Chapter-12 BIOTECHNOLOGY & ITS APPLICATION

Biotechnology is making Genetically modified organisms-microbes, plants, animals for industrial production of Bio-Pharmaceuticals and other useful products.

Applications –

i) Diagnostic & therapeutic

ii) Genetically modified crops

iii) Waste treatment

iv) Energy production

v) Food processing

vi) Bioremediation

Application in agriculture

Genetically modified organisms (GMO)-Plants, bacteria, fungi, animals.whose genes are altered by manipulation.

Transgenic crops(GMO) -Crops contain or express one or more useful foreign genes.

Advantages -i) More tolerant to stresses (heat, cold, draught).

ii) Pest resistants GM crops, reduce the use of Chemical pesticides. Eg- BT-Cotton

iii) Reduced post harvest losses. Eg- Flavr savr tomato.

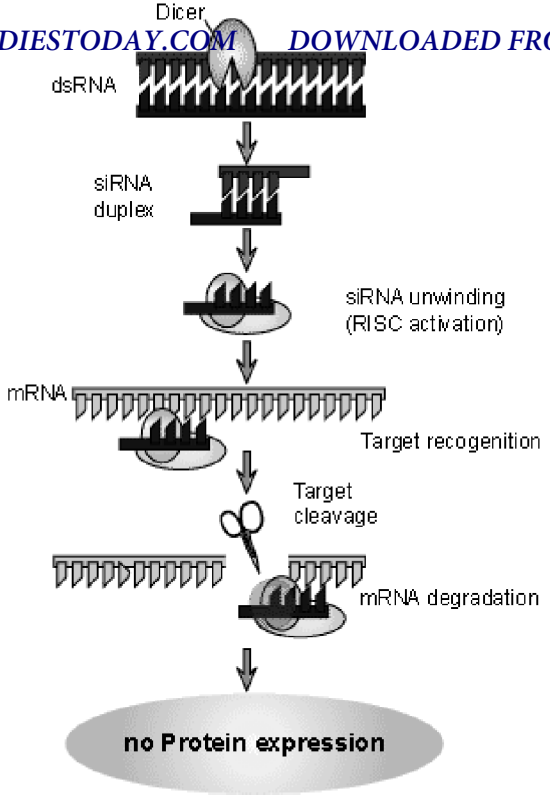
iv) Enhance nutritional value of food. eg.- Golden Rice (Vitamin A enriched).

v) Increased efficiency of mineral use.

PEST RESISTANT PLANTS

Bt- cotton -- BT stands for *Bacillus thuringiensis* (Soil Bacteria). Bacterium produces proteins (Crystal Protein-*cry* I AC, *cry* II AB). A crystalliane insecticidal protein that kills the insects.Hence *cry*-Genes have been introduced in plants to produce crystal proteins as Protoxin (inactive toxin), which is converted to toxins in alkaline medium (i.e. in the gut of insects) and cause death of the insect larva.

Protection of plants against nematodes –Nematode, *Meloidogyne incognita* infects tobacco plants & reduces yield. Specific genes (DNA) from nematodes introduced into the plants using *Agrobacterium tumifecians* (soil bacteria). Genes produce sense and antisense complementary RNA. Act as dsRNA and initiates RNAi (RNA interference) and silences the specific mRNA. Complementary RNA neutralizes the specific RNA of nematodes by a process called RNA Interference and parasite cannot live in transgenic host.



In medicine- genetically engineered insulin—

rDNA technology was applied in therapeutic application by generating genetically engineered insulin for man. In 1983, Eli Lilly, an American company prepared 2 DNA sequences coding for chains A & B.

Human insulin consists of two short Polypeptide chains A & B being linked by disulphide bridges.In man, Insulin secreted as Prohormone containing C peptides that is removed during maturation.

In rDNA technique, insulin could be generated by preparing two separate DNA sequences of A & B chain which are incorporated into plasmids of E. coli to produce insulin chains.

Gene therapy

- Gene therapy involves correction of the gene defects in child or embryo.
- Adenosine deaminase deficiency is a kind of immuno-disorder caused by deletion of gene coding for ADA.
- It can be cured by bone marrow transplantation or enzyme replacement therapy.
- A functional ADA-cDNA(through Retrovirus) is introduced in lymphocyte culture for genetic infusion and transfered to the patient body for normal functioning.

Molecular diagnosis --

Early & accurate detection of diseases substituting conventional diagnostic tecniques may be done by following methods:

PCR (Polymerase chain reaction): Short stretches of pathogenic genome is amplified for detection of suspected AIDS, Cancer or genetic disorder.

ELISA *(Enzyme Linked Immunosorbent Assay)* used to detect AIDS based on detection of antibodies produced against antigen of pathogen.

Transgenic Animals

Animals with manipulated genes or a foreign gene to be expressed are called as transgenic animals. They are useful-

1. To know how genes contribute to development of disease.

2. To use proteins for treatment of disease.
3. To verify vaccine and chemical safety.

Biopiracy -- Some organizations and multinational companies exploit or patent bioresources of other nations without proper authorization. Indian patent bill is there to prevent such unauthorized exploitation.

GEAC- For validity of GM research and the safety of introducing GM organism

Three mark question

1) What is the main advantage of producing genetically engineered insulin?

Ans- i) Produces only A&B peptides ii) No C-Peptides produced iii)No need to remove C-Peptides during maturation.

2) What are the advantages of Molecular diagnosis technique?

Ans- i) Accurate ii) disease can be detected at very early stage iii)Can be diagnosed even if the number of pathogens is very low.

3)What are the potential risks (Three) of using GM food?

Ans – Potential risks- i) Products of transgene - allergic or toxic ii) Cause damage to natural environment iii) Weeds also become resistant iv) Can endanger native species

4)What is hirudin? How do you get it?

Ans- Anti coagulant obtained from transgenic Brassica napus.

5) How does agro bacterium help to increase Tobacco production?

Ans –i) Introduction of Nematode specific gene.ii)Production of dsRNA(Sense and anti-Sense)

iii)Silence specific mRNA.

6) Why do farmers face the problems in Agro chemical based farming?

Ans – i) Too expensive ii) Conventional breeding procedure do not ensure increased production.

7) Why should farmers in India cultivate GM crops?

Ans - Tolerant to stress,pest resistant,less post-harvest losses, increased mineral use efficiency.

Five mark question

1)Explain the steps involved in the production of genetically engineered insulin?

Ans- i) Human insulin consists of 51 amino acids arranged in chains of A and B bearing 21 and 30 a. a respectively interconnected by disulphide bridges.

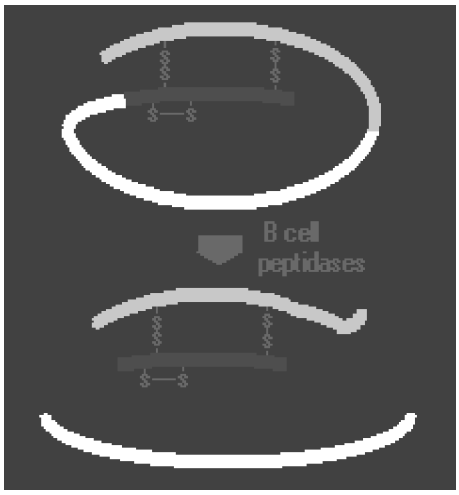


Diagram- Maturation of proinsulin into insulin after removal of c- peptide

ii) Insulin synthesized as prohormone has extra c -peptide which is removed during maturation.

iii) In 1983 , Eli Lilly, American company prepared two DNA sequences similar to A and B chains of
human insulin(humulin).

iv) Chain A and B extracted and combined by creating disulphide bonds.

Keywords of the chapter

Genetically Modified Organism(GMO), Bt cotton, insecticidal proteins, cry genes, pest resistant plants, RNA interference(RNAi)/RNAsilencing, dsRNA, Genetically engineered insulin, gene therapy, ADA deficiency , c DNA, Molecular diagnosis, transgenic animals, Bio ethics, Genetic Engineering Approval Committee(GEAC), Bio piracy, Indian patent bill.

(HOTS) CHAPTER 12:

1.Name the disease in plants caused by Ti Plasmid?
Crown gall disease.

2. What is the main objective of Gene therapy in biotechnological techniques?
Gene therapy involves replacement of defective genes by normal genes.

3.Which organism is considered as Natural genetic engineer?
Agrobacterium tumefaciens.

4.Which kind of bioweapon is most widely used ?
Bacillus anthracis.

5.What is the main objective of herbicide resistant GM crop ?
It effectively eliminates the weeds without involving manual labour .

6. From which species is human insulin commercially produced?
Escherichia coli

7.Gene medicine refers to use of gene manipulation technology to ameliorate or even permanently cure diseases in human. Name the technique.

8.The bacterium *Bacillus thuringiensis* provides the major source of insect resistant gene-clarify.

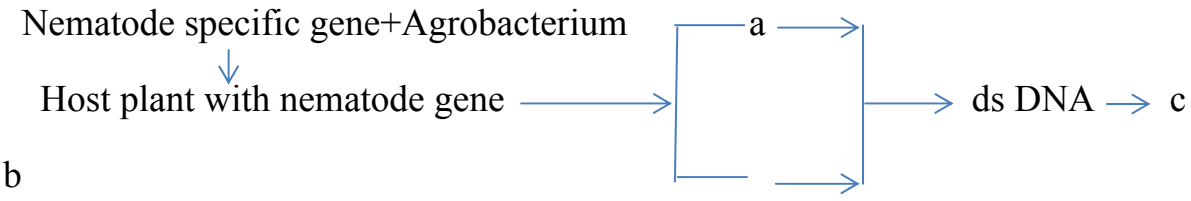
Produces insecticidal protein i.e. 'cry protein' that kills certain insect pests.

The gene encoding for ' cry protein' is isolated from bacteria & incorporated in major crop plants as bio-pesticides.

9. 'RNAsilencing is a form of genomic defense'. Elucidate the statement taking *M. incognitia* as an example.

RNA-interference technique is adopted to prevent infestation of nematode *M. incognitia* in the roots of Tobacco plants .Nematode specific genes introduced into host plants by complementary ds RNA developed through 'transposons' .

10. Identify a, b, c from the table given below:



a) sense RNA b) Anti sense RNA c)silencing mRNA

LIST OF TRANSGENIC PLANTS & ITS USES

Sl. No.	Transgenic plants	Application
01.	Bt Cotton	Pest resistant(Cotton bollworm) , Herbicide tolerant, High yield
02.	Flavr Savr Tomato	Improved nutrient quality(Increased solid nutrient)
03.	Potato	Increased nutritional quantity(Starch content)
04.	Brassica napus	Hirudin protein prevents blood clotting
05.	Golden Rice	Enriched in Vitamin-A(B-carotene)
06.	Wheat	Herbicide resistant
07.	Maize	Herbicide resistant
08.	Corn	Insecticide resistant

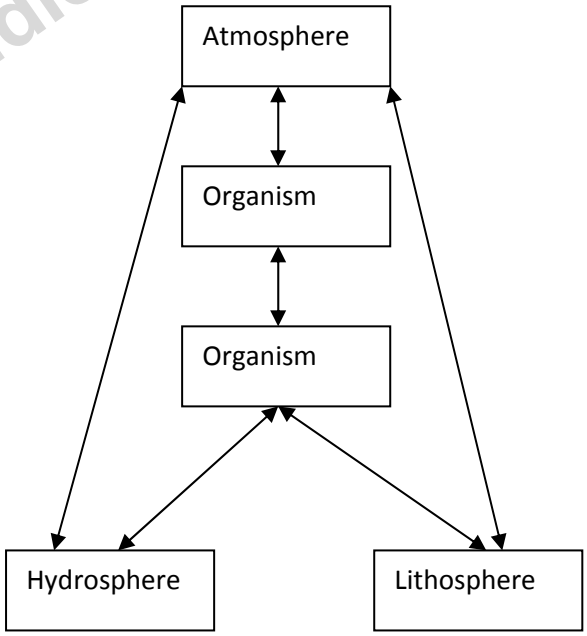
LIST OF TRANSGENIC MICROORGANISMS & ITS USES

Sl. No.	Transgenic microorganisms	Application
01.	*Bacillus thuringiensis*	Produces cry protein as plant insecticide
02.	*Escherichia coli*	Produces human insulin, interferons,interleukin
03.	Pseudomonas fluorescence	Prevents frost damage of fruits
04.	Pseudomonas putida	Scavenging of oil spillage.
05.	Rhizobium meliloti	Nitrogen fixation by Nif gene
06.	Trichoderma	Biocontrol of fungal diseases in plants.
07.	Tramates	Removal of lignin from wood pulp.

Chapter 13 ORGANISMS AND POPULATIONS

Ecology

It deals with the interaction **Among**organisms **Between** organisms &**Physical** environment.



Biome

Biome: the largest ecological regions distinguishable by characteristic plants and animals.

There are six: tundra, conifer, deciduous forest, grassland, tropical, and desert.

Biomes are subdivided into associations made up of societies.

Environment simply means the surrounding

Environment

Abiotic factors — Temperature, soil, water, light

Biotic factors — Microorganisms, plants, Animals

Temperature

Average temperature varies seasonally

Organisms may be Eurythermal or Stenothermal

Eurythermal- **wide range** of temperature tolerance

Stenothermal-N**arrow range** of temperature tolerance

Water

Influences life of organisms. No life without water.

Productivity and distribution of plants are water dependent.

#Organisms may be Euryhaline or Stenohaline.

Euryhaline- **Wide range** of salinity tolerence

Stenohaline.**Narrow range** of salinity tolerance.

Light

Photosynthesis and release of oxygen light dependent.

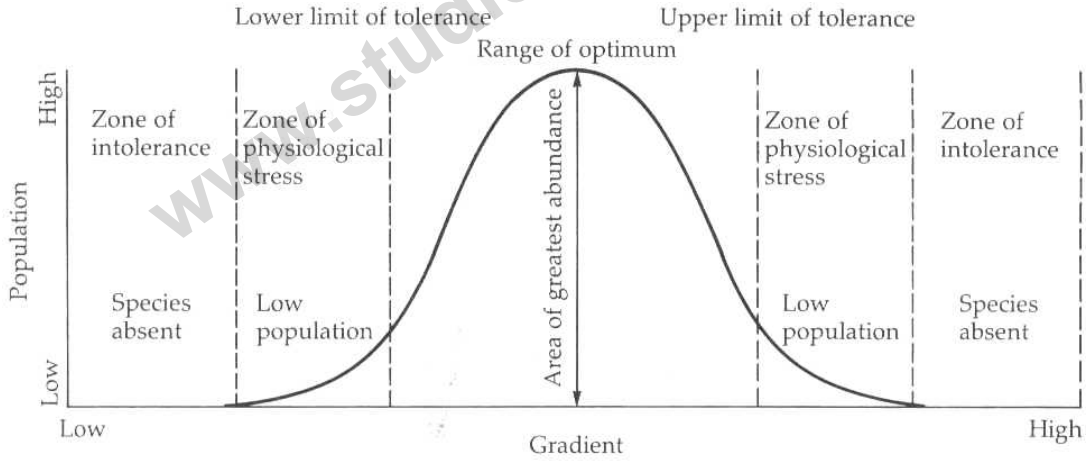
Sciophytes need to use diurnal and seasonal light intensity of forage, migration and reproduction.

Soil

Nature and proportion of soil in a place depends on climate, weathering process and types of soil.

Soil composition, grain size and aggregation determine percolation and water holding capacity of soil.

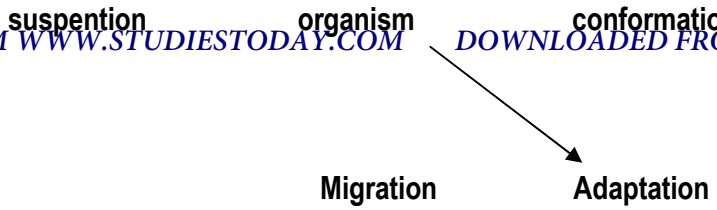
Physical and chemical properties determine type of plants and Animals that survive in a habitat.



Graph showing abundance of species w.r.t. low and high limits of abiotic factor e.g. temperature or salinity etc.

Response to environmental condition

Regulation



Regulation

Organisms maintain homeostasis achieved by physiological and behavioral means

Thermo regulation and osmoregulation.

Conformation

Cannot maintain constant internal Environment

Body temperature and osmotic concentration of body changes with ambient temperature and concentration of medium.-Thermo confirmer and osmo confirmer

Migration

Organism moves away temporarily to another habitat in stressful condition.

e.g.- Migratory birds like Siberian crane

Suspension

Organisms suspend their metabolic activities during stressful condition

Resume their function at the return of favorable conditions.

E.g**. Hibernation** (winter sleep) of Frog, Reptiles, Polar Bear etc

Aestivation (summer sleep) in Snail and Fish.

Seed dormancy.

Adaptation

Morphological, physiological and behavioral changes that enable organisms to adjust to the ever changing environment .

E.g. Kangaroo rat survives in desert conditions through internal oxidation of fat, removing concentrated urine of limited quantity.

Allen's rule-cold climate mammals have shorter ears and limbs to minimize heat loss.

Polar mammals like seals have **blubber** to prevent heat loss.

Burrowing habit to escape from heat

Higher count of RBC, Hb(haemoglobin) at high altitudes.

Population attributes

*Birth Rate – Number of individuals born per thousand per year.

*Death Rate – Number of individuals die per thousand per year.

*Sex Ratio – Ratio of male-female in the population.

*Population density. - the number of individual organisms per unit area (appropriate measure – total number-sometimes difficult to determine or meaningless because 4 factors **N+I-M+E** are concerned w.r.t habitat concerned)

Age pyramids

Three ecological ages:

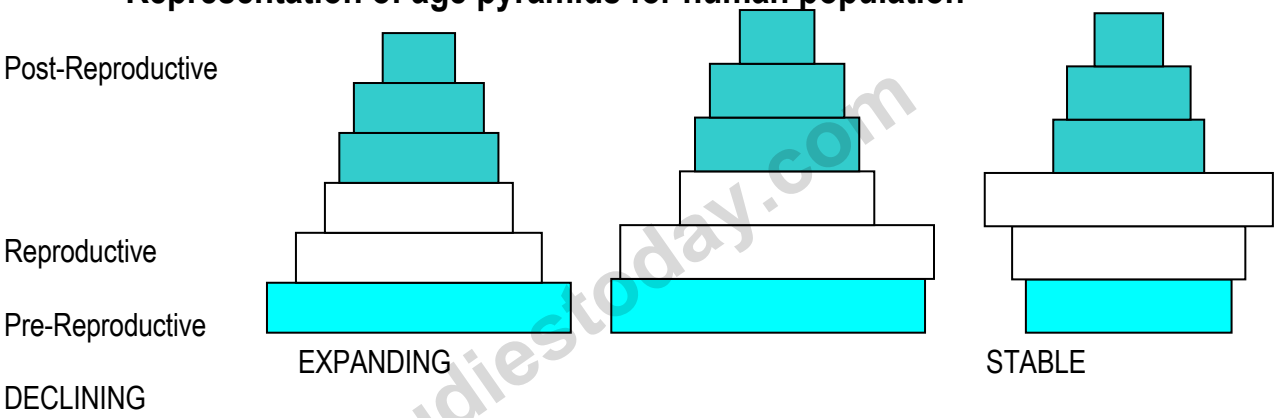
Pre-reproductive, Reproductive and Post-Reproductive

High proportion pre-reproductive individuals occur in **Expanding** population

Pre-reproductive individuals are uniform in **Stable** population.

Pre-reproductive individuals are less in **Declining** population.

Representation of age pyramids for human population



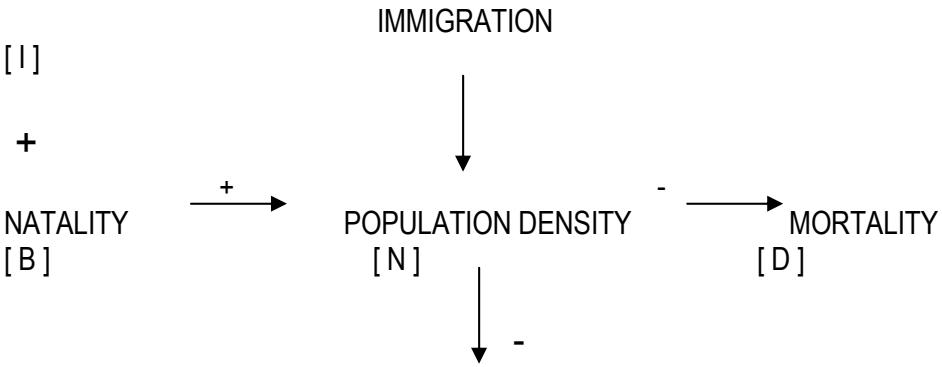
Population growth

Factors that affect the size of population

Food availability
Weather
Predation pressure
Competition
Density of population at any time at a given place depends on
Natality, Mortality, Emigration Immigration

Population growth models

Factors that affect population density



[E]

The characteristics of populations are shaped by the interactions between individuals and their environment

- Populations have size and geographical boundaries.
  - The **Density** of a population is measured as the number of individuals per unit area.
  - The **Dispersion** of a population is the pattern of spacing among individuals within the geographic boundaries.
- **MEASURING DENSITY**
- **Density – Number of individuals per unit of area.**
- **Population will grow if B+I > D+E**
- **Population will shrink if B+I < D+E**
- **Population will be in equilibrium if B+I=D+E**

(1) Population

(a) A population in an ecological sense is **a group of organisms, of the same species,** which roughly occupy the **same geographical area** at the **same time**

(2) Population size

(a) A population's size depends on how the population is defined

(b) If a population is defined in terms of some degree of reproductive isolation, then that population's size is the **size of its gene pool**

(c) **I**f a population is defined in terms of some geographical range, then that population's size is the **number of individuals living in the defined area**

(3) Population density

(a) Given that a population is defined in terms of some natural or arbitrarily defined geographical range, then population density may be defined as simply **the number of individual organisms per unit area**

(b)

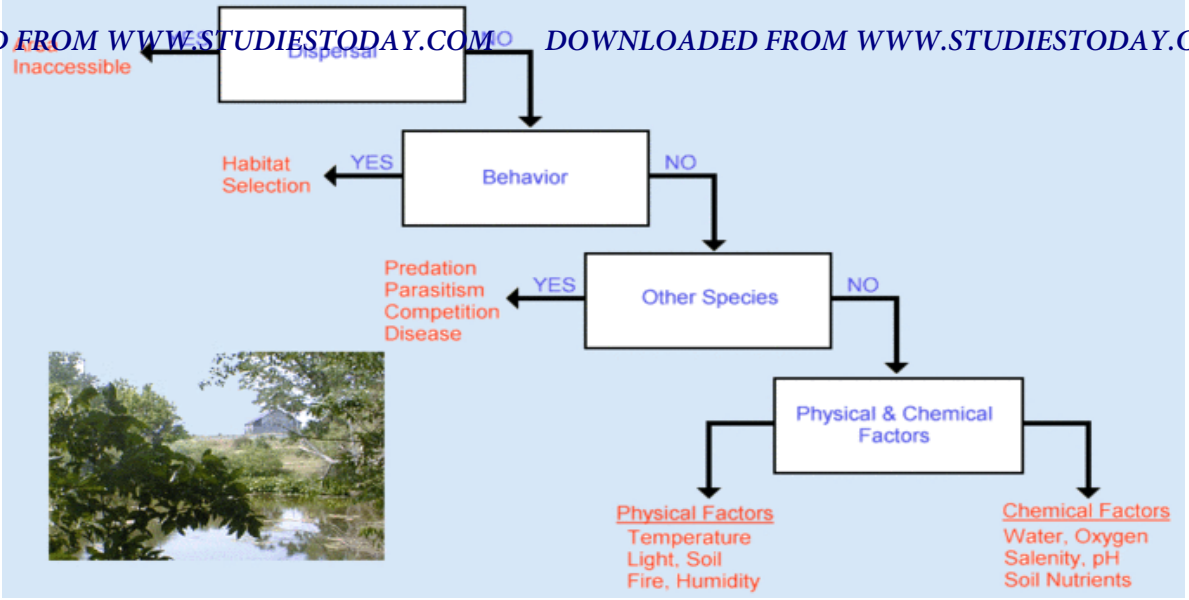
(4) Patterns of dispersion

(a) Individual members of populations may be distributed over a geographical area in a number of different ways including

(i) Clumped distribution (attraction)

(ii) Uniform distribution (repulsion)

(iii) Random distribution (minimal interaction/influence)



Types of population interactions

INTERACTION	SPECIES " a"	SPECIES " b"
Mutualism	+	+
Predation	+	-
Parasitism	+	-
Commensalism	+	0
Competition	-	-
Ammensalism	-	0

Mutualism Both species benefited.
Lichens Relationship between Non-photosynthetic Fungi and photosynthetic Algae or Cyanobacteria.
Mycorrhiza Association between Fungi and Higher Plants like Pinus.
Plants and insects for pollination
Orchid ophrys and male bee a good example for co-evolution of plants and animals.

PREDATION

One species gets benefited and the other harmed.
Tiger and Deer
Snake and Frog
Herbivores and plants

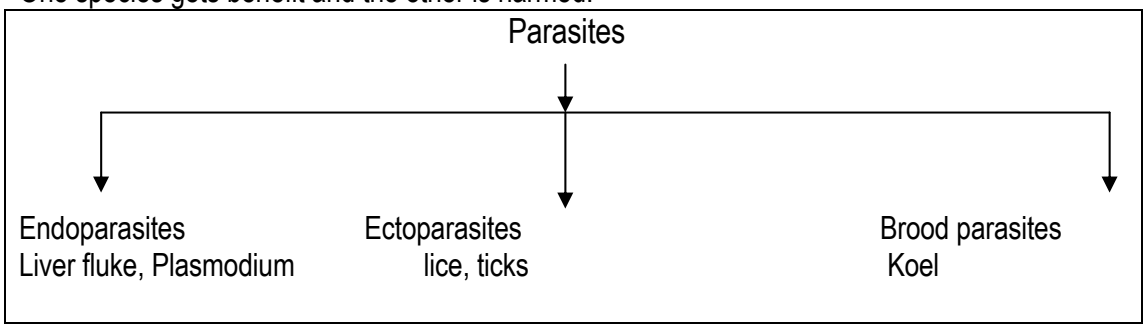
Competition

Both the species are harmed.
Flammingoes and resident fishes compete for the common food zooplankton in South American lakes.
Abington Tortoise and goats in Galapagos Islands for food.

Gause's Competitive Exclusion Principle -Two closely related species competing for the same resource cannot co-exist indefinitely and the competitively inferior one will be eventually eliminated.

Parasitism

One species gets benefit and the other is harmed.



Adaptations of parasites

Loss of sense organs
Presence of adhesive organs or suckers
Loss of digestive system
High reproductive capacity.

Ammensalism

One species hurts the other but the other is not affected.
Penicillium secretes Penicillin and kill Bacteria but by this Penicillium does not benefit.
Algal bloom leads to death of fishes, but the death of fishes is of no use to the algal bloom.

Commensalism

One species benefits and the other neither harmed nor benefited.
The cattle egret catches the insects disturbed by moving cattle, but the cattle neither harmed nor benefited.

Another example

Clown fish gets protection from predators by close association with sea anemone, but the sea anemone is not effected.

Short questions HOTS

1. Why is temperature considered to be the most relevant abiotic factor that influences life of organisms?
   - Because it affects the enzyme activity.

2. During global warming which type of organism can cope up better – Eurythermal or stenothermal? Why?
   - Eurythermal as it can tolerate wide range of temperature.

3. Why does the logistic growth curve becomes S shaped?
- Sigmoid curve, population becomes stable due to environmental resistance.

Short answer type questions (3 marks)

1. What is brood parasitism? Give an example. What adaptation has evolved in this phenomenon?

Ans. One species lays eggs in the nest of another bird, lets the host incubate them. e.g. Cuckoo lays eggs in the nest of a crow.

The Eggs of the parasite resemble the eggs of the host in colour, size. Reduce chances of the host bird detecting the foreign eggs and ejecting them from nest.

2. Name and explain the kind of interaction in the following.

Ans. 1. Algae and Fungi in Lichens
2. Head Louse Humans

3. Hermit Crab and Sea Anemone

(i) Interaction of mutualism where the two species are equally benefited. Fungus provides protection, helps in absorption of water and minerals, Algae provide food for the Fungus.

(ii) This is case of Parasitism where the louse is an ectoparasite. Parasite takes shelter on humans and also derives nutrition.

(iii) It is commensalisms where one species is benefited and the other is neither benefited nor affected. Sea

Anemone is benefited as it does not have to move to places rich in nutrients, while hermit crab is neither

benefited nor harmed.

3. How does Ophrys get pollinated by bees?

Ans.1. Sexual deceit.

2. One petal resembles female.

3. Male pseudocoupulates with the flower.

4. Pollen grain transferred from one flower to another.

4. Biomass is a more meaningful measure of population size. Explain with an example.

Ans. (i) Population large Total number is not an easily adoptable measure. Counting takes long time or practically impossible

(ii) There is no need to know the absolute population size for some investigations.

(iii) Number may sometimes be misleading eg. In a given area there are 200*Parthenium* plants and a single banyan tree. Here biomass size of the banyan tree is much more than those of 200*Parthenium* plants.

5. Give example of how plant protects themselves from the predators.

Ans. (i) Thorns.eg. – Rose, babool etc.

(ii) Chemicals that can kill the animals. eg.- Calotropis etc.

6. What is interference competition? Define competitive exclusion principles.

Ans. (i) Feeding efficiency may be reduced due to interference of another species. eg. –Tiger and deer.

(ii)Two closely related species need same resource can not co-exist indefinitely.

(5 Marks) Questions:

1.What are the different types of population growth pattern? Mention their differences.

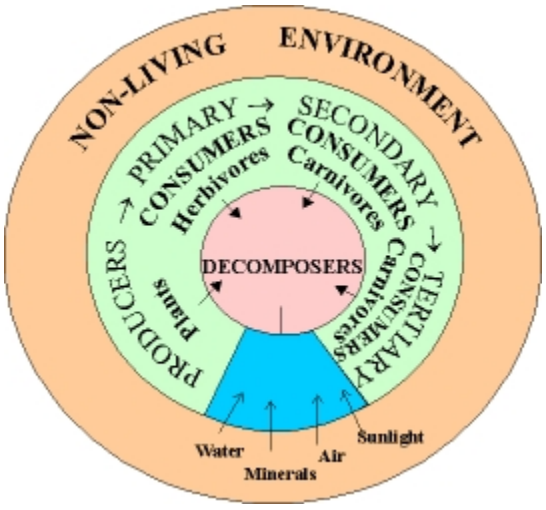
Ans: a. Logistic and Exponential growth

b. S Shaped curve, J shaped curve. Limiting Factors, No-limiting Factors

2.With the help of age pyramids explain the nature of a population.

Ans: a. Pre-reproductive/ re-productive/ post-reproductive

b. increasing population/ stable population/ declining population



The country has 10 different biogeographic zones and 26 biotic provinces.

S.No. Biogeographic zones Biotic provinces

1.	Trans-Himalaya	Ladakh mountains, Tibetan plateau
2.	Himalaya	Northwest, West, Central and East Himalayas
3.	Desert	Thar, Kutch
4.	Semi-arid	Punjab plains, Gujarat Rajputana
5.	Western Ghats	Malabar plains, Western Ghats
6.	Deccan Peninsula	Central highlands, Chotta-Nagpur, Eastern highlands, Central Plateau, Deccan South
7.	Gangetic plains	Upper and Lower Gangetic plains
8.	Coast	West and East coast, Lakshadweep
9.	North-East	Brahmaputra valley, Northeast hills
10.	Islands	Andaman and Nicobar

Source: Wildlife Protected Area Network in India: A Review, Wildlife Institute of India, 2000.

The exponential model of population describes an idealized population in an unlimited environment

- We define a change in population size based on the following verbal equation.

Change in population size during time interval = Births during time interval – Deaths during time interval

- Using mathematical notation we can express this relationship as follows:
  - If ***N*** represents **population size**, and ***t*** represents **time**, then **Δ*N***is the **change in population size** and **Δ*t***represents the **change in time**, then:
    - **$\Delta N/\Delta t = B-D$**
    - Where ***B*** is the **number of births** and ***D*** is the **number of deaths**
  - We can simplify the equation and use ***r*** to represent the difference in per capita birth and death rates.
    - $\Delta N/\Delta t = rN$ OR $dN/dt = rN$
  - If $B = D$ then there is **zero population growth (ZPG)**.
  - Under ideal conditions, a population grows rapidly.
    - **Exponential population growth** is said to be happening
    - Under these conditions, we may assume the maximum growth rate for the population (r_{max}) to give us the following exponential growth
    - $dN/dt = r_{max}N$

The logistic model of population growth incorporates the concept of carrying capacity

- Typically, unlimited resources are **rare**.
  - Population growth is therefore regulated by **carrying capacity** (K), which is the maximum stable population size a particular environment can support.

POPULATION GROWTH RATE

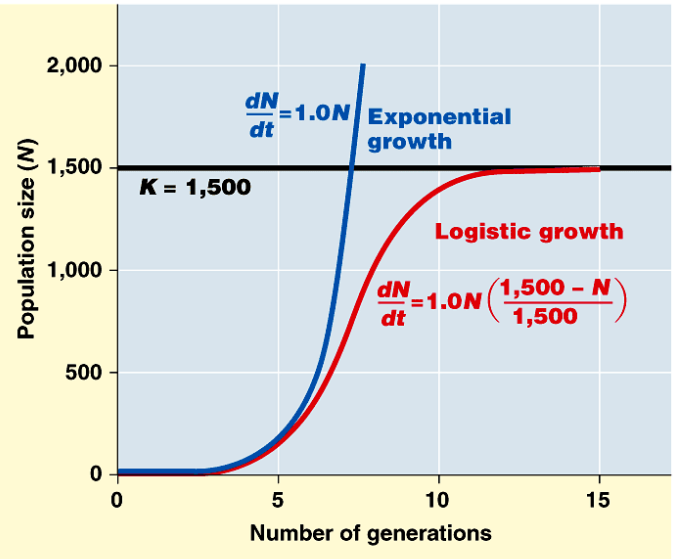
LOGISTIC GROWTH RATE

Assumes that the rate of population growth slows as the population size approaches carrying capacity, leveling to a constant level.

S-shaped curve

CARRYING CAPACITY

The maximum sustainable population a particular environment can support over a long period of time.



Population growth

(a) The simplest case of population growth is that which occurs when there exists no limitations on growth within the environment

(b) In such situations two things occur

(i) The population displays its **intrinsic rate of increase**

(ii) The population experiences **exponential growth**

Intrinsic rate of population increase (r_{max})

(a) Intrinsic rate of **population** increase is the rate of growth of a population when that population is growing under ideal conditions and without limits, ie.as fast as it possibly can

(b) This rate of growth implies that the difference between the **birth rate** and **death rate** experienced by a population is maximized

(e) However, a population that is not growing maximally can still experience **exponential growth**

(f) "A population with a higher intrinsic rate of increase will grow faster than one with a lower rate of increase. The value of r_{max} for a population is influenced by life history features, such as age at the beginning of reproduction, the number of young produced, and how well the young survive."

(24) Exponential growth

(a) Exponential growth simply means that a population's size at a given time is equal to the population's size at an earlier time, times some greater-than-one number

(b) For example, if a population increased in size per unit time in the following manner: 1, 2, 4, 8, 16, 32, 64, 128, etc.

(b) "It has been difficult to demonstrate a direct relationship between population growth rate and specific life history characteristics. Increasingly, ecologists are recognizing that most populations show a mix of the traditional *r*-selected and

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K-selected characteristics; life history evolves in the context of a complex interplay of factors."

Mishra is known as father of Ecology in India

	r **Unstable environment, density independent**	***K*** **Stable environment, density dependent interactions**
Organism size	Small Variable	Large constant

Loss as heat And light

Photo synthetically Active Radiation

Respiratory Loss 0.2-1%

Energy used to make each individual	Low	High
# Offspring produced	Many	Few
Timing of maturation	Early	Late (with much parental care)
Life expectancy	Short(i.e. high mortality)	Long
Lifetime reproductive events	One	More than one
Environment	Variable and unpredictable	Constant or variable but predictable

Chapter-14:ECOSYSTEM

Ecology [Gkeek: *oikos;* home and *logos;* the study of] – First coined by **Earnst Haechel** (1869). Ecology therefore - study of an organism in its natural home.

Odum (1963) defined ecology as the study of structure and function of nature or the study of inter-relationships between organisms and their environment.

Inter relationship between components of ecosystem

Incident solar radiation (100%)

50% lost due to

Absorption by gases & water vapour

Reflected by clouds

Scattered by dust particles

Gross primary productivity

1-5%

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