 = 10 - 2 = 8$

[1]

(iv) Describe how the student used the probability table to find out if the value for $r = 0.722$ is significant.

* student will determine the critical value of r at 0.05 which is equal to 0.632
* calculated value of r is greater than the critical value
* which implies that there is a significant negative linear correlation.

[3]

Spearman's Rank Correlation Coefficient (r_s)

* r_s is used if:

- the data is not normally distributed.
- the scatter plot shows an increasing or decreasing relationship.
- the data is ordinal.

* r_s is determined by ranking the two sets of data (collected using quadrats) and calculating the difference in ranks (D) for each pair of data.

* The values of r_s range b/w -1 to +1.

* r_s can be calculated using the expression:

$$r_s = 1 - \left(\frac{6 \times \Sigma D^2}{n^3 - n} \right)$$

n → no. of pairs of data sets

* Once calculated, the critical value of rs at $p = 0.05$ is determined from the Spearman's table.

* If calculated value of rs corresponds to $p < 0.05$:

  => we reject the null hypothesis

  => there is a significant correlation b/w two variables.

* We do NOT calculate degree of freedom for rs.

* We only require n and the calculated rs value To accept or reject the null hypothesis.

8 (a) Describe a method that could be used to estimate the population size of a mobile animal, such as a brown rat.

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..... [5]

(b) The soft rush plant, *Juncus effusus*, grows in many habitats in Northern Europe. An investigation was carried out to assess whether there was a relationship between the height of soft rush plants and the altitude at which they grow on exposed hillsides.

The mean height of 10 soft rush plants was calculated at each of eight different altitudes.

The results are shown in Table 8.1.

Table 8.1

altitude/m	mean height of soft rush plants/cm
100	85
150	86
200	83
250	79
300	72
350	74
400	68
450	63

The statistical test, Spearman's rank correlation (r_s), was applied to find out if there was a relationship between the altitude and the mean height of the soft rush plants.

(i) The formula for calculating Spearman's rank correlation is:

$$r_s = 1 - \left(\frac{6 \times \Sigma D^2}{n^3 - n}\right)$$

- ΣD^2 is the sum of the differences between the ranks of the two samples
- n is the number of samples.

In this investigation the value of ΣD^2 is 164.

Calculate the value of r_s.

Show your working and write your answer to **two** decimal places.

$$r_s = 1 - \left(\frac{6 \times 164}{8^3 - 8}\right)$$

$$= -0.95$$

r_s = −0.95 ..... [2]

(ii) Use your value for r_s to evaluate the relationship between the altitude and the mean height of the soft rush plants.

* strong negative correlation
* with increase in altitude, the mean height of the soft rush plants decrease

..... [2]

Biodiversity, classification & conservation

Previously,

* Biodiversity - definition
* Species, genetic & ecosystem diversity
* Simpson's index of diversity (D)
* Sampling → random
  → systematic
* Mark-release-recapture method
* Correlation → Pearson's linear correlation coefficient (r)
  → Spearman's rank coulation coefficient (r_s)

Q1.

1 Fig. 1.1 shows some of the plants growing in a pond and on the land around the pond.
Some students decided to investigate the changes in the distribution and abundance of species of land plants at different distances from the edge of the pond.

They started their investigation at the plants growing next to the water, as shown in Fig. 1.1.

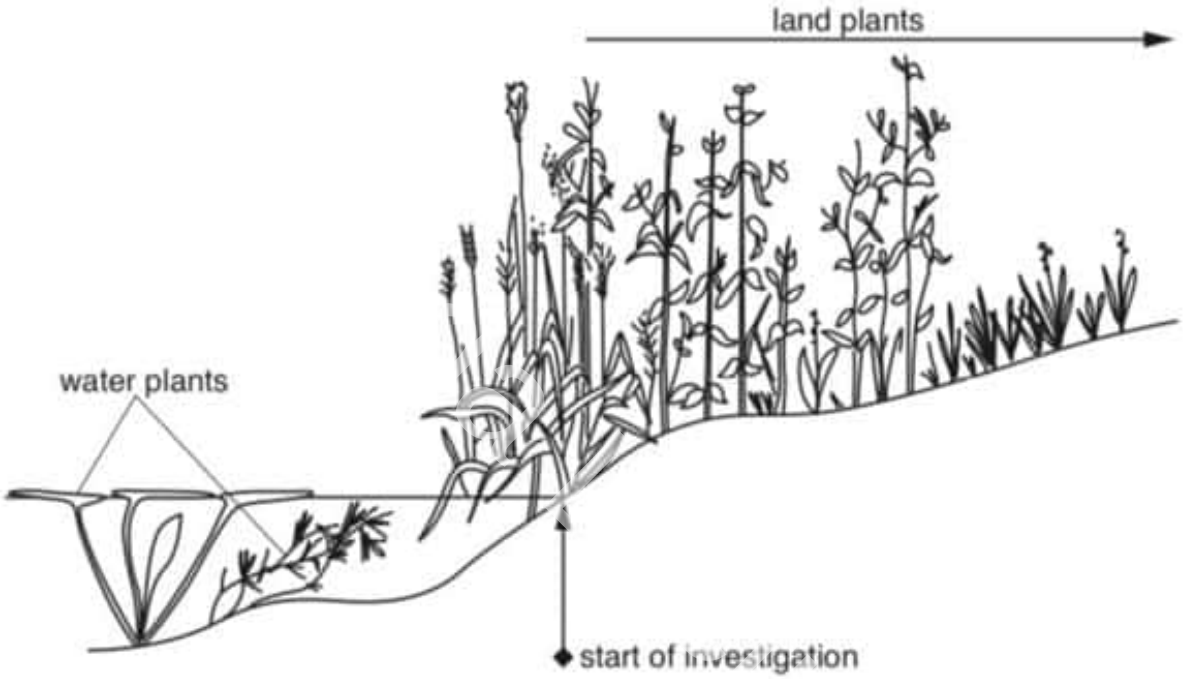

Fig. 1.1

(a) (i) State the independent and dependent variables in this investigation.

independent variable distance from the edge of the pond

dependent variable distribution &/: abundance of land plants [2]

(ii) Describe a systematic sampling method the students could use to find out how the distribution and abundance of the plant species changed as the distance from the edge of the pond increased.

Your description of the sampling method should be detailed enough for another person to use.

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.....[8]

(b) The students also collected samples of soil at different distances from the pond edge and estimated the water content.

The students wanted to find out if the water content of the soil at the different distances sampled was related to the number of different plant species found at the same distances. To do this, a Spearman's rank correlation (r_s) was carried out using the data in Table 1.1.

Table 1.1

sample	water content / arbitrary units	rank	number of species	rank	rank difference (D)	D^2
1	28	1	3	10	–9	81.00
2	26	2	4	9	–7	49.00
3	21	3	5	8	–5	25.00
4	18	4	6	7	–3	9.00
5	15	5.5	8	6	–0.5	0.25
6	14	7.5	9	4.5	3	9.00
7	15	5.5	10	3	2.5	6.25
8	14	7.5	9	4.5	3	9.00
9	13	9.5	11	2	7.5	56.25
10	13	9.5	12	1	8.5	72.25
					ΣD^2 = 317	

The formula for Spearman's rank correlation is:

$$r_s = 1 - \left(\frac{6 \times \Sigma D^2}{n^3 - n}\right)$$

r_s = Spearman's rank correlation
n = number of pairs of observations
D = difference between each pair of ranked measurements
Σ = sum of

(i) Complete Table 1.1 to show ΣD^2. [1]

(ii) Use the information in Table 1.1 to calculate the value for r_s.
Show the values for:

- $6 \times \Sigma D^2$
- $n^3 - n$

$$r_s = 1 - \left(\frac{6 \times 317}{10^3 - 10}\right)$$

$$= -0.92$$

r_s = -0.92 [2]

(iii) State what the value for r_s shows about the relationship between soil water content and the number of species present.

* strong negative correlation

[1]

(c) (i) The group of students then investigated the relationship between soil air content and the number of different plant species at the same sampling points.

The students calculated the r_s value as +0.86.

Table 1.2 shows part of a Spearman's rank probability table.

Table 1.2

n (number of pairs)	8	9	10	11	12
p=0.05 significance level 5%	0.738	0.700	0.648	0.618	0.618
p=0.01 significance level 1%	0.881	0.883	0.794	0.755	0.727

The students concluded that their r_s value of +0.86 for the relationship between soil air content and the number of species present was significant at both the 5% level and 1% level.

Explain how the students reached this conclusion.

* students determined the critical value of r_s at 5% (0.648) and 1% (0.794) significance
* the calculated value of r_s (+0.86) is greater than the critical value [2]

(ii) Based on the result of their Spearman's rank test and the significance of the r_s value, the students concluded that:

Soil air content caused the difference in the number of plant species that could grow at different distances from the edge of the pond.

Suggest why this conclusion may not be valid.

* correlation never establishes cause-effect relationship

* sample may not be representative of the entire ecosystem.

[2]

Q2.

(c) The number of prescriptions issued for antibiotics varied considerably between clinics.

The researchers wanted to find out whether there was a correlation between the number of prescriptions for each of the five antibiotics issued by a clinic and the percentage of urine samples containing resistant *E. coli*.

Spearman's rank correlation test was used for this analysis.

The results of this analysis are shown in Table 2.2.

Table 2.2

antibiotic	Spearman's rank correlation coefficient (r_s)
cephalosporin	0.30
trimethoprim	0.62 significant
co-amoxiclav	0.23
ampicillin	0.71 significant
quinolone	0.44 significant

Table 2.3 shows the critical values for r_s at five levels of significance for the data collected in this study.

Table 2.3

level of significance (p)	0.20	0.10	0.05	0.02	0.01
critical value of r_s	0.240	0.306	0.362	0.425	0.467

(i) Suggest why the Spearman's rank correlation test was used in this study.

* the data is NOT normally distributed

.....[1]

(ii) State a null hypothesis for the Spearman's rank correlation test for this study.

* no significant correlation bw the no. of prescriptions and the % of urine samples with resistant E-coli

.....[1]

(iii) Using Table 2.2 and Table 2.3, identify which antibiotics showed a statistically significant correlation between the number of prescriptions and the presence of resistant strains of *E. coli* in urine samples. Give a reason for your answer.

antibiotics trimethoprim, ampicillin, quinolone

reason b/c the calculated r_s is greater than the critical r_s at $p = 0.05$

.....

.....

.....[2]

Q3.

(c) The students carried out a second investigation to determine the effect of cell density on the carbon dioxide production of suspensions of *Chlorella*. All the suspensions were kept at a constant temperature. The students used a probe to measure the production of carbon dioxide in the suspensions of *Chlorella*.

The results are shown in Table 1.1.

Table 1.1

cell density in suspension /arbitrary units	carbon dioxide concentration after 15 min / mg dm^{-3}	rate of carbon dioxide production / mg min^{-1}
10	2.0	0.13
20	2.4	0.16
30	3.0	0.20
40	4.7	0.31
50	7.4	0.49

(i) Complete Table 1.1 by calculating the rate of carbon dioxide production for the cell density of 40 arbitrary units. [1]

The students used Pearson's linear correlation to test the hypothesis:

As cell density increases the rate of carbon dioxide production increases.

(ii) Suggest a null hypothesis for this test.

* no significant correlation between cell density and rate of CO_2 production

..... [1]

(iii) The Pearson's linear correlation coefficient (r) was calculated as 0.85.

State what the calculated value, $r = 0.85$, indicates about the results.

* strong
* positive correlation

..... [2]

(iv) The students concluded that the results showed that their hypothesis is correct.

Explain why this conclusion may not be valid.

* correlation never establishes a cause-effect relationship.
* results not reliable since one reading of rate of CO_2 production is measured at each cell density.

..... [2]

International Organisations For the Conservation Of Nature

WWF

* World Wide Fund for Nature

CITES

* Convention on the International Trade of Endangered Species

International Organisations for Conservation of Nature

* There are many international organisations striving to conserve animal and plant species at the verge of extinction due to habitat destruction, climatic changes & human activities. e.g. hunting.

* The two relevant organisations include:

(A) WWF

(B) CITES

(A) WWF (World Wide Fund for nature)

*The largest international NGO (non-governmental Organisation) specialising in conservation strategies.

- WWF's motto: To prevent the degradation of the planet's natural environment and to build a future in which the humans live in harmony with the nature.

* The role of WWF includes:

1) Funding conservation projects
2) Restoration of degraded habitats.
3) Publicising environmental issues by campaigns.
4) Saving species from extinction
5) Promoting educational awareness regarding endangered species and conservation of the ecosystem.

(B) CITES (Convention on International Trade in Endangered Species of the wild flora & fauna)

CITES is an international agreement signed by 145 countries to prevent and control the trade of endangered organisms & their products.

* Based on the evidence presented, CITES categorises the organisms into one of the following three apendices:

Appendix	Criteria	Trading Regulation
I	Species most endangered and threatened with extinction.	All trade in species and its product is banned.
II	Species NOT threatened with extinction but will be unless trade is closely controlled	Trade is only allowed if an export permit is granted.

Appendix	Criteria	Trading Regulation
III	Species included at the request of the country to prevent illegal or unsustainable exploitation.	Trade in species is regulated, permit is required but it's easier to get the permit.

* Listing an organism in one of the appendix is NOT always beneficial.

Restoration Of Degraded Habitats

Restoration techniques:

1. Reforestation
2. Remove old soil and replace it with new nutrient rich soil
3. enhance soil fertility via fertilisers
4. bubble O_2 through soil water
5. improve the soil pH
6. cleaning lakes, river beds and other small bodies of water
7. remove alien plant or animal species from an ecosystem

(b) Outline how degraded habitats may be restored, with reference to named examples. [7]

Invasion by alien species

Alien Species

*Alien or invasive species are those that have moved from one ecosyslēm To another where they were previously unknown.

* Humans are largely responsible for the inFroduction of alien species in most eco-syslēms.

* This may have been inadverlant due To people carrying these species on ships or Frading them.

* Some species were introduced to act as pest control.
* Others were added for sport.

Effect of alien Species:

- They may compete effectively with native organisms that occupy the same niche, pushing them to extinction.
- They may feed on some native organisms causing their numbers to decrease.
- They may introduce diseases that spread to native organisms that have never been

exposed To the pathogens.

- They may also outcompete native species by reducing the space where they can grow.

* Red lionfish

① native to South East Asian water

② now also observed in Carribean water

* Indian mongoose

① Introduced into Jamaican sugar-cane field to feed on rats (pests)

② acted as a predator of other native organisms too.