

**SUPPLEMENTARY MATERIAL  
FOR  
SENIOR SECONDARY BIOLOGY**

National Curriculum for 2012 (Class XI & XII) has been revised under the aegis of COBSE in consensus with NCERT and CBSE.

In an effort to assist teachers to handle the revised curriculum, supplementary material has been prepared by experts at CBSE. The additional inputs have been proposed to motivate teachers to make conceptual linkages and create deeper interest in Biology.

# CLASS XII-BIOLOGY

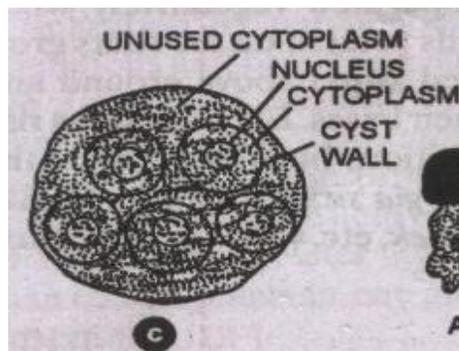
## Unit VI

### Chapter-1

#### Reproduction in organisms

#### Sporulation

When the products of multiple fission become individually surrounded by resistant coats, the cyst walls before their release from the parent, the process is known as sporulation and the encysted products are termed spores. The spores remain inactive during unfavorable conditions such as desiccation and extremes of temperature. When condition becomes favorable, the cyst hatches and gradually grows into an adult. Sporulation is thus not only a mean of reproduction, but also enables the organism to survive during unfavorable conditions and disperse to new localities with air. It occurs in amoeba.



#### Uniparental

It is the condition where a person receives two copies of a chromosome or part of a chromosome, from one parent and no copies from the other.

## **Fragmentation**

Fragmentation is a form of asexual reproduction where an organism splits into fragments. Each of these fragments develops into mature fully grown individual followed by mitosis. It occurs in some algae (*Spirogyra*), fungi, some annelids and sea stars.

## **Regeneration**

Regeneration is the process of renewal, restoration and growth. It can occur at the level of the cells, tissues and organs. It is common in Hydra, planarian flatworm and echinoderms. A lizard can discard a part of tail when in danger, and the tail can regenerate later. In humans too the liver can regenerate if partially damaged.

## **Unit VI- Reproduction**

### **Chapter 2**

### **Sexual Reproduction in Flowering Plants**

#### **Significance of seed and fruit formation**

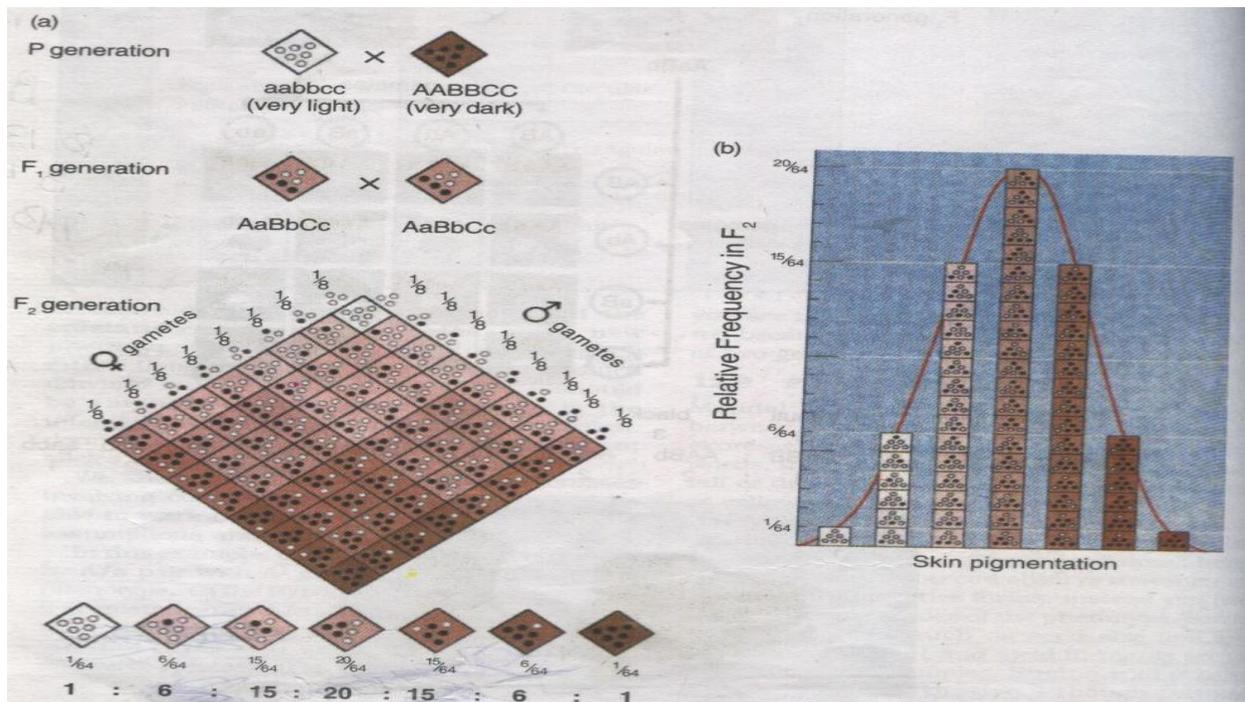
Significance of fruit formation

The fruits protect the seeds from unfavorable climatic conditions. Both fleshy and dry fruits help in the dispersal of seeds to distant places. They are a source of many chemicals like sugars, protein, oil, organic acids, vitamins and minerals. Some fruits may provide nutrition to the developing seedlings. Generally hard seeds are surrounded by soft fleshy fruit pericarp (for example guava) and soft seeds by a hard fruit shell (for example almond). The fleshy, edible parts of the fruit become the source of food and energy for the animals which often act as dispersal agents.

## **Polygenic Inheritance**

Galton in 1883 suggested that many instances of continuous variation are heritable. He was impressed by the fact that taller human beings generally produce taller children. He suggested that characters such as height and mental capabilities in humans are heritable although these show a continuous range of variation in a population. Galton's postulate gained experimental support when it was found that at least in some instances the same

character can be determined by more than one gene, each with the same but cumulative phenotypic effect. Quantitative characters like plant height, yield of crops (size, shape and number of seeds and fruits per plant), intelligence in human beings and milk yield in animals have been found to be determined by many genes and their effects have been found to be cumulative. Each gene has a certain amount of effect, and the more the number of dominant genes, the greater expression of the character. Quantitative inheritance is also known as polygenic inheritance or multiple factor inheritance. Though polygenic traits can be easily influenced by environment, these are generally controlled by three or more genes with phenotype reflecting the contribution of each allele (Quantitative). Let us discuss the polygenic trait by studying the inheritance of human skin colour. There are no contrasting phenotypes for this trait. Let us assume that this trait is controlled by three genes **A, B, and C**. **in this cross, there is a mating between dark-skinned and fair-skinned human beings and then the intermediate skin coloured individuals expected at F1 are mated to obtain F2 progeny.**



### Polygenic inheritance

- (a) A cross depicting the inheritance of human skin colour controlled by polygenes.
- (b) In the relative frequency of F<sub>2</sub> progeny in a polygenic cross is plotted against the extent of phenotypic expression – a typical inverted bell shaped curve is seen.

It is clear that:-

- (i) Few individuals fall into parental categories;
- (ii) The expression level of the phenotype is dependent upon the number of contributive alleles and is hence more quantitative.

If the  $F_2$  data are plotted graphically, a bell-shaped curve results.

In this example, we have assumed the involvement of three gene pairs, However if higher number of genes are involved in determining a phenotype, greater variety would be expected in  $F_2$  generation.

Other examples that can be studied are the kernel colour in wheat and inheritance of cob length in maize. It is generally believed that during evolution there was duplication of chromosome or chromosome parts thereby leading to multiple copies of the same gene. A large number of characters are controlled by polygenes in which alleles contribute additively to a phenotype. This results in polygenic inheritance.

## **Unit VII**

### **Chapter 5**

#### **Principles of Inheritance and Variation**

##### **Pleiotropy**

Pleiotropism is defined as a phenomenon when single gene may produce more than one effect (the multiple effect of a gene) or control several phenotypes depending on its position.

The basis of Pleiotropy is the interrelationship between the metabolic pathways that may contribute towards different phenotypes. In phenylketonuria, mutation of a gene that codes for the enzyme phenyl alanine hydroxylase.

This results in a phenotypic expression characterized by mental retardation and a reduction in hair and skin pigmentation.

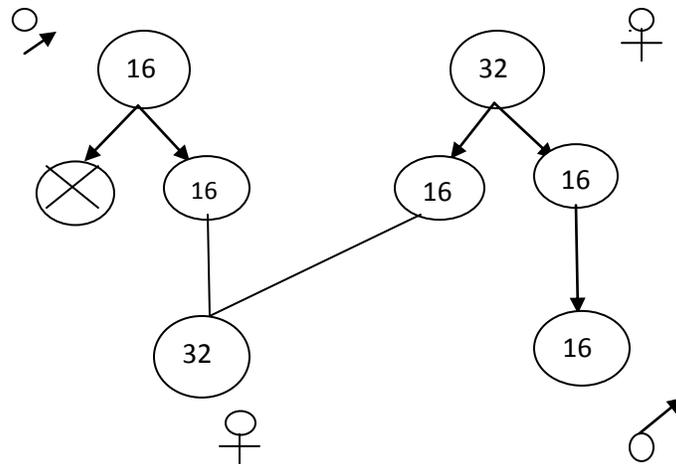
In drosophila white eye mutation leads to depigmentation in many other parts of the body, giving a pleiotropic effect.

In transgenic organisms, the introduced gene can produce different effects depending on where the gene has introgressed.

## Sex-determination in honey bee

The brood cells in a hive reveal two distinct sizes. The smaller of the two are reserved for the development of the workers, which are females, whereas the larger ones are for drones which are males. During the queen's nuptial flight, she is pursued by many drones. She finally allows herself to be inseminated by a drone. Sperms are stored in a seminal receptacle within her body. When she lays an egg in a worker cell, sperms are emitted from the seminal receptacle to fertilise the egg which will develop into a female, as all fertilised eggs form females (Incidentally, the workers can make this egg into a queen by enlarging the cell and feeding the developing larva on a rich diet, but both workers and queens are females.)

When the queen comes to a drone cell she exerts some sort of pressure on the ducts leading from the seminal receptacles so that the sperm cannot pass out and fertilise the egg as it passes down the oviduct. Thus an unfertilised egg is laid, which later hatches and produces a male. All unfertilized eggs produce males.

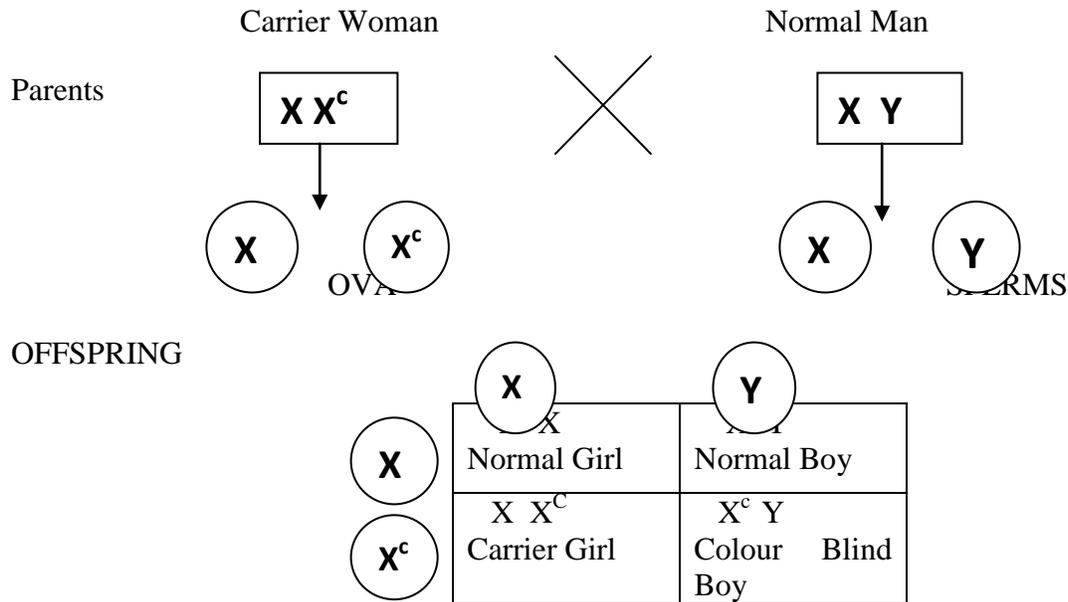


A diploid male could be obtained in the following manner. Suppose, there is a heterozygous female  $X^a$  and  $X^z$ . When crossed with a male  $X^m$ , the females would be  $X^a/X^m$  and  $X^z/X^m$ . If the male with  $X^m$  is crossed with either of the females i.e.  $X^a/X^m$  or  $X^z/X^m$  then diploid male  $X^m/X^m$ . At the same time, the females would lay some infertile eggs which would hatch into normal, fertile, haploid males.

## COLOUR BLINDNESS

Colour blindness is a recessive sex-linked trait in which the eye fails to distinguish red and green colours. The gene for normal vision is dominant. The normal gene and its recessive allele are carried by X-chromosome. In female colour blindness appears only when both the sex chromosomes carry the recessive gene ( $X^c X^c$ ). The females have normal vision

but function as carrier if a single recessive gene for colour blindness is present ( $XX^c$ ). However, in human males the defect appears in the presence of a single recessive gene ( $X^c Y$ ) because Y chromosomes of males do not carry any gene for colour vision. Colour blindness, like any other sex-linked trait, shows criss-cross inheritance.



1 Normal Girl: 1 Carrier girl  
1 Normal Boy: 1 Colour Blind Boy

### Colour blindness

Colourblindness does not mean not seeing any colour at all, it means that those who are colourblind have trouble in seeing the differences between certain colours.

Most colourblind people can't tell the difference between red or green. That does not mean that they can not do their normal work - Infact they can also drive – they learn to respond to the way the traffic signal lights up-the red light is generally on the top and green is on the bottom.

### THALASSAEMIA

Thalassaemia is a genetic defect, originated in Mediterranean region – by their mutation or deletion. In thalassaemia too few globins are synthesised whereas in sickle cell anaemia there is a synthesis of incorrectly functioning globin.

Thalasseмии are a group of disorders caused by defects in the synthesis of globin polypeptide. Absence or reduced synthesis of one of the globin chains results in an excess of the other. In this situation free globin chains, which are insoluble, accumulate inside the red

cells and form precipitates which damage the cell, causing cell lysis and resulting in anemia. There are two main types of Thalassemias in which synthesis of  $\alpha$  or  $\beta$  globin is defective. It is common in Mediterranean, Middle East, Indian subcontinent and in south east Africa.

### **Alpha ( $\alpha$ ) Thalassaemia**

The  $\alpha$  Thalassaemias involve the genes HBA1 and HBA2, inherited in a Mendelian recessive fashion. There are two gene loci and so four alleles. It is also connected to the deletion of the 16p chromosome.  $\alpha$  Thalassaemias result in decreased alpha-globin production, therefore fewer alpha-globin chains are produced, resulting in an excess of  $\beta$  chains in adults and excess  $\gamma$  chains in newborns. The excess  $\beta$  chains form unstable tetramers (called Hemoglobin H or HbH of 4 beta chains) which have abnormal oxygen dissociation curves.

### **Beta ( $\beta$ ) Thalassaemia**

Beta Thalassaemias are due to mutations in the HBB gene on chromosome 11, also inherited in an autosomal-recessive fashion. The severity of the disease depends on the nature of the mutation. Mutations are characterized as ( $\beta^0$  or  $\beta$  Thalassaemia major) if they prevent any formation of  $\beta$  chains (which is the most severe form of  $\beta$  Thalassaemia); they are characterized as ( $\beta^+$  or  $\beta$  Thalassaemia intermedia) if they allow some  $\beta$  chain formation to occur. In either case there is a relative excess of  $\alpha$  chains, but these do not form tetramers: rather, they bind to the [red blood cell](#) membranes, producing membrane damage, and at high concentrations they form toxic aggregates.

### **Delta ( $\delta$ ) Thalassaemia**

As well as alpha and beta chains being present in hemoglobin about 3% of adult hemoglobin is made of alpha and delta chains. Just as with beta Thalassaemia, mutations can occur which affect the ability of this gene to produce delta chains.

## **Unit VII**

### **Chapter 7**

#### **Evolution**

#### **Evidence from embryology**

Embryos of the vertebrate series exhibit many features that are not seen in adults. For example, all embryos of vertebrates develop a row of vestigial gill slits just behind the head. Since these

gill slits are functional only in fishes, why do these structures appear in the land vertebrates? It could mean that land vertebrates descended from fishes that had gill slits to help in aquatic respiration. Generalized features such as brain, spinal cord, axial skeleton and aortic arches are common to all vertebrates. Organisms that share common descent show embryological patterns on which they later build their adult patterns. This was first observed by von Baer Ernst Haeckel reinterpreted Baer's law in the light of evolution. This law held that ontogeny (development of the embryo) is recapitulation of phylogeny (development of race). This is summarized as biogenetic law which states that ontogeny recapitulates phylogeny. However, this proposal was disapproved on careful studies by von Baer as it was noted that the embryos do not pass through the adult stages of other animals. There are stages that related embryo to share.

Embryological evidence of evolution (adapted from NCERT)

Examples of this phenomenon are also seen in plants.

For example-

- (i) The Protonema, an early stage in the development of moss or fern gametophyte, resembles the filamentous green algae in structure, physiology and growth pattern. This suggests an algal ancestry of bryophytes and pteridophytes.
- (ii) The gymnosperms have normally become independent of water in fertilisation. However, the primitive gymnosperms such as Cycas and Ginkgo have flagellated sperms and need water for fertilization just like the pteridophytes, their most likely ancestors.
- (iii) The seedlings of acacia tree initially develop simple leaves, but the leaves that develop later are compound.

## **Molecular evidence in Evolution**

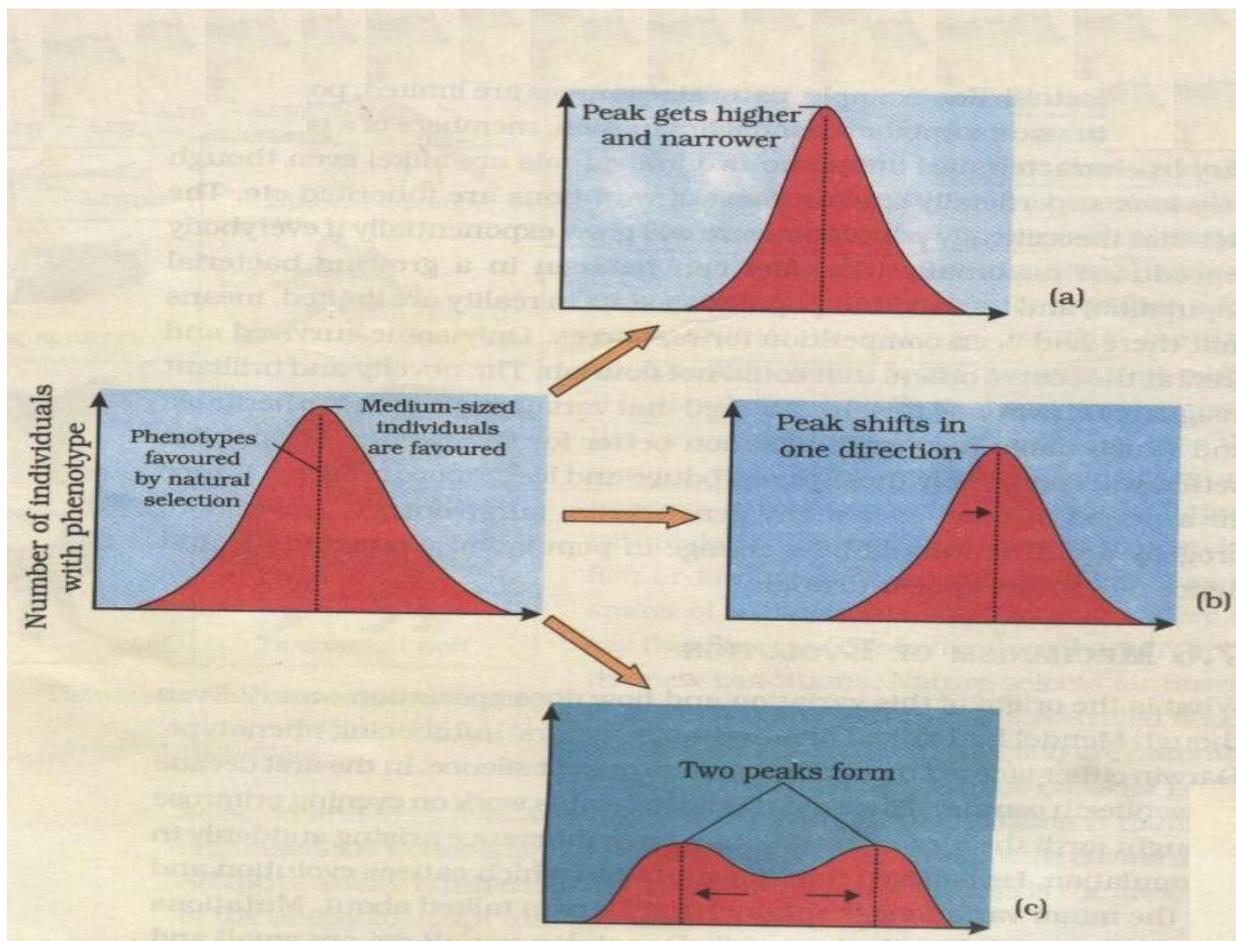
Similarity of organisms at the molecular level indicates phylogenetic relationship. The degree of similarity in the base sequence in their nucleic acids, and amino acid sequence in their proteins are indicated. Human DNA differs in only 1.8% of its base pairs from chimpanzee DNA, and there is no difference between the two in the amino acid sequence for the protein cytochrome C. Similarity in the molecular structure of actin and tubulin proteins in all animals point to their common ancestry.

A common genetic code is overwhelming evidence that all organisms are related.

## MODERN SYNTHETIC THEORY OF EVOLUTION

Darwinism, the theory of natural selection has a wide acceptance. However, it has been criticised too, on the ground it could not explain how the variations arise. With progress in genetics, the sources of variation were explained and Darwin's theory was modified. Now, the most accepted theory of evolution is known as **SYNTHETIC THEORY OF EVOLUTION**, in which the origin of species is based on the interaction of genetic variation and natural selection.

### Types of Natural Selection



Diagrammatic representation of the operation of natural selection on different traits (a)Stabilising (b)Directional (c)Disruptive - adapted from NCERT

Natural selection causes allele frequencies of a population to change. Depending upon which traits are favoured in a population it can produce three different results.

- (1) Stabilizing selection - If both the smallest and largest individuals contribute relatively fewer offspring to the next generation than those closer to average size do, then stabilizing selection is operating. It reduces the variation but does not change mean value.
- (2) Directional selection – If individuals at one extreme of the size distribution e.g. (the larger ones) contribute more offspring to the next generation than the other individuals do, then the mean size of individuals in the population will increase. In this case directional population is operating. If directional selection operates for many generations, an evolutionary trend within the population results.
- (3) Disruptive selection- When natural selection simultaneously favours individuals at both extremes of the distribution, disruptive selection is operating. As a result we can see two peaks in the distribution of a trait.

## UNIT - IX

### CHAPTER 12

#### BIOTECHNOLOGY AND ITS APPLICATIONS

##### **Patent**

A set of exclusive rights granted by a state (national government) to an inventor or their assignee for a limited period of time in exchange for a public disclosure of an invention.

Patents are supposed to satisfy three criteria of : Novelty, non-obviousness, and Utility.

Novelty implies that the innovation must be new. It cannot be part of ‘prior art’ or existing knowledge. Non-obviousness implies that it may not be documented but is otherwise well known. The disclosed fact or product should be of a particular use for the human beings.

##### **Controversies in India regarding patent and biopiracy**

**Turmeric:** In May, 1995 the US Patent Office granted to the University of Mississippi Medical Center a patent for “Use of Turmeric in Wound Healing.”

Consider the implication of ‘turmeric patent’. If an Indian in America sprinkles turmeric powder – just as her ancestors in India have done for centuries – on her child’s scrape, she would in fact be infringing US patent laws and would be open to prosecution.

The patent was promptly challenged by Dr. R A Mashelkar, an Indian scientist who has done much to awaken India to Intellectual property Rights issues. After four months of submissions it was established that the use of turmeric as a healing agent was well-known in India for centuries. The patent was revoked.

**Neem:** In 1996, Vandana Shiva challenged the patent granted to the firm of W.R. Grace & Co. by the European Patent Office, Munich for ‘fungicidal uses of neem oil’. Although the patent has been granted on an extraction technique, the Indian press described it as a patent on the neem tree itself: the result was widespread public outcry, which was echoed throughout the developing world. Vandana Shiva and Ajay Phadke, who had researched neem in India, flagged ancient Indian texts to point out that there was no ‘novelty’ factor in neem’s magical properties that Grace & Co. had unveiled – Indians had known them for long. Legal action by the Indian government followed, with the patent eventually being overturned in 2005.

**Basmati Rice:** In September 1997, a Texas company called Rice Tec won a patent on “basmati rice lines and grains.” The patent secured lines of basmati and basmati-like rice and ways of selecting that rice for breeding. Rice Tec, owned by Prince Hans-Adam of Liechtenstein, international outrage over allegations of biopiracy. It has also caused a brief diplomatic crisis between India and United States with India threatening to take the matter to WTO ( World Trade Organization) as a violation of TRIPS (trade-related aspects of intellectual property rights) which could have resulted in a major embarrassment for the United States. Both voluntarily, and due to review decisions by the United States patent Office, Rice Tec lost most of the claims of the patent.

## **UNIT – X**

### **CHAPTER 13**

#### **ORGANISMS AND POPULATION**

##### **Niche**

A habitat can contain many ecological niches and support a variety of species. The ecological niche of an organism represents the range of conditions that it can tolerate, the resources it utilizes, and its functional role in the ecological system. Each species occupies a distinct niche, and no two species are believed to occupy the same niche.

# CLASS XI- BIOLOGY

## UNIT - I

### Chapter -2

#### Biological Classification

**Five kingdom classification** is based on complexity of organism and type of nutrition. The five kingdoms are:

Monera, Protista, Mycota, Plantae and animalia.

**Six kingdom classification:** proposed by Carl Woese who has suggested a separate kingdom for Archaebacteria that are included in Monera in Whittaker's five - kingdom classification in addition to the five kingdom classification of R.H. Whittaker.

**Three domains of life:** These are Archaea, Bacteria and Eukarya. Archaea has kingdom Archaebacteria, Bacteria has kingdom Eubacteria and Eukaryota has kingdoms -Protista, Mycota, Plantae and Animalia.

## Unit IV-Plant Physiology

### Chapter 15

#### Plant Growth and Development

##### Seed Germination

The first step in the process of plant growth is seed germination. The seeds germinate under favourable conditions of the environment. Some seeds undergo a period of dormancy and can germinate only after dormancy period gets over.

Seed germinates to form seedling which grows into a plant. After the dormancy of the seed is over or is broken, and the necessary conditions for germination are available the dormant embryo becomes metabolically active and starts growing. This process is known as seed germination. The conditions necessary for seed germination are availability of water and oxygen. The imbibitions or the uptake of water is the first step towards the germination of seed. It causes swelling of seed that ruptures the seed coat to enable the radical to emerge from one end of embryonic axis the metabolic activities require oxygen for breaking down the food reserves. The mobilization of food reserves involves the hydrolysis of stored polysaccharides, proteins, and lipids with the help of enzymes.

The emergence of radical which gives rise to root system is considered the first step towards seed germination. As radical emerges from one end of the embryonic axis, plumule which forms the shoot arises from the other end. The rate of respiration increases rapidly during seed germination. The growth of radical and plumule is due to the cell extension, cell division and initiation of several biochemical processes. The seed also needs a suitable temperature (optimum between 25 to 35).

Some plants such as Rhizophora and Sonneratia show special type of germination known as vivipary. These plants grow in marshy lands. Vivipary is the germination of a seed while it is still attached to the parent plant and is nourished by it. As the germinating seed forms a seedling, its weight increases and the seedling separates and falls down into the mud. The lateral roots then develop to help proper anchorage of the seedling.

### **Seed Dormancy**

The development of embryo stops once the seed matures. It sheds most of its water content, the metabolic activities become extremely low, the seed coat becomes impermeable to oxygen and moisture and it usually hardens.

In many plants, the seed undergoes a period of suspended growth and does not germinate as soon as it is formed. The suspension of growth is referred to as quiescence when it is due to exogenous factors, such as the environmental conditions. The seeds may be in a state of dormancy or rest due to endogenous control during which metabolic activity of the seed is greatly reduced. While quiescence is the condition of a seed when it is unable to germinate because the conditions for germination are not available, dormancy is the condition of seed when it is unable to germinate in spite of the availability of all environments conditions suitable for germination.

Dormancy in seeds may be due to impermeable or mechanically resistant seed coats, rudimentary or physiologically immature embryos and even due to the presence of germination inhibitors such as abscisic acid, phenolic acid, short chain fatty acids and coumarin. Dormancy of the seed can be broken, or its duration can be reduced to initiate germination, by mechanical or chemical scarification of the seed coat, stratification of seeds or changing environmental conditions such as temperature, light and pressure.

Scarification of seed involves scratching of seed coat to help break the dormancy caused by hard and impermeable seed coat. Stratification of seeds is subjecting the moist seeds to oxygen for variable periods of low or high temperatures.

## Unit V- Human Physiology

### Chapter 16

#### Digestion and Absorption

**Calorific value of carbohydrate, protein and fat:** We all recognize the vital importance of food for life. A certain part of the nutrients that we take is used for building cell structures, synthesizing functional molecules or replacing worn-out parts. However, most of the foods are used as sources of metabolic fuels. Carbohydrates, proteins and fats serve as the chief sources of energy in humans. These are oxidized and transformed into ATP, the chemical energy form used by cells to drive their multitudes of activities.

Since heat is the ultimate form of all energy, the energy value of food (or any fuel) is expressed in terms of a measure of heat energy it produces on combustion. The heat energy released by combustion of one gram of food is usually known as its gross **calorific value**. It is defined as the amount of heat produced in calories (cal) or in joules (J) from complete combustion of 1 gram of food in a bomb calorimeter (a closed metal chamber filled with O<sub>2</sub>). The calorific value is usually expressed in terms of kcal per gram or kilojoules per gram. (1kcal = 4.184kJ) One kilocalorie is the amount of heat energy needed to raise the temperature of one kilogram of water through 1°C (1.8°F). Nutritionists traditionally refer to kcal as the **Calorie** or to kJ as **Joules** (always capitalized). The calorific values of carbohydrates, proteins and fats are 4.1 kcal /g, 5.65 kcal /g and 9.45 kcal /g, respectively. The actual amounts of energy liberated in the body by these nutrients, referred to as the physiologic value of the food, are 4.0 kcal /g, 4.0 kcal /g and 9.0 kcal /g respectively.

#### DEFICIENCY DISEASES

Humans require a wide range of nutrients to perform various functions in the body and to lead a healthy life. You have already learnt about the functions of various nutrients in previous classes. Inadequate nutrients in the diet cause various deficiency disorders, particularly among the children and the poor.

The important deficiency disorders include protein energy malnutrition (PEM) and disorders due to deficiencies of Vitamin A, iron and iodine. Deficiency of protein and energy or both, called PEM, has been identified as a major health and nutritional problem in India. Protein and energy intake are difficult to separate because diets adequate in energy are adequate in protein. Young children (0-6 years) require more protein for each kilogram of body weight than adults. So they are more vulnerable to malnutrition. Malnutrition is not only an important cause of childhood mortality and morbidity, but it also leads to permanent impairment of physical and mental growth of those who survive. The details of the disorders are given below.

**PEM:** it is an important nutritional problem among pre-school children.

It leads to various degrees of growth retardation. This is due to lack of adequate quantity of protein or carbohydrate or both.

PEM is of 2 types: Kwashiorkor and marasmus

Deficient Nutrient	Name of Deficiency	Deficiency Symptoms
Protein (PEM)	Kwashiorkor  (usually observed in children in the age group of 1-5 years)	Wasted muscles, thin Limbs, retarded growth of body and brain, swelling of legs due to retention of water (oedema), reddish hair, pot belly and diarrhea.
Protein and Calorie (PEM)	Marasmus (it usually affects infants below the age of one year)	Impaired growth and replacement of tissue proteins, thin limbs and prominent ribs (emaciated body), dry, wrinkled and thin skin, diarrhea.

The child suffering from PEM can recover if adequate quantities of protein and carbohydrate rich food are given.

## Chapter 19

### Excretory Products and their elimination

#### Diabetes Insipidus

Antidiuretic hormone (ADH) is one of the hormones that efficiently monitors and regulates the functioning of the kidneys. Can you recall the other hormones involved? Why is ADH so called? (Diuresis is urine production). Antidiuretic hormone released from the posterior pituitary, prevents wide swings in water balance, helping to avoid dehydration or water overload. Try to recollect how ADH facilitates reabsorption of water by the distal parts of the kidney tubules and thereby prevents diuresis. Deficiency of ADH leads to *diabetes insipidus*, a condition marked by the output of huge amounts of urine and intense thirst. The name itself (*diabetes* = overflow; *insipidus* = tasteless) distinguishes it from diabetes mellitus (*mel* = honey), in which insulin deficiency causes large amounts of blood sugar to be lost in the urine.

## **Artificial kidney**

You have studied about various disorders of the excretory system. Hemodialysis is an artificial process of removing toxic substances from the blood in patients of kidney failure. The hemodialysis machine is therefore also known as the artificial kidney.

## **Chapter 20**

### **Locomotion and Movement**

#### **Types of movements: Flagellar movement.**

Movement is most basic characteristic of living organisms. There are three main types of movements shown by the cells of the human body, viz amoeboid, ciliary and muscular. Human sperms (typical example of flagellated cells) exhibit yet another type of movement, the flagellar movement. The flagellum is the propulsion equipment for the movement of sperm towards the ovum. This propulsion is brought about by the whip like movement of the tail and the middle piece of the sperm.

## **Chapter 21**

### **Neural control and coordination**

#### **Sense organs**

We humans are responsive organisms. Aroma of a freshly cooked dish makes our mouth water, loud thunder makes us jump in our seat and stepping on a nail causes intense pain. We sense the changes in our environment (both internal and external) with the help of special sensory receptors. These environmental changes, called stimuli, once detected by the special sensory cells, are conveyed to the brain in the form of nerve impulses. The meaning of each stimulus is interpreted in the brain and appropriate order is sent to the body parts for its appropriate response to ensure well being.

Traditionally, there are five senses: touch, vision, hearing, smell and taste. While touch is a complex **general sense**, the other four are **special senses**. The general sensory receptors are **simple receptors** that are mostly modified dendritic ends of sensory neurons. Such receptors are present throughout the body – in the skin, mucous membranes, connective tissues and muscles. These monitor most of the types of general sensory information such as tactile sensation (a mix of touch, pressure, stretch and vibration), heat, cold, pain and muscle sense (proception).

In contrast, special sensory receptors are distinct receptor cells that are actually confined to the head region and are highly localized within complex sensory organs like eyes and ears and tissues of the taste buds and olfactory epithelium. These sensory organs and tissues are collection of cells of many different types (receptor and non receptor cells}, working together to accomplish a specific receptive process. Recall the structure of eye and ear that you have studied. Which type of sensory receptor are these made of? Yes, the special sensory receptors called the photoreceptors and the auditory receptors respectively.

Though the complex sense organs are more familiar to us, the simple sensory receptors associated with general senses are no less important. These keep the central nervous system well informed about what is happening, both deep within the body and on its surface. In this lesson you will learn about a few of these simple receptors present in the skin. You will also learn about the special senses of taste and smell.

### **The chemical senses: the taste and smell**

The receptors for taste and smell are classified as chemoreceptors as these respond to special chemicals in aqueous solution. In each case, the chemicals must go into solution in the film of liquid coating the membranes of the receptor cells before these can be detected. The taste receptors are specialized cells that detect chemicals present in quantity in the mouth itself, while smell receptors are modified sensory neurons in the nasal passage which detect the volatile chemicals that get wafted up the nostrils from distant sources. These two types of receptors complement each other and often respond to the same stimulus. You can now guess why a very strong perfume leaves a peculiar taste in your mouth. The smell receptors can be as much as 3,400 times more sensitive than the taste receptors.

**Sense of smell (olfaction):** Nose contains the receptors of smell, in the mucous coated thin, yellowish patch (about 5 cm<sup>2</sup>) of modified pseudo stratified epithelium called **olfactory epithelium**. It is located way up at the roof of the nasal cavity on either sides of the nasal septum.

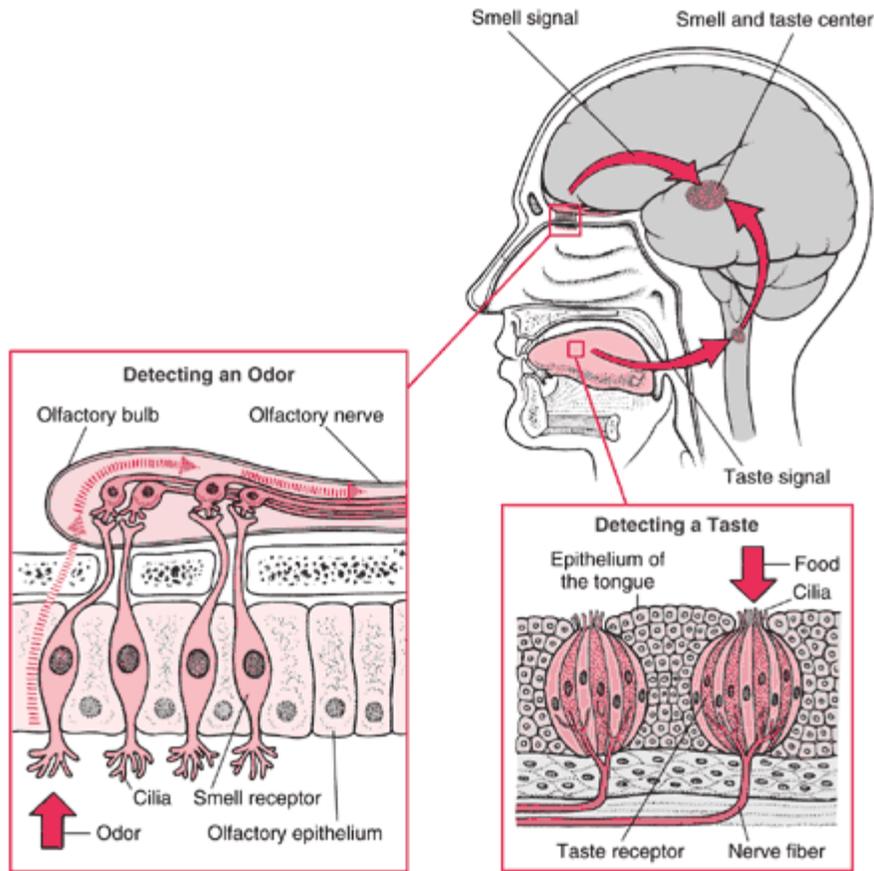


Figure 1 Human nose showing olfactory bulb and magnified view of olfactory epithelium

[smsm2a2012.weebly.com/reading-site.html](http://smsm2a2012.weebly.com/reading-site.html)

The olfactory epithelium contains three types of cells: (a) millions of olfactory receptor cells; (b) columnar supportive cells; (c) short basal cells. Olfactory receptors are unusual bipolar sensory neurons. The thin dendrites of each of these neurons run to the surface of the epithelium where these bear a cluster of about 20 modified cilia which function as receptor sites. These cilia extend from the olfactory epithelium into the thin coat of nasal mucous secreted by the supportive cells and olfactory glands. This mucous is a solvent that captures and dissolves the air borne odour molecules. Once dissolved, the chemicals bind to the specific receptors on the cilia stimulating the receptor cells. This causes depolarization and ultimately action potential in the receptor cell. The axons of the olfactory receptors unite to form the olfactory nerve which transmits the information directly to the overlying olfactory bulb, a relay station in the brain. Unlike receptor ends of other senses, the axons of the olfactory receptors directly extend from the outside environment (the nasal cavity) into the olfactory bulb, a part of the brain. The number of receptors stimulated indicates the strength of the stimulus.

As with taste, some of what we call smell, can be really painful. The nasal cavity contains pain receptors that respond to irritants such as ammonia, vinegar or hot chilly pepper. Impulses from these pain receptors reach the brain. The brain combines these sensations with those of smell to identify the odours. Although humans do have a good sense of smell - we can detect about 10,000 different odours - our olfactory capability is not as good as those of many vertebrates, especially fish and mammals such as a dog.

### **Sense of taste (gustation)**

The sense of taste and smell work closely together. If we cannot smell some thing we cannot taste it either. When we speak of taste sensations we are often referring to the combined sensation produced by both taste and smell receptors. One reason why we cannot taste (or smell) food well with a common cold is that with the nasal passages inflamed and coated with thick mucus layer the smell receptors are practically non functional. The receptor cells for taste are located in **taste buds**. Humans have about 10,000 taste buds. The majority of taste buds are located in pockets around the papillae (peg-like projections of the mucous membrane) on the surface and sides of the tongue, but there are some on the surface of the pharynx and the larynx. Each taste bud contains about 40 specialized receptor cells or **gustatory cells**, many more supporting cells and some basal cells that replace the worn out cells of the taste buds. Unlike the receptors for smell, that are modified sensory neurons, the receptor cells for taste are not neurons, but rather specialized cells with slender microvilli on their outer ends. The microvilli protrude into the surrounding fluids through a narrow opening called the **taste pore**. Dissolved chemicals contacting the microvilli bind to specific receptor proteins on the microvilli, thereby depolarizing the cell. The dendrites of the associated sensory neurons coil intimately around the receptor cells and synapse with them so that, when a receptor cell is stimulated and depolarized, it releases neurotransmitter which leads to the generation of an action potential in the associated sensory neuron. Each dendrite receives signals from several receptor cells within the taste bud. Nerve fibers emerging from the taste buds pass to the brain stem. From here the nerve impulse is relayed to the taste centre in the cerebral cortex of the brain that perceives the taste sensation.

Normally our taste sensations are complicated mixture of qualities. In humans there are four basic taste senses: sweet, sour, salt, and bitter. The receptors for these four basic tastes have their areas of greatest concentration on different parts of the tongue - sweet and salty on the front, bitter on the back, and sour on the sides. A few substances stimulate only one of the four types of receptors, but most stimulate two, three, or all four types to varying degrees. The sensation and flavour of the food we experience are thus produced by a combination of these four basic sensations, modified by accompanying sensations of smell, texture and temperature.

### **Sense of touch**

Skin is the sensory organ for touch and is also the largest sense organ. Our sense of touch allows us to feel light sensation like the touch of a feather as well as a heavy sensation like a stone falling on the toe. These sensations come from millions of microscopic simple sensory receptors

located all over the skin and associated with the general sensations of contact or pressure, heat, cold, and pain. The receptors are located at different levels within the skin and distributed unevenly. Some parts of the body have a large number of these such as the finger tips, making them more sensitive. Can you name the parts of your body that are less sensitive and why?

Structurally, these touch receptors are either free dendritic endings or encapsulated dendritic endings present in the skin (and other parts of the body). When stimulated, these transmit the sensation to the brain. Given below is a list of some of these receptors present in the skin.

Free or bare dendritic nerve endings are present throughout the epidermis taking an extensive branching or “zigzag” form. These respond chiefly to pain and temperature but some respond to pressure as well. The root hair plexuses, net work of free nerve endings that surround hair follicles, are light touch receptors that detect bending of hairs. These report on wind blowing through your hair.

Meissner’s corpuscles are small receptors in which a few spiraling dendrites are surrounded by specialized capsule (Schwann) cells. These are found just beneath the skin epidermis in dermal papillae and are especially abundant in finger tips and soles of the feet. These are light pressure receptors that allow us to become aware of a caress or feel of our shirt against our skin.

Pacinian corpuscles are the large egg shaped bodies. In each a single dendrite is surrounded by multilayers of capsule cells. These are scattered deep in the dermis and in the subcutaneous tissue of the skin. These are stimulated by deep pressure and respond only when pressure is first applied. Thus, these receptors are best suited to monitor vibrations (on-off pressure stimulus the sense of touch allows us to detect different textures, temperatures, hardness and pain. Pain serves as a warning or alert system for the body. Whenever one or more of these sensory receptors are stimulated (by heat, cold, vibrations, pressure or pain) an impulse or action potential is generated. This impulse is then taken to the spinal cord and from there to the brain which analyses the stimulus and then generates appropriate response. The way brain interprets the sensation in our lives is also shaped by our personal experience in the past. Try to recollect your experience of touching a sharp object/ a hot plate by accident.

## Chapter 22

### Chemical coordination and integration

**Exophthalmic goitre, also called Grave’s disease:** It is an endocrine disorder that is the most common cause of hyperthyroidism. In Grave’s disease excessive secretion of thyroxine hormone is accompanied by diffuse enlargement of the thyroid glands. It is an autoimmune disease where patients produce antibodies that act on the thyroid glands to increase thyroxine hormone production and thyroid size. Patients suffering from cancer of thyroid glands or those with

nodules in the thyroid glands suffer from very high levels of thyroid hormones leading to hyperthyroidism. Such patients show some typical symptoms that include elevated metabolic rate, sweating, rapid and irregular heartbeat, weight loss despite increased appetite, frequent bowel movement and nervousness. Some patients may also experience *exophthalmos* ( or protrusion of the eye balls). Thus this condition is also known as *exophthalmic goitre* .Do you recollect another condition that may also lead to goitre (enlargement of the thyroid glands)? Lack of iodine in our diet also results in goitre which, however, is associated with hypothyroidism and not hyperthyroidism.

### **Addison's' disease:**

The cortex of the adrenal glands secretes many hormones, commonly called as corticoids. Hyposecretory disorder of the adrenal cortex or destruction of adrenal cortex in diseases such as tuberculosis leads to deficit of both glucocorticoids and mineralocorticoids. This condition is known as Addison's disease. Persons with Addison's disease tend to loose weight, their blood glucose and sodium levels drop and potassium levels rise. Can you explain why? Severe dehydration is also common in them.