

CLASS 12 - BIOLOGY

FORMULA BOOK

FOR

CBSE BOARD

1. Reproduction in Organisms

	Sexual reproduction	Asexual reproduction
1.	It involves two parents.	It involves single parent.
2.	Special sexual organs are present in male and female individuals called male and female reproductive organs.	No special organ is needed
3.	Involves sperm and ova, gametes produced by male and female respectively.	No involvement of sperm and ova.
4.	It is mostly found in higher animals and plants.	It is mostly found in unicellular and lower animals and plants.

2. Sexual Reproduction in Flowering Plants

Table : Differences between self pollination and cross pollination

Characteristic	Self pollination	Cross pollination
Occurrence	Occurs within a flower or between two flowers of the same plant.	Occurs between two flowers of two different plants of the same species.
Agent of pollination	No external agent of pollination required (usually).	External agents such as wind, water, insects and birds required.
Production of pollen grains	Produced in small numbers, thus no wastage of pollen grains occurs.	Produced in large numbers (usually), thus, wastage of pollen grains occurs.
Appearance of flowers	Flowers are not attractive (usually).	Flowers are attractive with coloured petals.
Fragrance and nectar	Flowers do not (usually) produce scent or nectar.	Flowers generally produce scent and nectar.
Nature of offsprings produced	Offsprings produced have genetic make-up identical to the parent plant, purity of race maintained, no variation occurs.	Offsprings produced may differ in genetic make-up, and variations occur.

3. Human Reproduction

- **Puberty** is the period in life at which sexually immature boy or girl becomes sexually mature and capable of reproduction.
- When fertilization does not occur, the released egg and the lining of uterus are shed. This causes bleeding in women every 28 days. This phenomenon is called **menstruation**.
- The first menstrual flow begins at puberty and is called **menarche**. At 45 to 50 years of age, the menstrual cycle stops. This stoppage of menstruation is termed as **menopause**.
- **Menstrual cycle** consist of four phases:
 - **Menstrual phase** (1-5 days) : The wall of the uterus breaks down and menstruation begins.
 - **Proliferative phases** (6-13 days) : Proliferation of the uterine wall occurs. The uterine wall becomes thicker by cell division.
 - **Ovulatory phase** (14th day) : Ovulation (release of ovum) occurs.
 - **Secretory phase** (15 to 28 days) : Uterine glands produce increased amount of watery mucus. Such a uterine wall is necessary for the implantation of the fertilized ovum. In the absence of fertilization, uterine wall breaks leading to menstruation marking a new cycle.

4. Reproductive Health

- **Methods of contraception**
 - **Barrier method:** These are physical devices to prevent the entry of sperm into the female genital tract during copulation. They also protect against sexually transmitted diseases *e.g.*, condoms.
 - **Chemical method:** Foam tablets, jellies, pastes, creams and spermicides are some common chemicals used by females. These are placed in vagina. These chemicals adhere to the mucous membrane and immobilise and kill the sperms.
 - **Surgical method:** Surgical methods are safe in the long run but they may cause infections and other problems if not done properly. These methods include – (i) **Vasectomy** and (ii) **Tubectomy**.
 - (i) Vasectomy is a small surgical operation performed in males. It involves removal of a small portion of the sperm duct (or vas deferens) by surgical operation. The two cut ends are then ligated (tied) with threads. This prevents the sperms from coming out.
 - (ii) Tubectomy is done in females where oviducts are cut and cut ends tied with threads.

5. Principles of Inheritance and Variation

- **Heredity** is the study of transmission of characters from parents to offsprings or from one generation to the next.
- **Variations** may be defined as the differences in characteristics shown by the individuals of a species and also by the offsprings or siblings of the same parents.

- **Gene** is the inherited factor that determines the biological character of an organism. A pair of contrasting characters is called **allelomorph** or **allele**. **Dominant allele** is one of the factors of an allelic pair which can express itself whether present in homozygous or heterozygous state, e.g., T (tallness in pea) and **Recessive allele** is the factor of an allelic pair which is unable to express its effect in the presence of its contrasting factor in a heterozygote, e.g., t (dwarf in pea) in Tt.

Mendel had conducted several hybridisation experiments on **garden pea**, *Pisum sativum*. The number of characters studied by Mendel in pea plant were **seven**.

- **Law of dominance** states that only one factor expresses itself in F₁ generation. In a hybrid where both the contrasting alleles are present, only one factor/allele called **dominant** is able to express its effect while the other factor called **recessive** remains suppressed in F₁ generation. F₂ generation expresses both the dominant and the hidden recessive factors in the ratio of 3 : 1 in the monohybrid cross.
- **Principle of segregation** states that when a pair of contrasting factors are brought together in a hybrid; these factors do not blend or mix up but simply associate themselves and remain together and separate again at the time of gamete formation.
- **Principle of independent assortment** states that the genes of different characters located in different pairs of chromosomes are independent of one another in their segregation during gamete formation.
- **Incomplete dominance** is the phenomenon where dominant allele does not completely express itself. This was first studied in flower colour of *Mirabilis jalapa* or four O'clock plant. The phenotypic as well as genotypic monohybrid ratio in F₂ generation in incomplete dominance is 1 : 2 : 1.
- **Codominance** is the phenomenon of two alleles lacking a dominant-recessive relationship where both of them express themselves together and equally in the organisms. The codominant alleles are able to express themselves independently when present alone. The phenotypic ratio is 1 : 2 : 1.
- **Multiple alleles** : These alleles are multiple forms (more than two alternatives) of a Mendelian factor or gene which occur on the same gene locus, distributed in different organisms in the gene pool with an organism carrying only two alleles and gamete only one allele. **ABO blood group system** in human beings is an example of both **codominant** and **multiple alleles**.
- **Complementary genes** : If two genes present on different loci produce the same effect when present alone but interact to form a new trait when present together, they are called complementary genes.
- **Supplementary genes** : These are two non-allelic genes in which one type of gene produces its effect whether the other is present or not and the second (supplementary) gene produces its effect only in the presence of the first, usually forming a new trait.
- **Pleiotropic genes** : When a gene affects many aspects of phenotype or controls several phenotypes, it is said to be pleiotropic gene and this phenomenon is called pleiotropy.
- **Walter Sutton and Theodor Boveri** (1902) postulate the "chromosomal theory of inheritance".

Linkage is the phenomenon of certain genes staying together and their inheritance from generation to generation without any change or separation due to their presence on the same chromosome.

- **Sex-linked inheritance** is the transmission of characters and their determining genes along with sex determining genes present on the sex chromosomes, which are inherited together from one generation to the next. Sex-linked traits are more apparent in males than in females. Females generally function as carriers of sex-linked disorders because recessive genes can express themselves in females only in the homozygous state. E.g., colour blindness, haemophilia, etc.
- **Pedigree** is a chart showing a record of inheritance of certain traits for two or more ancestral generations of human being or domesticated animal in the form of a diagram of family tree.

6. Molecular Basis of Inheritance

- DNA is the macromolecule which consists of two **complementary strands** of deoxyribonucleotides that run **antiparallely** and are held together by **hydrogen bonds** between their opposite nitrogen bases.
- The unit of compaction of DNA packing is **nucleosome**. There are **five types** of histone proteins-- H1, H2A, H2B, H3 and H4.
- **Griffith** conducted a series of experiments on bacteria *Streptococcus pneumoniae* and concluded that there was some factor in heat-killed virulent bacterial strain that **transformed** live non-virulent into virulent strain.
- In 1944, **Avery, McCarty and MacLeod** performed experiment and concluded that DNA caused the transformation.
- **Hershey and Chase** worked with viruses that infect bacteria called bacteriophages. Bacteria which were infected with viruses (that had radioactive DNA) were radioactive indicating that DNA was the genetic material that passed from the virus to the bacteria.
- RNA (ribonucleic acid) is the hereditary material in some viruses (**retroviruses**). It is a **polymer of ribonucleotides** and is made up of **ribose sugar, phosphoric acid and nitrogenous bases (A, U, C, G)**.
- The unique process of making an identical copy of a double stranded DNA, using existing DNA as a template for the synthesis of new DNA strands is called **DNA replication**.
- **Meselson and Stahl (1958)** proved that DNA replicates by **semi-conservative** method by experimenting on *E.coli* and used the heavy isotopes of nitrogen, *i.e.*, ¹⁵N.
- **Transcription** is a process of making a copy of genetic information stored in a DNA strand into a complementary strand of RNA (*mRNA*).
- Transcription requires an enzyme RNA polymerase. The entire or complete enzyme (**holoenzyme**) consists of a **core enzyme** and a **sigma factor** (σ). The sigma factor recognises the start signal on DNA and directs the binding of the enzyme to the promoter region. It thus enhances the specificity of transcription.
- Transcription in eukaryotes occurs within the nucleus and *mRNA* moves out of the nucleus into the cytoplasm for translation.
- The genetic representation of codon by which the information in RNA is decoded in a polypeptide chain is called **genetic code**.
- **Translation** is the mechanism by which the triplet base sequence of an *mRNA* guides the linking of a specific sequence of amino acids to form a polypeptide (protein) or ribosomes.
- It is a messenger RNA which brings **coded information** from DNA and takes part in its translation by bringing amino acids in a particular sequence during the synthesis of polypeptide. The **codons** of *mRNA* are recognised by **anticodons** of *tRNAs*. The synthesis of polypeptide can be considered in terms of **initiation, elongation and termination stages**.
- The expression of the genetic material occurs normally through the production of proteins. This involves two consecutive steps. These are transcription and translation. **F.H.C. Crick** described this unidirectional flow of information in 1958 as the '**Central dogma of molecular biology**.'
- Jacob and Monod (1961) from their study in bacterial genetics proposed that genetic material has a number of functional units called **operons**. An operon consists of minimum four types of genes-- **regulator, operator, promoter and structural**.
- *Lac* operon of *Escherichia coli* is an inducible operon system which was discovered by Jacob and Monod (1961). *Lac* operon has **three structural genes z, y and a**.
- DNA fingerprinting is a technique for identifying repeated sequences in the human genome that produce a **pattern of bands unique for every individual**.

7. Evolution

	Genetic drift	Natural selection
(i)	It is a sudden and quick process.	It is gradual and slow process.
(ii)	It selects harmful or useful variations by chance.	It selects only adaptatively useful variations.

- Both **connecting** link and **missing** link are intermediate stages between the two groups of organisms. Missing link is referred to such intermediate form which is now extinct, while connecting link is that intermediate form which still exists.
 Example of missing link-*Archaeopteryx* (link between class Reptilia and Aves)
 Example of connecting link-*Peripatus* (link between phylum Annelida and Arthropoda), *Euglena* (connecting link between plants and animals).

	Inherited traits	Acquired traits
1.	These are obtained from the parents.	These are developed during the life of an individual.
2.	These are genetic variations.	These are somatic variations.
3.	These develop due to crossing over phenomenon and mutations.	These develop due to use and disuse of organs and direct effect of environment.
4.	These are passed on from one generation to the other.	These are lost with the death of the individual.

	Artificial selection	Natural selection
1.	It is an artificial process.	It is a natural phenomenon.
2.	It is conducted by man on limited scale in specific laboratories.	It is conducted on large scale all over the earth.
3.	Traits selected for improvement are beneficial to man.	Traits selected for evolution are beneficial to species.
4.	Results are achieved in a short period.	Results are achieved over a long period.

	Homologous organs	Analogous organs
1.	Homologous organs have similar origin and internal structure.	Analogous organ have different origin and anatomy.
2.	Homologous organs perform different functions.	Analogous organs perform similar functions.
3.	Homologous organs are morphologically different.	Analogous organs are morphologically similar.
4.	They give evidence of divergent evolution (<i>i.e.</i> , evolution in closely related species to adapt them for different habitat.)	They give evidence of convergent evolution (<i>i.e.</i> , evolution in different species to adapt them for similar habitat).

8. Human Health and Disease

	Symptoms	Signs
1.	Symptoms indicate the presence of disease.	Signs provide information about the presence of particular disease.
2.	These are the manifestations or evidences of the presence of disease(s) of various body parts.	These are distinct for different diseases.

	Acute diseases	Chronic diseases
1.	These last for only short period of time.	These last for a long time, even as much as a lifetime.
2.	These do not cause long term bad effects on human health.	These cause drastic long term effects on human health.
3.	Patient recovers fully after the treatment.	Patient does not recover completely.
4.	Examples include cold, cough, typhoid, cholera, etc.	Examples include elephantiasis, cardio-diseases, tuberculosis, diabetes, arthritis, cancer, etc.

	Infectious diseases	Non-infectious diseases
1.	These occur due to external (extrinsic) factors.	These generally occur due to internal (intrinsic) factors.
2.	These are caused by the attack of pathogens (viruses, bacteria, fungi, protozoans, worms).	These are caused by factors other than living pathogens.
3.	These can spread from infected person to healthy person(s).	These cannot spread from infected person to healthy person(s).
4.	Infection is transmitted through direct contact (physical contact, sexual contact) or through medium (air, water, food, insects etc.).	Infection is not transmitted through direct contact or through medium except in hereditary diseases where it occurs from parent to offspring.

Table: Common diseases caused by infectious agents

	Infectious agents	Diseases
1.	Viruses	1. Common cold 2. Influenza 3. Dengue 4. Poliomyelitis 5. Hepatitis-B 6. AIDS (Acquired Immuno Deficiency Syndrome) 7. Chicken pox 8. Measles 9. Mumps

2.	Bacteria	1. Typhoid 2. Cholera 3. Tuberculosis 4. Anthrax 5. Tetanus 6. Food poisoning 7. Diphtheria
3.	Fungi	1. Many common skin infections
4.	Protozoans	1. Malaria 2. Kala-azar 3. Amoebic dysentery 4. Sleeping sickness
5.	Worms	1. Intestinal worm infections 2. Elephantiasis

Table : Common deficiency diseases

	Deficient nutrient	Disease
1.	Protein	Kwashiorkor
2.	Protein and total food calories	Marasmus
3.	Vitamin A	Xerophthalmia, Night blindness
4.	Vitamin B ₁	Beriberi
5.	Vitamin B ₂	Cheilosis
6.	Niacin	Pellagra
7.	Vitamin B ₁₂	Pernicious anaemia
8.	Iron	Microcytic anaemia
9.	Vitamin C	Scurvy
10.	Vitamin D	Rickets (in children), Osteomalacia (in adults)
11.	Vitamin K	Bleeding disease
12.	Fluorine	Dental caries
13.	Iodine	Goitre

Table: Important vaccines for babies and children

	Vaccine	Disease	Safety (Efficacy)
1.	BCG	Tuberculosis (TB)	50-80%
2.	Polio	Poliomyelitis	90-95%
3.	DPT	Diphtheria, Pertussis (Whooping cough), Tetanus	70-90%
4.	Hepatitis B	Hepatitis	> 95%
5.	Hib	<i>Haemophilus influenzae</i> type B	90-95%
6.	Measles	Measles	95%

9. Strategies for Enhancement in Food Production

- **Breeds of Cow :**
 - **Indigenous breeds:** Sahiwal, Gir, Red Sindhi, Tharparkar.
 - **Exotic breeds** (breeds which have been imported from abroad and reared in India): Jersey, Holstein-Friesian, Brown Swiss.
 - **Cross-breeds of improved breeds:** Karan Swiss, Karan Fries, Frieswal.
- Murrah, Meshsana and Surti are some common **breeds of buffaloes** reared in India.
 - **Karan Swiss :** It is a cross-breed of Brown Swiss and Sahiwal.
 - **Karan Fries:** It is a cross-breed of Holstein-Friesian and Tharparkar.
 - **Frieswal:** it is a cross-breed of Holstein-Friesian and Sahiwal.
- **Diseases of animals transmitted to human beings :**
 - **Viral diseases:** rabies, cow pox, encephalities.
 - **Bacterial diseases:** anthrax, tuberculosis, brucellosis.
 - **Fungal diseases:** actinomycosis, aspergillosis, ringworm.
 - **Parasitic diseases:** amoebiasis, trypanosomiasis, ascariasis.

Table : Differences between Layers and Broilers

	Layers	Broilers
1.	Layers are egg-laying birds, managed for the purpose of getting eggs .	Broilers are maintained for getting meat .
2.	Layers start producing eggs at the age of 20 weeks. So they are kept for longer period depending upon laying period (approximate 500 days).	They are raised upto 6-7 weeks in poultry farms and then sent to market for meat purposes.
3.	They require enough space and adequate lighting.	They require conditions to grow fast and low mortality.
4.	They need restricted and calculated feed with vitamins, minerals and micronutrients.	The daily food requirement (ration) for broilers is rich in protein and vitamin A and K. The fat contents should also be adequate.

- Plant breeding is the genetic improvement of the crops in order to create desired varieties of plant types that are better suited for cultivation, give better yields and are disease resistant.
- The development of several high yielding varieties of wheat and rice in the mid-1960s, as a result of various plant breeding techniques led to dramatic increase in food production in our country. This phase is often referred to as the **Green Revolution**. Some Indian hybrid crops are wheat, rice, sugarcane and millets, etc.
- In 1963, several wheat varieties such as *Sonalika* and *Kalyan Sona*, which were high yielding and disease resistant, were introduced all over the wheat-growing belt of India.
- Breeding crops with high levels of vitamins and minerals or higher protein and healthier fats is called **biofortification**.

- One of the alternate sources of proteins for animal and human nutrition is **single cell protein (SCP)**.
- **Plant tissue culture** is the technique of maintaining and growing plant cells, tissues or organs aseptically on artificial medium in suitable containers under controlled environmental conditions *in vitro*. The part which is cultured is called **explant**.

10. Microbes in Human Welfare

- The organisms which are not visible with naked eyes and viewed under the microscope are called **microorganisms** or **microbes**. These include bacteria, fungi, algae, protozoans, and viruses, etc. Microbes are both useful and harmful for humans.
- Lactic acid bacteria (LAB) like *Lactobacillus* convert lactose sugar of milk into lactic acid. *Lactic acid* causes coagulation of milk protein **casein**. **Curd** is prepared by inoculating skimmed/creamed milk with *Lactobacillus acidophilus* at temperature of about d° 40°C.
- **Cheese** is the partially degraded concentrate of milk fat and casein manufactured by microorganisms.
- Yeast species used in **alcoholic fermentation** are *Saccharomyces cerevisiae*, *S. ellipsoidens*, etc.
- **Antibiotics** are organic compounds produced by a microorganism in low concentration which inhibits the growth or kills the pathogenic organism without harming the host. Antibiotics are obtained from bacteria and fungi.
- **Acetic acid** is produced from fermented alcohol with the help of bacteria, *Acetobacter aceti*. **Citric acid** is obtained through the fermentation carried out by *Aspergillus niger* on molasses-based medium.
- **Statins** are produced by yeast *Monascus purpureus*. It acts as competitive inhibitor during cholesterol synthesis. So, it is used as blood cholesterol lowering agent.
- **Cyclosporin** is an important bioactive chemical produced by the fungus *Trichoderma polysporum*. It is used as an **immunosuppressive agent** in organ transplantation.
- **Streptokinase** (tissue plasminogen activator or TPA) is an enzymes obtained from the cultures of some haemolytic *Streptococci*.
- Sewage or municipal waste contains human excreta and other organic wastes. It also contains a number of pathogenic microbes, so should not be passed into rivers, streams and other water bodies. It is made less polluting by passing it through **sewage treatment plants (STPs)**.
- Biogas is a **methane rich fuel gas** produced by anaerobic break down or digestion of biomass with the help of **methanogenic bacteria**.
- The natural method of pest and pathogen control involving use of viruses, bacteria and other insects (which are their natural predators and pests) is called **biocontrol** or **biological control**. They include bioherbicides, bioinsecticides, etc. These inclusively are called as biopesticides.
- **Bioinsecticides** are those biological agents that are used to control harmful insects. They include predators, parasite, pathogens and natural insecticides.
- **Organic farming** is the technique of raising crops through the use of manures, fertilisers and pesticides of biological origin, resistant varieties, crop rotation, intercropping, etc.
- **Mycorrhiza** is a mutually beneficial or symbiotic association of a fungus with the roots of higher plants. Many members of Genus *Glomus* form mycorrhiza. The fungal symbiont absorbs phosphorus for the plant.
- Nitrogen fixing cyanobacteria (blue-green algae) form symbiotic association with several plants, *e.g.*, *Anabaena*, *Nostoc*, *Oscillatoria*.

11. Biotechnology : Principles and Processes

- Biotechnology is the use of **living organisms** in systems or processes for the **manufacturing of useful products**.
- Genetic engineering was introduced by **Paul Berg** (1972). He is often considered as the “**Father of genetic engineering**”. Genetic engineering is alternately called **recombinant DNA technology** or **gene cloning**.
- The **process of rDNA technology** involves : isolation of the genetic material, cutting of DNA at specific locations, amplification of gene of interest using PCR, preparation and insertion of rDNA into host cell and obtaining desirable gene product.
- **Cleaving enzymes** are used to break DNA molecules. They are further of 3 kinds: (a) exonucleases, (b) endonucleases and (c) restriction endonucleases. **Exonucleases** cut off nucleotides from 5' or 3' terminal ends of DNA molecule. **Endonucleases** cleave DNA duplex at any point except the terminal ends. **Restriction endonucleases** cleave DNA duplex at specific point. They were isolated for the first time by **W. Arber** in 1963. They act as “**molecular scissors**” or “**chemical scalpels**”.
- Gel electrophoresis is a technique of separation of charged molecules under the influence of an electrical field so that they migrate in the direction of electrode bearing the opposite charge, through a medium/matrix.
- The DNA used as a carrier for transferring of a fragment of foreign DNA into a suitable host is called **vehicle DNA** or **cloning vector**.
- **Plasmids** are extra-chromosomal, self replicating, usually circular, double stranded DNA molecules found naturally in many bacteria and also in some yeasts. **pBR322 vector** was the first artificial cloning vector constructed in 1977 by **Boliver and Rodriguez**.
- **Bacteriophages** are viruses that infect bacterial cells by injecting their DNA into these cells. The injected DNA is selectively replicated and expressed in the host bacterial cell resulting in a number of phages which burst out of the cell (lytic pathway) and reinfect neighbouring cells.
- **Origin of replication (Ori)** is a sequence from where replication starts. The replication occurs inside the host cells. A prokaryotic DNA has a single origin of replication while eukaryotic DNA may have more than one origin of replication.
- **Selectable markers** are required to identify and eliminate non-transformants and selectively permit the growth of the transformants. Generally, the genes encoding resistance to antibiotics such as tetracycline, ampicillin, kanamycin or chloramphenicol, etc., are useful as selectable markers for *E. coli*.
- Competent host is essential for transformation with recombinant DNA. Many kinds of host cells, including *E. coli*, yeast, animal and plant cells are available for genetic engineering. For the expression of some eukaryotic proteins, eukaryotic cells may be the preferred hosts.
- The vector DNA (*e.g.*, plasmid DNA) and alien (foreign) DNA carrying gene of interest are cut by the same restriction endonuclease to produce complementary sticky ends. This process of cutting DNA by restriction enzyme is called **restriction digestion**. With the help of DNA **ligase enzyme**, the complementary sticky ends of the two DNAs are joined (**annealing**) to produce a **recombinant DNA (rDNA)**.
- The polymerase chain reaction or PCR, was originally invented by **Kary Mullis** in 1985. PCR results in the **selective amplification** of a specific region of DNA molecule and so can also be used to generate

microgram quantities of DNA copies (upto billion copies) of the desired DNA (or RNA) present even as a single copy in initial preparation.

- **Bioreactors** are considered as vessels in which raw materials are biologically converted into specific products by microbes, plant and animal cells or their enzymes.

12. Biotechnology and its Applications

- The applications of biotechnology include therapeutics, diagnostics, genetically modified crops, processed food, bioremediation, waste treatment and energy production.
- The plants in which foreign gene has been introduced through genetic engineering are called **transgenic plants**. Transgenic plants can be obtained by **combination of tissue culture and genetic engineering**.
- The vector used to introduce new genes into plant cells is most often a plasmid from the soil bacterium *Agrobacterium tumefaciens*. This is the **Ti plasmid** (tumour inducing plasmid), so called because in nature, it induces tumours in broad leaf plants.
- **RNA interference (RNAi)** is the phenomenon of inhibiting activity of a gene by synthesis of RNA molecules complementary to the *mRNA*.
- ‘**Flavr Savr**’ tomato was the first transgenic variety to reach the market. Here inactivation of gene which produces **polygalactouronase enzyme** has been done. The non-availability of this enzyme prevents over-ripening because the enzyme is essential for degradation of cell walls.
- **Golden rice** is a transgenic variety of rice (*Oryza sativa*) which contains good quantities of β -carotene (provitamin A – inactive state of vitamin A).
- The biotechnological processes have made great impact in the area of healthcare by mass production of safe and more effective **therapeutic drugs**. This is known as medical biotechnology or **red biotechnology**.
- In 1921, **Banting and Best** along with **MacLeod** succeeded in preparing a pure extract of **insulin** from the pancreatic islets of a dog.
- In 1983, **Eli Lilly** an American company, prepared two DNA sequences corresponding to A and B chains of human insulin and introduced them in plasmids of *E.coli* to produce insulin chains. Chains A and B were produced separately, extracted and combined by creating disulphide bonds to form human insulin (humulin).
- **Gene therapy** is a collection of methods that allow genes to be inserted into a person’s cells and tissues to treat a disease. Correction of a genetic defect involves delivery of a normal gene into the individual or embryo to take over the function of and compensate for the non-functional gene. The first clinical gene therapy was given in 1990 to a 4-year old girl with **adenosine deaminase (ADA) deficiency**.
- In case of many pathogens, the gene encoding a critical antigen has been isolated and expressed in bacteria or animals, and the recombinant protein so produced is used as a vaccine ; such vaccines are called **recombinant vaccines**.
- A transgenic animal contains in its genome, a gene or genes introduced by one or the other technique of transfection.

- Transgenic animals that produce useful **biological products** can be created by the introduction of the portion of DNA (or genes) which codes for a particular product such as human protein (α -1-antitrypsin) used to treat **emphysema**. Similar attempts are being made for treatment of **phenylketonuria** (PKU) and **cystic fibrosis**. In 1997, the first transgenic cow, **Rosie** produced human protein-enriched milk (2.4 grams per litre). The milk contained the human alpha-lactalbumin and was nutritionally a more balanced product for human babies than natural cow milk.
- **Transgenic mice** are being developed for use in testing the safety of vaccine before they are used on humans.
- A **patent** is the right granted by a government to an inventor to prevent others from commercial use of his invention.
- Some organisations and multinational companies exploit and/or patent biological resources or bioresources of other nations without proper authorisation from the countries concerned, this is called **biopiracy**.
- **Biowar** is the use of highly infectious pathogens, their spores and toxins as agents of biological weapons against humans, crops and animals of enemy country.
- **Bioweapons** are almost invisible, low cost weapons which can cause more casualties than conventional or chemical weapons.

13. Organisms and Populations

- **Ecology** may be broadly defined as the study of interrelationship between living organisms and their environment.
- **Habitat** is a specific place or locality delimited by a combination of factors, physical features and barriers where a community resides. **Niche** or **ecological niche** is a specific part of habitat occupied by individuals of a species which is circumscribed by its range of tolerance, range of movement, microclimate, type of food and its availability, shelter, type of predator and timing of activity.
- Environmental factors are of two types: abiotic and biotic. **Biotic factors** include living organisms *i.e.*, plants, animals and microorganisms. **Abiotic factors** are non-living factors, substances and conditions of the environment which influence survival, form, function, behaviour and reproduction in organisms. Four major abiotic factors are light, temperature, water and soil.
- In plants, temperature affects various processes such as photosynthesis, respiration, reproduction and flowering, mineral and water absorption, growth and development, etc. Similarly, in animals, temperature affects metabolic activities, distribution, sex ratio, colouration, growth and development and behaviour, etc.
- Plants of aquatic habitats are called **hydrophytes** and they have various adaptations to survive in such environment. On the basis of moisture availability, terrestrial plants have been categorised into different types such as mesophytes (moderate water availability), xerophytes (dry habitats with minimal water availability), etc.
- Soil is a very important ecological factor as it provides water, mineral nutrients and support to plants. On the basis of the soil conditions, plants can be *i.e.*, **halophytes** (plants growing in saline soil), **oxylophytes**

(plants growing in acidic soil), **psammophytes** (plants growing in sandy soil), **chasmophytes** (plants growing in rock crevices) and **lithophytes** (plants growing on rocks).

- A process by which the organism keeps the internal environment constant despite drastic changes in external conditions is called **homeostasis**.
- **Adaptation** is any attribute of the organism (morphological, physiological, behavioural) that enables it to survive and reproduce in its habitat.
- **Bergmann's rule** : Temperature also affects the absolute size of an animal and the relative proportions of various body parts. **Allen's rule** : The tail, snout, ears and legs of mammals are relatively shorter in colder areas than in the warmer areas. The basic characteristic of a population is its size or density, which is affected by four primary population parameters such as **natality (births B)**, **mortality (deaths D)**, **immigration (I)** and **emigration (E)**. Therefore, if N is the population density at time t , then its density at time N_{t+1} is $N_t + (B + I) - (D + E)$. **Population density** is defined as numbers of individuals of a species per unit area or per unit volume at a given time.
- Populations have characteristic pattern of increase which are called **population growth forms**.
- The interactions among individuals of the same species are known as **intra-specific interactions** and among the organisms of different species are termed as **inter-specific interactions**. The interactions may be **positive** (mutualism symbiosis, proto cooperation and commensalism) or **negative** (amensalism, competition, parasitism and predation).
- **Mutualism** is the mutual beneficial relationship between individuals of two different species where none is capable of living separately. The association is **obligatory i.e.**, necessary for existence of both. Examples : (i) **Lichens** (a matrix formed by a fungus within which cells of alga are embedded). The alga depends upon the fungus for water, minerals and protection and fungus receives carbohydrates prepared by the alga. (ii) **Mycorrhiza** (it is an association between roots of higher plants and fungal hyphae).
- In **proto cooperation** the two organisms are mutually benefitted by each other but the **association is non-obligatory**, e.g., *Pluvianus aegyptius* (**crocodile bird**) enters the open mouth of crocodile and rids the latter of leeches.
- In **commensalism** one might get the benefit from the association while the other is neither benefitted nor harmed. E.g., orchids, are found growing on the branches and in the forks of trees.
- In **amensalism**, one organism inhibits the effect of the other. The inhibiting organism does not gain much benefit. This inhibition is done by secreting **allochemicals**.
- **Parasitism** is a relationship between two living organisms of different species in which one organism called parasite, obtains its food directly from another living organism called host.
- **Brood parasitism** in birds is a fascinating example of parasitism in which the parasitic bird lays its eggs in the nest of its host and lets the host incubate them.
- **Competition** may be defined as the active demand by two or more individuals of the same species or members of two or more species at the same trophic level for a common resource, thereby contributing to the density and diversity of a population. It is of two types – intraspecific and interspecific. **Intraspecific** competition is among the individuals of same species and is more severe due to similar needs and adaptations. **Interspecific** competition is amongst members of different species. It is less severe.
- **Predation** differs from parasitism in the sense that the parasite that lives on or in its host derives nourishment without usually killing it while the predator kills and devours its prey.

14. Ecosystem

Table : Differences between autotrophs and heterotrophs.

	Autotrophs	Heterotrophs
1.	They are producer organisms.	They are consumer organisms.
2.	They prepare their organic nutrients themselves.	They do not prepare their organic nutrients themselves.
3.	They get only inorganic materials from outside, using which they synthesize organic materials inside their body.	They get both organic and inorganic materials from outside.
4.	These obtain energy from sunlight or inorganic chemical reactions.	These obtain energy from organic nutrients.
5.	These usually add O ₂ to the environment.	These add CO ₂ to the environment.
6.	These include plants and blue green algae.	These include animals, many protists, bacteria and fungi.
7.	These possess photosynthetic pigments (e.g., chlorophyll).	Photosynthetic pigments are lacking in them.
8.	They constitute the first trophic level.	They belong to second and higher trophic levels.

Table : Differences between Food chain and Food web

	Food chain	Food web
1.	It represents series of organisms feeding on one another.	It is made up of number of interlinked food chains.
2.	Members of higher trophic level feed upon single type of organism of lower trophic level.	Members of higher trophic level can feed upon organisms of lower trophic levels of other food chains also.

- **Decomposers** are microbes (bacteria and fungi), which act on the dead bodies of producers and consumers to break the complex organic substances into simpler ones. They absorb some of the substances and release others into the environment to be recycled and to be used in future by the producers.

In this way, decomposers have a **very important role in cycling the materials** in the biosphere and maintaining the food chain by providing raw materials for producers. They also make the soil fertile and have become the integral part of ecosystem.

15. Biodiversity and Conservation

The **International Union for Conservation of Nature and Natural Resources (IUCN)** has classified threatened species into the following categories:

- (i) **Endangered species:** The species that are not likely to survive and will soon become extinct if the same causative factors continue, are called **endangered species**. Indian rhinoceros, Asiatic lion, lion-tailed macaque, crocodile and blue whale are some examples of endangered species.
 - (ii) **Extinct species:** The species of which last remaining member has died are known as extinct species, *e.g.*, dodo, passenger pigeon.
 - (iii) **Extinct in wild:** The species of which captive individuals survive, but there is no free living natural population comes under this category, *e.g.*, alagoas, curassow.
 - (iv) **Critically endangered:** The species which faces an extremely high risk of extinction in the immediate future are known as critically endangered species, *e.g.*, ivory-billed woodpecker, Arakan forest turtle.
 - (v) **Vulnerable species:** These are species which are likely to move to endangered category in near future, if causative factors continue to operate. Chinkara deer, black buck and golden langur are examples of vulnerable species.
- Some species of plants and animals are found exclusively in a particular area, and do not occur naturally anywhere else. Such species are called **endemic species** to that state, country or geographical area. For example, Asiatic lion (babbar sher) is endemic to Gir forests in Gujarat, Himalayan weasel is endemic to Himalayan region, snow leopard is endemic to Himalayan range found from Kashmir to Sikkim, wild mango and sal trees form endemic flora of Pachmarhi biosphere reserve, bison, Indian giant squirrel and flying squirrel are endemic fauna of Pachmarhi Biosphere Reserve.
 - A **national park** is a protected land area preserved in natural conditions to provide natural habitat to wildlife. Forestry, grazing, cultivation and free entry of people are not allowed in national parks.
 - **Jim Corbett National Park** in Uttarakhand was the first national park established in India in 1936.
 - A **sanctuary** is a protected land area reserved for the conservation of wild animals and birds. Hunting is strictly prohibited there. However, private ownership rights for collecting minor forest products, harvesting of timber and cultivation are granted so long as they do not interfere with the life of wild animals.
 - A **biosphere reserve** is a specified land area in which multiple use of land is permitted for preserving biodiversity. It is divided into three zones for different activities:
 - (i) **Core zone** where no human activity is permitted. It is also known as **natural zone**.
 - (ii) **Buffer zone** where limited human activity is allowed.
 - (iii) **Manipulation zone** where several human activities are permitted.

- There are two main categories of conservation: *in situ* conservation and *ex-situ* conservation.
- ***In situ* conservation** : When conservation of natural resources is done in their natural habitats (= home), it is called *in situ* conservation. For example, National Parks, Wildlife sanctuaries, Natural monuments, cultural landscapes, Biosphere Reserves.
- ***Ex situ* conservation**: When conservation of natural resources is done outside their habitats, it is called *ex situ* conservation. For example, botanical gardens, zoos, seed banks, pollen storage, tissue culture, etc.

16. Environmental Issues

Table: Various sources of wastes.

	Sources of wastes	Types of wastes
1.	Industrial wastes	<ul style="list-style-type: none"> • CO, CO₂, SO₂, H₂S and hydrocarbons (air released from automobiles also). • Hydrochloric acid, chlorine, nitrogen oxides, etc. • Heavy metals like mercury, lead, cadmium, nickel, etc. • Many organic compounds like phenol, naphtha, aromatic compounds, etc.
2.	Domestic wastes	<ul style="list-style-type: none"> • Sewage of sanitary facilities of residential, commercial, institutional and other public places. • Sewage with many types of pathogenic organisms like bacteria, encysted protozoans, viruses, eggs of helminthes, etc.
3.	Agricultural wastes	<ul style="list-style-type: none"> • CO₂, Methane (from paddy fields), organopesticides and chlorinated hydrocarbons, etc. • Traces of fertilizers with nitrates, phosphates and sulphates of potassium.
4.	Commercial wastes	<ul style="list-style-type: none"> • Building wastes, printing press wastes, biomedical wastes of medical institutions and hospitals, etc.

	Character	Biodegradable wastes	Nonbiodegradable wastes
1.	Microbial decomposition	Undergo microbial degradation.	Do not undergo microbial degradation.
2.	Main sources	Living organisms	Industries, hospitals, nursing homes etc.
3.	Examples	Domestic sewage, animal wastes, agricultural wastes, etc.	Pesticides, plastics, aluminium cans, synthetic polymers, heavy metals etc.

- **Sulphur** is present in coal as an impurity. It affects our lungs. It combines with the oxygen in the air to form sulphur trioxide (SO₃). This reacts with water in the clouds to form sulphuric acid (H₂SO₄). Rain mixed with acids is called **acid rain**.

- **Nitrogen dioxide** is given off by exhausts of automobiles, and by some industries. Nitrogen dioxide also reacts with water vapours present in the air to form nitric acid (HNO_3). This too causes acid rain.
- A **lead** compound is added to petrol to prevent engines from 'knocking'. Lead compounds emitted by exhausts of automobiles. They cause various problems such as mental disorder and brain damage.
- **BOD** is a measure of oxygen required by aerobic decomposers for the biochemical degradation of the organic materials (*i.e.*, biodegradable materials in water). Higher the BOD, lower would be the DO (dissolved oxygen). BOD indicates the degree of organic pollution in water.
- **Biomagnification** or **biological concentration** or **biological amplification** is increase in the amount of non-biodegradable substances in successive trophic levels of a food chain.
- **Harmful effects of biomagnification:**
 - (i) DDT interferes with the egg-shell formation in many birds. The shells remain thin and break by bird's weight during incubation. Dieldrin is about 5 times more toxic than DDT when ingested and 40 times more poisonous when absorbed.
 - (ii) The chlorinated hydrocarbons are known to affect CNS (central nervous system), cause softening of brain, cerebral haemorrhage, cirrhosis of liver, hypertension, cancer, malformation of sex hormones, etc.
 - (iii) Biomagnification of mercury into fish through the food chain was responsible for large number of deaths due to **Minamata disease in Japan**.
 - (iv) Selenium accumulates in the plants growing on selenium-rich soils. Through food chain, such plants cause stunted growth, loss of appetite, gastro-intestinal disorders, etc. in the animals grazing on such plants.
- Excess carbon dioxide in the atmosphere traps the heat of the sun. This is called the **greenhouse effect**. This is believed to cause an increase of the temperature of the earth, called **global warming**. Gases such as methane, nitrous oxide and water vapours also contribute towards the greenhouse effect. All such gases are known as **greenhouse gases**.
- Several countries have signed the **Kyoto Protocol** to reduce the emission of greenhouse gases.
- **Chlorofluorocarbons (CFCs)** are compounds used in refrigerators, air conditioners and aerosols. They damage the **ozone layer** in the atmosphere, causing an increase in the amount of ultraviolet rays from the sun reaching the Earth.
- For **conservation of forests** :
 - (i) It should be checked that illegal cutting of trees is banned and made a punishable act.
 - (ii) Stakeholders should take care of the maintenance of the forest.
 - (iii) Forest fires should be checked and controlled.
 - (iv) Nearby villages or people should be trained and educated to manage forests.

(v) Over-grazing in the forest should be presented.

(vi) Afforestation, social forestry and agroforestry should be promoted..

(vii) Soil erosion must be prevented.

- **Strict application of conservation strategies** may lead to strict ban on tree felling, wood cutting etc. But such bans will adversely affect human economy. Besides we have been using forest products and other resources from such a long period that now life seems impossible without them *e.g.*, in absence of timber we will not get furniture. To solve this problem idea of **sustainable development** has been developed that harmonises human growth and resource conservation *E.g.*, it says that we should plant at least as many plants as we cut to maintain that plant population. hence, it is considered to be an advanced idea of conservation.



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