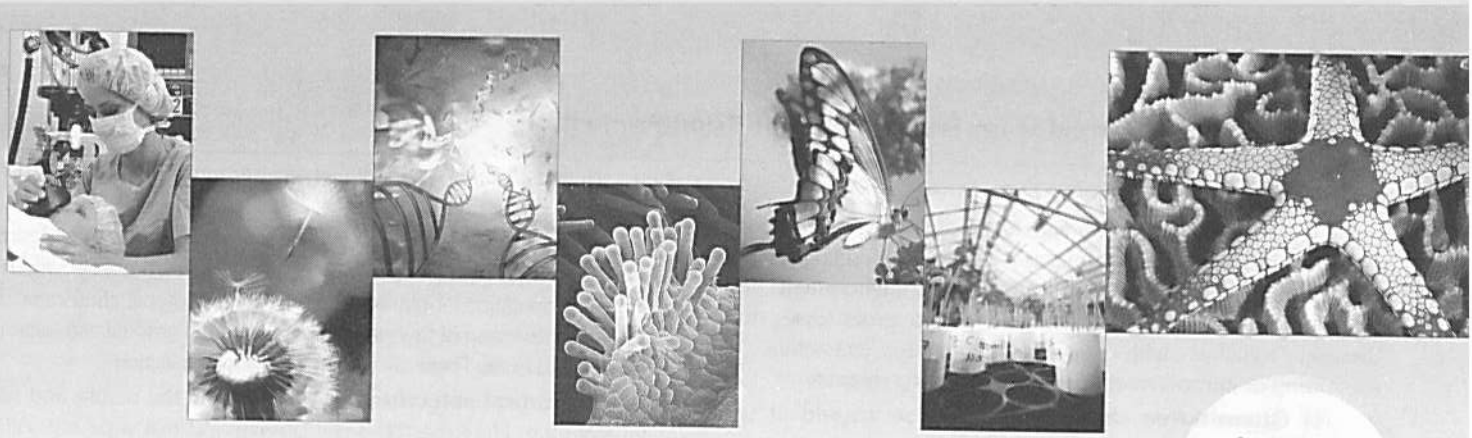


Chapter

8.4

Strategies for Enhancement in Food Production

All the present species of cultivated plants are of wild species origin and this **process of cultivation of wild species** in order to fulfil human needs is called **domestication** of plants. Domestication plays foremost role in development of human civilization. Further effective agriculture is the result of domestication of crop plants. Origin of agriculture dates back to **7000–13,000 years ago** in high and well watered lands of Indus,' Tigris, Nile and Euphrates. Carl Scanner has pointed out that first plants that grew wild and then cultivated, were nitrogen loving and multipurpose plants.

The plants cultivated early in the development of agriculture were, hemp *(Cannabis sativa)* and baobab tree (*Adansonia digitate*) in Africa, mulberry tree *(Morus alba)* in China and coconut palm (*Cocos nucifera)* in tropical areas such as Mexico and coastal areas in India. In South Africa, the individuals of Kung tribe depends on two plants for their survival. These were mongongo nut (*Reicinidendron rautanenii*) and marama bean (*Bauhinia esculenta*). Another multipurpose plant of tropical areas is coconut palm *(Cocos nucifera)* which is known as "mans most useful tree" and in India it is known as "Kalpa vriksha " or "Tree of heaven".

Centre of origin : Nikolai Ivanovitch Vavilov (1926) proposed different centres of origin for various crop plants on two criteria, that are occurrence of wild relatives and occurrence of maximum variation in the crop.

(1) **South East Asia :** Rice, Pigeon pea, Banana, Mango, Orange, Brinjal, Black Pepper, Sugarcane.

(2) **China :** Onion, Tea, Soybean.

(3) **South West Asia :** Wheat.

(4) **Asia minor and Afganistan :** Rye, Lentil, Apple, Pear, Apricot, Pomegranate, Pistachio, Almond.

(5) **Mediterranean :** Oat, Lettuce, Cabbage, Beet.

(6) **Ethiopia :** Barley, Sorghum, Coffee.

(7) **Brazil :** Groundnut, Pineapple, Rubber.

(8) **Peruvian Andes (South America) :** Potato, Tomato, Chilli.

(9) **Mexico and Central America :** Maize and Cotton.

(10) **U.S.A. :** Sunflower.

(11) **Australia :** Mocadamia Nut.

Important plants of new world are Maize, Potato, Tomato, Sunflower, Groundnut, Red pepper, Pineapple, Guava, Sapota Coca.

Natural home : Place of origin of a cultivated crop. *e.g.*, South-West Asia is the natural home for wheat.

Secondary home : The major centre of production of a crop where wild relatives do not occur and which is far away from the centre of origin or natural home. India is secondary home for groundnut (natural home is Peru and Brazil).

Dwarf wheat : A dwarfing gene Norin-10 was recorded in Japan. American plant breeders produced single dwarf wheats. Norman Borlaug (1963) of Mexico produced triple dwarf wheats popularly called mexican wheats. They had high yield, were resistant to lodging common pathogens and pests, responsive to inputs and with smaller growth period. Sonora-64 and Lerma Rojo-64 were brought to India, modified through mutations and integrated to Indian Agriculture.

Dwarf rice : A dwarfing gene, dee-geo-woo-gene, was noted in Taiwan. It was introduced in rice varieties by IRRI, Philippines – IR-8, IR-24. To check grassy stunt virus, Dr. Gurdev S.Khush crossed 13 rice varieties from six countries and *Oryza nivara* (wild rice from central India) to produce early maturing, high yielding and resistant variety IR-36.

Crop improvement

The development of new variety of plants possessing desirable characters from the existing ones is called plant breeding. The crop improvement depends upon favourable environment (good irrigation, better fertilizers and precautions to avoid losses due to disease) together with superior hereditary characters. This superiority or improvement may be in following respects :

(1) **Quantitative characters :** Increase in yield of seeds, grains, fibres, oil etc.

(2) **Qualitative characters :** Increase in biochemical components as well as taste, milling, baking, cooking etc.

(3) **Resistance :** To diseases, insects, pests, drought, frost, cold, lodging etc.

(4) **Earliness or lateness :** In maturity period or change in maturity behaviour.

(5) **Adaptability :** To wider range of conditions etc.

Important plant breeders

(1) N.I. Vavilov famous Russian plant breeder, who gave centres of origin of cultivated plants.

(2) N.E. Borlaug famous Mexican plant breeder, who was awarded Nobel peace prize (1970) for developing high yielding dwarf varieties like Sonora–64, Lerma rojo 64 etc. He is known as father of green revolution.

(3) Dr. M.S. Swaminathan is pioneer mutation breeder. He has produced sharbati sonora variety of wheat by mutation, which is responsible for green revolution in India. Dr. Swaminathan is called father of green revolution in India.

(4) Thomas Fairchild (1717) produced first hybrid plant artificially.

(5) Cotton Mather (1761) recognised the process of natural selection in maize.

(6) Joseph Kolreuter (1760-66) produced many hybrids in tobacco.

(7) Dr. Boshisen : Famous maize breeder.

Methods of plant breeding

(1) **Plant introduction**

(i) Plant introduction means introducing a plant having desirable characters (*e.g.*, genetic improvement, high yield, disease resistance and vigorous growth) from a region or a country where it grows naturally to region or a country where it did not occur earlier.

(ii) If brought from foreign country, it is called Exotic Collection (EC) but if brought from same country, then it is called Indigenous Collection (IC).

(iii) Introduced plants may be used directly for cultivation (Primary introduction) or may be used after subjecting to selection/ hybridization (Secondary introduction).

(iv) Acclimatization : The adjustment of newly introduced plant to new or changed environment is called Acclimatization.

(v) There is a definite procedure for introducing a plant material from abroad and strict plant protection and quarantine laws have been made. If the plant material is found suitable, phytosanitary certificates are issued and only then the plant material is introduced in the country.

(vi) New plants are usually introduced in the form of cuttings or seeds.

(vii) Portugese traders and East India Company were foreign agencies which introduced many plants in India.

National Bureau of Plant Genetic Resources, Delhi (Estd., 1976) helps in plant introduction in India.

(2) **Selection :** It is the picking up of a plant having desirable characters (*e.g.*, high yield, disease resistant and vigorous growth) from a given population of plants based on its phenotypic characters. This involves preserving of favourable characters and gradual elimination of undesirable ones. There are two main types of selection :

(i) **Natural selection :** This is a rule in the nature and result in evolution. Here the fittest can survive and rest wipe out. All the local varieties of crop resulted because of such selection.

(ii) **Artificial selection :** Artificial selection is to choose certain individual plants for the purpose of having better crop from a mixed population where individuals differ in character. These are divided into following types :

(a) **Mass selection :** It is practised in naturally cross-pollinated crops *e.g.*, Maize. The first step involves selection of plants, having desirable characters from a given population of plants, based on phenotypic characters. The seeds of selected plants are then mixed and sown in the same field (Mixed cropping) to allow natural cross pollination. The plants are selected from this field by eliminating the undesirable ones and saving the best. The seeds of selected plants are multiplied in large numbers and supplied to the farmers.

Advantage

(i) It is the simplest, easiest and quickest method of crop improvement.

(ii) It is only method for improving the wild or local varieties to meet the immediate needs of farmers.

(b) **Pure line selection :** It is practised in natural self - pollinated crops *e.g.*, Wheat.

First step involves selection of few plants each having one or more desirable characters from a genetically mixed population. Each of these selected plant is then selfed through several generation to attain homozygosity for the selected characters. The homozygous plants are then multiplied. A population of homozygous plants raised from a single homozygous plant is called pure line (Johannsen). The pure lines are now crossed to introduce several desirable characters in to a single synthetic one which is then multiplied and supplied to the farmers for cultivation. Pure line selection is method of improvement in self-pollinated plants.

Advantage : In pure line selection the selected plants retain their desirable characters for several years.

Disadvantage : No new genotype are created by pure line selection. It requires 10 - 12 years for raising the desired variety.

(c) **Clonal selection :** It is practised in vegetatively propagated plants *e.g.*, sugarcane, banana, potato, onion, turnip etc. Clonal selection is the method of selection of desirable clones from the mixed population of vegetatively propagated crops. All the progenies of a single plant obtained vegetatively are known as clone (clone is homozygote which is produced by asexual means).

The first step is selection of a plant from a population of a crop based on phenotypic characters. The plant is then multiplied vegetatively and supplied to the farmers for cultivation.

Advantage

(i) Varieties are stable and easy to maintain.

(ii) Hybrid vigour is easily utilized.

(iii) Only methods to improve the clonal crops.

Limitations

(i) Only applicable to vegetatively propagated crops.

(ii) Creates no new variation.

(3) **Hybridization :** It is the method of producing new crop varieties in which two or more plants of unlike genetical constitution are crossed together. The plants which are crossed together may belong to the same species different species or different genera. Hybridization doesn't change genetic contents of organisms but it produces new combination of genes.

- First natural hybridization was reported in corn (maize) by Cotton Mather (1716).
- First artificial hybrid was obtained by crossing sweet william and carnation by Thomas Fairchild (1717) and was known as Fairchild's mule.
- Hybridization was first of all practically utilized in crop improvement by Kolreuter (1760).

According to this relationship between parental plants, the hybridization is divided into following categories :

(i) **Intravarietal hybridization :** The crosses are made between the plants of same variety.

(ii) **Intervarietal hybridization :** The crosses are made between the plants belonging to two different varieties of the same species and is also known as intraspecific hybridization.

(iii) **Interspecific hybridization :** The plants of two different species belonging to the same genus are crossed together. It is also known as intrageneric hybridization.

(iv) **Intergeneric hybridization :** The crosses are made between the plant belonging to two different genera.

(v) **Introgressive hybridization :** In this type of hybridization one species is completely replaced by another in nature.

(a) **Hybridization procedure**

Selection of parents : The first step in hybridization is to select the plants which are to be used as parents and can supply all the desired important characters which lack in a good standard variety.

Selfing of parents : This is the second step consisting of artificial self pollination of parents. It is very essential for eliminating the undesirable characters and obtaining inbreeds.

The selected inbreeds, before utilization, are tested for combining ability, both specific and general and the most suitable ones are further utilized in the hybridization technique.

Hybridization Technique

The inbreeds are grown under normal and protected conditions in the isolated plots so that they may develop properly and get full shelter against insects, pests, animals, birds and diseases.

They are sown at different dates to secure simultaneous flowering. The males and females to be crossed are marked in such a way that the dehiscence of anthers coincides with the stigma receptivity. They are then carried out under the following operations :

Emasculation : "The removal of stamens from female parent before they burst and have shed their pollens".

Bagging : To avoid contamination by unwanted pollen, the female and male flowers are covered with celophane or parchment or paper bags. This process is called bagging.

Crossing : "The artificial cross - pollination between the genetically unlike plants" and after that the female cross pollinated flower is again bagged.

Labelling : The crossed flowers are properly tagged and labelled.

Harvesting hybrid seeds and raising F_1 generation : The bags are removed and the crossed heads of desirable characters are harvested and collected with their attached labels separately in envelopes. After complete drying, they are threshed individually and preserved as such.

In coming season, these seeds are sown separately to raise the F_1 generation. The plants of F_1 generation are progenies of crossed seeds and called hybrids.

Hybridization methods : Handling of F_1 and subsequent generations by different selection methods of hybridization which are different for self and cross-pollinated crops.

Self pollinated crops : (i) Pedigree method (ii) Bulk method (iii) Back cross method.

Cross pollinated crops : (i) Single cross (AxB) (ii) Three cross (AxB) x C.

Heterosis or Hybrid vigour : Heterosis or hybrid vigour is the increased vigour growth yield or function of a hybrid over the parents, resulting from the crossing of genetically unlike organisms. Hybrid vigour is mostly due to heterozygocity. The term was coined by G.H. Shull (1914) though heterosis was first studied by Kolreuter (1763) followed by Darwin (1876). The heterosis normally involves two steps :

(i) The plants are selected for certain desirable characters and are selfed repeatedly through several generations to get pure lines for different characters.

(ii) The pure lines for different desirable characters are crossed to get the heterotic effect in the hybrids.

The hybrid vigour is lost after few generation. Hybrid vigour has been commercially exploited in different commerical crops like maize, sorghum, bajra, tomato, sugar beet, petunia, zinnia and cucumber.

(4) **Mutation :** Hugo devries was the first person who defined mutation as sudden phenotypic changes which are heritable.

But nowadays mutations are used in strict sense to cover only changes in the chemical structure of gene at the molecular level and it is specifically known as gene mutation or point mutation. Near about 1960, it was felt that mutations can be used in crop improvement.

Types on the basis of site

(i) **Somatic mutation :** It is mutation occurring in somatic or body cells. Somatic mutation can be used in crop improvement by vegetative propagation, *e.g.*, colour spots in apple, bhaskar variety of banana, seedless grape navel orange, superior shrubs in coffee.

(ii) **Germinal mutation :** Mutation occurring in germ cells which is transferable to the progeny is called germinal mutation. It may or may not be expressed because mutation is generally recessive and recessive traits appear only in homozygous state, *e.g.*, stiff ears in wheat, rice, spathe in maize, lint in cotton (White gold).

Mutations are spontaneous as well as induced, *i.e.*, can be artificially induced by certain mutagens or mutagenic agents.

These mutagens are of two types

(i) **Physical mutagens :** It comprise mainly of radiations. Radiation has been used to induce mutations for the first time by H.J. Muller (1927) on animals (Drosophila) and L.J. Stadler (1928) on plants *e.g. X*-rays, β-rays, γ-rays as well as *UV*-rays.

(ii) **Chemical mutagens :** *e.g.*, nitrous acid, maleic hydrazide, hydrazine, methyl methane sulphonate (MMS), ethyl methane sulphonate (EMS) etc.

Examples of Induced Mutations

(i) **Wheat :** Norman Borlaug, 1970 developed two wheat varieties – Sonora 64 and Lerma Rojo 64 A. Both varieties were red coloured and rejected by Indian population. When exposed to gamma radiation, they mutated into amber coloured, Sharbati sonora and Pusa Lerma.

Sonora 64 $\xrightarrow{\text{Gamma radiation}}$ Sharabati sonora

Lerma Roja 64 A $\xrightarrow[\text{radiation}]{\text{Gamma}}$ Pusa Lerma

(ii) **Rice :** In Indonesia, a high yielding rice variety Reimei was developed by gamma radiations. Pelita-I also was mutated into Atomita-I through gamma radiations. It is high yielding variety which is resistant to brown plant hopper.

(iii) **Peanut :** Mutation gave rise to thick shelled groundnut variety which could be handled without cracking.

(iv) **Penicillin production** has been increased enormously by UV-rays treatment of *Penicillium notatum* and *P. chrysogenum*.

Limitations of mutations breeding

(i) Most of the induced mutations are undesirable. Some of which result in death of the organism.

(ii) The rates of mutations are very low and large number of plants are employed to select a certain desirable mutant.

(iii) Most mutations are not stable and get reverted.

(iv) Since mutations are recessive they are expressed only in recessive homozygous condition otherwise they remain undetected.

(v) In sexually reproducing plants mutations are expressed and inherited only if they occur in gametes.

(5) **Polyploidy :** Organism with more than two sets of chromosomes are known as polyploids. It may be triploid with three sets of chromosomes (3*n*) or tetraploid with four sets of chromosomes (4*n*) and so on. Polyploidy is of three types :

(i) **Autopolyploidy :** It is a type of polyploidy in which there is a numerical increase of the same genome, *e.g.*, Autotriploid (AAA), autotetraploid (AAAA), *e.g.*, maize, rice, gram. Autopolyploidy induces gigas effect.

(ii) **Allopolyploidy :** It has developed through hybridization between two species followed by doubling of chromosomes (*e.g.*, AABB). Allopolyploids function as new species. *e.g.*, Wheat, American cotton, *Nicotiana tobacum*. Two recently produced allopolyploids are *Raphanobrassica* and *Triticale*.

(iii) **Autoallopolyploidy :** It is a type of allopolyploidy in which one genome is in more than diploid state, commonly autoallopolyploids are hexaploids (AAAABB), *e.g.*, *Helianthus tuberoseus*.

Polyploidy arises either due to fusing of one egg with two sperm or *vice versa*; or by failure of mitosis in somatic cells where chromosomes have duplicated in S- phase of interphase. Artificially polyploidy can be induced by using colchicine. Colchicine is an alkaloid obtained from *Colchicum autumnale* (Liliaceae).

Triploid condition arises by crossing a tetraploid (4n) and a diploid (2n) plant *e.g.*, sugarbeets, apple, pear, guava, banana, water melon, pea, etc.

They are more vigorous and they have higher yield.

Triploids exhibit a large degree of sexual sterility and have, therefore, to be propagated mostly by vegetative means.

The polyploids which possess an exact multiple of the haploid set of chromosomes are called "euploids".

Some polyploids where numerical change in chromosome number of individuals is not the exact multiple of haploid genome, are called "aneuploids".

Example : Back cross between hybrids of *Saccharum officinarum* X *S. spontaneum with either S. spontaneum* or *S. officinarum*.

Table : 8.4-1

Some major crop species of presumed polyploid origin

Common name	Scientific name	Number	Present diploid number and ploidy level
Wheat	*Triticum*	$x = 7$	2n = 28, tetraploid
(a) Durum	*T. turgidum*		2n = 28, tetraploid
(b) Club	*T. aestivum*		2n = 42, hexaploid
Sugarcane	*Saccharum officinarum* (Poaceae)	$x = 10$	2n = 80, octaploid
Tobacco	*Nicotiana tabacum* (Solanaceae)	$x = 12$	2n = 48, tetraploid
Coffee	*Coffea arabica* (Rubiaceae)	$x = 11$	2n = 44, tetraploid
Cotton	*Gossypium hirsutum* (Malvaceae)	$x = 13$	2n = 52, tetraploid
Potato	*Solanum tuberosum* (Solanaceae)	$x = 12$	2n = 48, tetraploid
Strawberry	*Fragaria ananassa* (Rosaceae)	$x = 7$	2n = 56, octaploid

(6) **Biofortification :** Breeding crops with higher levels of vitamins and minerals, or higher protein and healthier fats – is the most practical means to improve public health.

Breeding for improved nutritional quality is undertaken with the objectives of improving

(i) Protein content and quality;

(ii) Oil content and quality;

(iii) Vitamin content; and

(iv) Micronutrient and mineral content.

In 2000, maize hybrids that had twice the amount of the amino acids, lysine and tryptophan, compared to existing maize hybrids were developed. Wheat veriety, Atlas 66, having a high protein content, has been used as a donor for improving cultivated wheat.

(7) **Tissue culture :** Tissue culture requires separation of cells, tissues or organs of a plant and allowing them to grow in aseptic nutrient media under controlled light and temperature. The cultured parts termed explants, require energy (Usually a carbohydrate like sucrose) and salts (Both macro and micro nutrients) apart from vitamins and the amino acid glycine. When a tissue from an organ is cultured, It grows into undifferentiated tissue called "callus". The callus can be differentiated into shoot, root or complete plants by manipulating the concentration of auxin and cytokinin.

Tissue culture technique is based on totipotent nature of plant cell or phenomenon of totipotency, *i.e.*, each and every plant cell has inherent capacity to develop into complete plant.

The concept of totipotency was given by Haberlandt (1902) and practical application of totipotency was shown by Steward (1932), when he developed a complete carrot plant from a single cell obtained from root of wild carrot.

The procedure involves the following steps.

Explant → Disinfection → Culture medium → Callus → Plantlet (Embryoids).

The following techniques of tissue culture are useful in crop improvement.

(i) **Micropropagation :** Propagation through tissue culture is called micropropagation. Production of large number of individuals *in vitro* in a limited space which can be employed for agriculture, horticulture and forestry. *e.g.*, Potato, Bananas, *Begonia*, *Carnation*, *Chrysanthemum* and *Gerbera*.

(ii) **Somatic embryogenesis :** Somatic cells are cultured in electric shakers to obtain single cell suspension. When the number of cells has increased to a maximum depending upon the amount of medium, the culture is made stationary. Each cell starts differentiating into an independent embryo showing all the stages of embryo development such as globular heart shaped and torpedo shaped stages. They are called "embryoids". Somatic embryoids can give rises to a complete plant having normal root system. Success has been achieved in carrot, celery and alfalfa.

(iii) **Raising of disease free plants :** The virus free clones can be obtained from a virus infected plant by tissue culture since virus is translocated through sieve tubes. The apical meristem of virus infected plant remains free of virus. The shoot apex of such plant can be cultured.

(iv) **Androgenic haploids :** These are haploid plants raised from pollen grains by anther culture technique. The first example of androgenic haploid was reported by Guha and Maheshwari (1964) from anther culture of *Datura innoxia*. Haploid plants are always pure because they are having one gene for each trait, *i.e.*, no dominant and no recessive. If such a gene undergoes mutation, it can be easily expressed. In China, this technique has produced Jinghua-I (winter wheat) and Guan-18 (Rice variety). These two are superior, high yielding and disease resistant varieties.

(v) **Rescue of hybrid embryos :** The hybrid embryos produced as a result of interspecific or intergeneric crosses normally collapse due to incompatibility. These embryos can be isolated from female plants and rescued by growing on synthetic medium.

(vi) **Induction and selection of desirable mutants :** The single cell cultures raised in electric shakers are allowed to grow in static cultures where the cells divide to form colonies. These cells are treated with chemical or physical mutagens to induce mutations. The desirable mutants are selected and multiplied.

(vii) **Somaclonal variations :** The spontaneous variations which appear in cells or tissues in artificial medium are known as somaclonal variations. The variants having desirable traits such as tolerance to pests, pesticides, diseases and environmental stresses are selected and exploited for agricultural purpose.

(viii) **Somatic hybridization :** Cells of two plants belonging to different varieties, species and even genera are first treated with pectinase and cellulase enzymes. The enzymes dissolve away the walls. The naked protoplasts of the two are made to fuse by electrofusion (high frequency alternating electric field with short current pulses) and chemofusion through sodium nitrate or polyethyleneglycol (PEG). It produces hybrid protoplasts. The latter may have a single fusion nucleus (synkaryon) or two unfused nuclei (heterokaryon). Sometimes one of the two nuclei degenerates. In that case the hybrid protoplast is called cytoplasmic hybrid or cybrid (heteroplast).

Pomato is a somatic hybrid between tomato and potato and is example of intergeneric hybrid.

(8) **Single-Cell-Protein (SCP) :** Microorganisms can be used directly as a food source or as a supplement to other foods, are called single-cell-protein.

Prof. C.L. Wilson (1966) gave the term single-cell-protein. The Central Food Technology Research Institute (CFTRI), Mysore is conducting research on its use as food supplement.

It has been estimated that a cow of 250 *kg* produces 200g of protein per day. On other hand, 250g of a micro-organism like *Methylophilus methylotrophus*, due to its high rate of biomass production and growth can produce 25 tonnes of protein.

Spirulina – It is a microscopic blue-green alga in the shape of spiral coil. It is living both in sea and fresh water source. Which is used for human and animal food supplements because of its high rate of protein, vitamins, essential fatty acids etc.

Some microorganisms used for SCP Production

Microorganism	Substrate for growing
Yeast – *Candida utilis* (torula yeast)	Confectionery effluents, ethanol and sulphite liquor
Fungi – *Chaetomium Cellulotytium* *Fusarium graminearium*	Cellulos wastes, starch hydrolysates
Bacteria – *Brevibacterium* sp. *Methylophylus methylotrophus*	Hydrocarbons, Methanol

(9) **Genetic engineering :** This is the latest method of crop improvement in which instead of involving whole chromosomal set (genome), manipulation of a segment of DNA (gene) is done.

In this technique, introduction or deletion of one or more genes is done into an organism or plant. Here, the first step is isolation of a segment of DNA (gene) controlling a particular character. Restriction enzymes (endonucleases) are the specific enzymes, which are used to cut DNA at specific sites (hence called genetic scalpels). The second step is to transfer the specific DNA segment from one organism to the other. Protoplast is used for this purpose, where microinjection of DNA is done by fine needles. The third step involves cloning the DNA. Here, foreign DNA and plasmid DNA are joined with the help of DNA ligase enzyme to give rise to recombinant DNA (having additional characters).

Now vectors or carriers (like bacterial, plasmids, bacteriophages, plant viruses etc.) are used to carry this recombinant DNA. These carriers are multiplied to obtain clone of cells having the same foreign DNA (cloning the DNA). These multiplied foreign DNA (genes) are now transferred to cells of different target crop plants. But this process is not so simple as it appears. It requires complete knowledge of location and functions of different genes in different crop plants. As each crop is having 1-10 million genes, so detailed genone analysis is very complex. Thus genetic engineering or recombinant DNA technology has many problems and obstacles.

A plant in which a specific character has been introduced is called transgenic. The first transgenic commercial crop was tobacco. It was made tolerant to certain herbicides used for removing weeds. Transgenic tomato has been made resistant to horn-worm larvae.

Many transgenic plants such as tomato, cotton, tobacco, etc., have been developed which are resistant to certain specific insects and pests.

Genetic engineering is helpful in producing tomatoes with delayed ripening, mangoes with less ethylene production and potatoes with 20–40% more starch content.

Insect resistant transgenic cotton has been produced through genetic engineering by inserting a piece of DNA from bacterium *Bacillus thuringiensis*.

Tips & Tricks

- Nobel prize of 1978 for restriction endonuclease technology and their role in genetic engineering was given by Daniel Nathans, Hamilton smith and Werner Aber.
- In culture medium, shoot tips are made to develop more buds by NAA and high salt content.
- Aryans developed art of agriculture (L. agri = field; Culture = cultivation) and use of OX and Plough.
- Modern plant breeding started in the early twentieth century, after Mendel's work was rediscovered.
- Cryobiology : Dry freezed storage of germplasm.
- Wheat is an allopolyploid, developed in past by a cross between a variety of wheat with a species of *Aegilops*.
- Two bacteria Escherichia and Agrobacterium found to be very useful in genetic angineering.
- FAO : Food and Agricultural Organisation of U.N.O.
- IRRI: International Rice Research Institute, Los Banos, Philippines.
- ICRISAT : International Crops Research Institute for Semi Arid Tropics, Hyderabad, India.

Ordinary Thinking

Objective Questions

Domestication of plants

1. The centre of origin of wheat is
   (a) South–east Asia
   (b) South–west Asia
   (c) Asia Minor and Afganistan
   (d) None of these
2. The origin of sunflower is believed to be in
   (a) Peruvian Andes
   (b) Mexico and Central America
   (c) Brazil
   (d) USA
3. Maize evolved in
   (a) USA
   (b) Brazil
   (c) Mexico and Central America
   (d) Peruvian Andes
4. South–east Asia is thought to be the centre of origin of
   (a) Rice, sugarcane, mango and banana
   (b) Rice, sugarcane and mango
   (c) Rice and sugarcane
   (d) None of these

5. Green revolution in India occurred during **[NCERT; CBSE PMT (Mains) 2012]**
(a) 1960's (b) 1970's
(c) 1980's (d) 1950's

6. Greatest genetic diversity of plants is found in
(a) Central America (b) Homelands
(c) South America (d) India

7. The famous cultivated plant which developed in China is
(a) Orange (b) Tea
(c) Coffee (d) Cotton

8. The centre of origin of almond and apple is
(a) Asia Minor and Afganistan (b) Peruvian Andes
(c) Brazil (d) Mexico

9. Which of the following crops originated in Peru and Brazil but is now mainly grown in India
(a) Maize (b) Potato
(c) Groundnut (d) None of these

10. Name the crop which had its birth place in Tropical America but now the centre of production is Mid–west USA
(a) Maize (b) Cocoa
(c) Pineapple (d) Oil palm

11. Barley, coffee and sorghum are native of
(a) Afganistan (b) Brazil
(c) Ethiopia (d) Peru

12. Agriculture was originated in mesolithic age about **[CBSE PMT 2001]**
(a) 2000 years ago (b) 3000-10000 years ago
(c) 7000-13000 years ago (d) 20000-25000 years ago

13. Sonalika and kalyan Sona are high yielding varieties of **[KCET 2015]**
(a) Sugarcane (b) Rice
(c) Wheat (d) Maize

14. Credit for bringing green revolution to India goes to **[MP PMT 1999; Manipal 2005]**

Or

Scented basmati rice is the contribution of **[NCERT]**
(a) B.P. Pal (b) Norman Borlaug
(c) M.S. Swaminathan (d) K.C. Mehta

15. Total number of centres of origin of crop plants given by Vavilov is
(a) 2 (b) 4
(c) 8 (d) 11

16. Pusa shubhra is a variety of **[MHCET 2015]**
(a) Cauliflower (b) Chilli
(c) Wheat (d) Cabbage

17. The dwarf varieties of wheat brought from Mexico into India were **[NCERT]**
(a) Sonara–64 and Sonalika
(b) Sonara–64 and Lerma Roja–64
(c) Sharbati sonara and Pusa Lerma
(d) Sonalika

18. Improved Indian variety of wheat, carrying genes of dwarfness and higher percentage of protein and lysine is

Or

Which was first Indian dwarf amber grained variety of wheat made from Sonara 64 by γ-rays (gamma rays) **[NCERT]**
(a) Lerma safed (b) Kalyan
(c) Sharbati sonara (d) Sonalika

19. Semidwarf rice variety IR-8 was developed in **[MHCET 2015]**
(a) Taiwan (b) Phillipines
(c) India (d) China

Plant Breeding-Introduction

1. Selection is the method of **[MP PMT 2001]**
(a) Plant physiology (b) Plant breeding
(c) Genetics (d) Cytology

2. A change in the chromosome number is called **[MP PMT 1997]**
(a) Chromosomal mutation (b) Gene mutation
(c) Somatic mutation (d) Polyploidy

3. In the hexaploid wheat, the haploid (n) and basic (x) numbers of chromosomes are **[NCERT; CPMT 2005; CBSE PMT 2007]**
(a) $n = 7$ and $x = 21$ (b) $n = 21$ and $x = 21$
(c) $n = 21$ and $x = 14$ (d) $n = 21$ and $x = 7$

4. The branch of biology which deals with improvement of plant variety **[Bihar CECE 2006]**
(a) Plant breeding (b) Eugenics
(c) Agrology (d) Serendipity

5. Cross between unrelated group of organisms is called **[MP PMT 2007]**
(a) Hybrid (b) Test cross
(c) Back cross (d) Heterosis

6. In plant breeding programme, the entire collection (of plants/seeds) having all the diverse alleles for all genes in a given crop is called **[NCERT; NEET 2013]**
(a) Germplasm collection
(b) Selection of superior recombinants
(c) Cross hybridization among the selected parents
(d) Evaluation and selection of parents

7. The process of mating of individuals, which are more closely related than the average of the population to which they belong, is called **[BHU 2000]**

Or

Which of the following is not used for crop improvement **[CMC Vellore 1994; Bihar CECE 2006]**
(a) Inbreeding (b) Hybridization
(c) Heterosis (d) Self breeding

8. Green house crops such as tomatoes and bell pepper produce higher yields. This is due to **[KCET 2015]**
(a) CO_2 enriched atmosphere leads to higher yields
(b) CO_2 is a limiting factor to photosynthesis
(c) Due to diffused light in green house
(d) Tomatoes and bell pepper are not C_3 plants

9. Haploid from anther culture were first obtained in **[CPMT 2005]**

(a) *Brassica* (b) *Gossypium*
(c) *Nicotiana* (d) *Datura*

10. Heterosis requires **[CPMT 2005]**

(a) Selection (b) Crossing
(c) Transformation (d) Mutation

11. Desired improved varieties of economically useful crops are raised by **[NCERT; BHU 2004]**

(a) Migration (b) Biofertilizer
(c) Hybridization (d) Natural selection

12. Production of plant without fertilization is done by **[AFMC 2003]**

(a) Vegetative propagation (b) Transplantation
(c) Grafting (d) None of these

13. The improved variety Indore 2 obtained by mutation breeding belongs to which of the following crop varieties **[MHCET 2002]**

(a) Bajra (b) Cotton
(c) Sugar cane (d) Potato

14. Pure line breed refers to **[NCERT; AIIMS 2002]**

(a) Heterozygosity only
(b) Homozygosity only
(c) Heterozygosity and linkage
(d) Homozygosity and self-assortment

15. Who coined the term '*heterosis*' **[BHU 2004]**

(a) Shull (b) Huxley
(c) Robard (d) Tansley

16. What is not true about emasculation of a flower while performing an artificial cross **[MHCET 2015]**

(a) It is removal of anthers from flower
(b) It is done before anthesis
(c) It is to avoid self pollination
(d) It is done in flowers of plants selected as male parent

17. The offspring from a cross between two individuals differing in at least one set of characters is called

(a) Polyploid (b) Hybrid
(c) Mutant (d) Variant

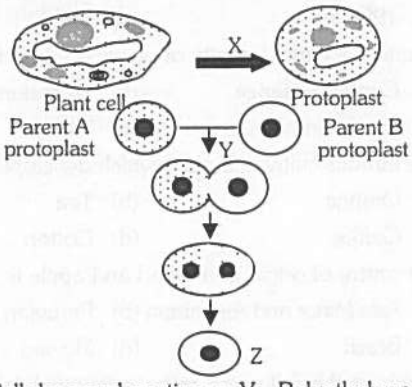
18. Which of the following effect is produced by colchicine

(a) Duplication of DNA
(b) Duplication of chromosomes
(c) Formation of spindle fibres
(d) Hinderance in the formation of middle wall

19. Crop cultivation was first started in

(a) Nile river valley (b) Chinese river valley
(c) Northern plains of India (d) All of the above

20. The following diagram refer to the process of somatic hybridization. Select the right option in which X, Y and Z are correctly identified **[NCERT]**



(a) X - Cellulase and pectinase, Y - Polyethylene glycol, Z - Zygotic cell
(b) X - Cellulase and pectinase, Y - Proteinase, Z - Somatic hybrid cell
(c) X - Proteinase, Y - Polyethylene glycol, Z - Somatic hybrid cell
(d) X - Cellulase and pectinase, Y - Polyethylene glycol, Z - Somatic hybrid cell

21. Majority of the high yielding varieties of 'Indian rice' have been developed by cross between

(a) *O.sativajaponicatimes O.sativaindica*
(b) *O.sativa indica times O.nivara*
(c) *O.nivaratimes O.sativajaponica*
(d) *O.nivaratimes O.rufipogon*

22. Tissue culture technique can produce infinite number of new plants from a small parental tissue. The economic importance of the technique is in raising **[NCERT; AIIMS 1994; NEET (Karnataka) 2013]**

(a) Genetically uniform population identical to the original parent
(b) Homozygous diploid plants
(c) Development of new species
(d) Variants through picking up somaclonal variations

23. Which is the oldest breeding method **[NCERT; MP PMT 1997]**

(a) Hybridization (b) Selection
(c) Mutation breeding (d) Introduction

24. The *indica* varieties of rice is crossed with *Japonic* varieties as these are **[NCERT; MP PMT 1994]**

(a) High yielding (b) Resistant to diseases
(c) Cheaper (d) Short life-cycled annual

25. A man made allopolyploid cereal crop is **[EAMCET 1995; Pb. PMT 2000, 04; BHU 2000; AIIMS 2004; Kerala PMT 2006; WB JEE 2011]**

(a) *Hordeum vulgare* (b) *Raphano brassica*
(c) *Triticale* (d) *Zea mays*

26. Aims of plant breeding are to produce **[NCERT; MP PMT 1996, 98, 2001, 03; Odisha JEE 2010]**
(a) Disease–free varieties (b) High yielding varieties
(c) Early maturing varieties (d) All of the above

27. Crosses between, the plants of the same variety are called **[MP PMT 1997]**
(a) Interspecific (b) Intervarietal
(c) Intravarietal (d) Intergeneric

28. A plant cell has potential to develop into full plant. This property of the plant cell is called **[NCERT; AIIMS 1998; HP PMT 2005]**
(a) Tissue culture (b) Totipotency
(c) Pleuripotency (d) Gene cloning

Methods and application of plant breeding

1. Select the wrong statement **[Kerala PMT 2008]**
(a) Pectinase and cellulase dissolve the cell wall
(b) Some cyanobacteria form symbiotic association with the fern *Azolla*
(c) Regeneration of cell wall in somatic hybridisation is induced by PEG
(d) Plants obtained through pollen culture are always haploids
(e) Shoot regeneration in callus is promoted by cytokinin like BAP

2. In maize, hybrid vigour is exploited by **[NCERT; CBSE PMT 2006, 07; AIIMS 2007]**
(a) Harvesting seeds from the most productive plants
(b) Inducing mutations
(c) Bombarding the protoplast with DNA
(d) Crossing of two inbreed parental lines

3. Which of the following is generally used for induced mutagenesis in crop plants **[CBSE PMT 2005]**
(a) *X*-rays
(b) UV (260 *nm*)
(c) Gamma rays (from cobalt 60)
(d) Alpha particles

4. In vitro clonal propagation in plants is characterized by **[CBSE PMT 2014]**
(a) Electrophoresis (b) HPLC
(c) PCR and RAPD (d) Northern blotting

5. Piece of sterile plant tissue to be used for tissue culture under aseptic condition is **[Odisha PMT 2002]**
(a) Inoculant (b) Explant
(c) Clone (d) Somaclone

6. *Triticale* is the hybrid between wheat and **[NCERT]**
CBSE PMT 2001, 06; AIIMS 2010; BHU 2012]
(a) Maize (b) Barley
(c) Rye (d) Bean

7. Mutations are caused due to **[CPMT 1999]**
(a) Radioactive mutagens
(b) Chemical mutagens
(c) Radiation mutagens
(d) Change in base sequence

8. The new varieties of plants are produced by **[NCERT; BHU 1998; CBSE PMT 1999; WB JEE 2009]**
(a) Selection and hybridization
(b) Mutation and selection
(c) Introduction and mutation
(d) Selection and introduction

9. The reason for vegetatively reproducing crop plants for maintaining hybrid vigour is that **[NCERT; CBSE PMT 1998]**
(a) They can be easily propagated
(b) They have a longer life span
(c) They are more resistant to diseases
(d) Once a desire hybrid is produced, no changes of losing it

10. Plants having similar genotypes produced by plant breeding are called **[NCERT; MP PMT 1998]**
(a) Clone (b) Haploid
(c) Autopolyploid (d) Genome

11. In which crops is the method of mass selection applied **[NCERT; MP PMT 1997]**
(a) Cross-pollinated
(b) Self-pollinated
(c) Both self and cross-pollinated
(d) Potato and sugarcane

12. Which of the following condition is hybrid breakdown **[AFMC 1997]**
(a) Failure of hybrid adult to produce functional gametes
(b) Failure of the fusion of ova and sperm plant breed of two species
(c) Failure of hybrid zygote to develop into an offspring
(d) None of these

13. Which one of the following chemical induces polyploidy in plant cells **[MP PMT 1996; DUMET 2009]**
Or
Autopolyploidy can be induced artificially by **[NCERT]**
(a) 2, 4–dichlorophenoxy acetic acid
(b) Rifampicin
(c) Cytokinine
(d) Colchicine

14. Single cell protein refers to **[DUMET 2010]**
(a) A specific protein extracted from pure culture of single type of cells
(b) Sources of mixed proteins extracted from pure or mixed culture of organisms or cells
(c) Proteins extracted from a single cell
(d) A specific protein extracted from a single cell

15. The alkaloid from *Colchicum autumnale* of Liliaceae induces **[EAMCET 1995]**
(a) Sterility (b) Dormancy
(c) Cell division (d) Polyploidy

16. Bombay green banana cultivation is the result of **[EAMCET 1995]**
(a) Mass selection (b) Pureline selection
(c) Clonal selection (d) Natural selection

17. Hereditary variations in plants have been produced by the use of
(a) X–rays (b) Gibberellic acid
(c) D.D.T. (d) Auxins

18. What is a clone **[KCET 2011]**
(a) A heterozygote produced by sexual means
(b) A homozygote produced by asexual means
(c) A heterozygote produced by asexual means
(d) A homozygote produced by sexual means

19. Which of the statement about breeding is wrong **[Kerala PMT 2012]**
(a) By inbreeding purelines cannot be evolved
(b) Continued inbreeding especially close inbreeding reduce fertility and productivity
(c) Cross breeding allows desirable qualities of two different breeds to be combined
(d) Inbreeding exposes harmful recessive genes that are elimlinated by selection
(e) A single outcross often helps to overcome inbreeding depression

20. Who used X–rays for the production of mutations **[MP PMT 1996]**
(a) Muller (b) Leeuwenhoek
(c) Recawsky (d) Hooker

21. Desired improved variety of economically useful crops are raised by **[MP PMT 1994; BHU 2004]**
(a) Natural selection (b) Hybridization
(c) Mutation (d) Biofertilizer

22. The *Triticum aestivum* wheat is **[NCERT; MP PMT 1993, 95, 2002, 09; CPMT 1995; BVP 2001, 04; DPMT 2003]**
(a) Haploid (7 chromosome)
(b) Diploid (14 chromosome)
(c) Tetraploid (30 chromosome)
(d) Hexaploid (42 chromosome)

23. Mutations caused by mutagenic agents are termed as **[EAMCET 1995]**
(a) Spontaneous mutations (b) Chemical mutations
(c) Induced mutations (d) Chromosomal mutations

24. What are micro–mutations
(a) Union of chromosomes
(b) Reduction of chromosomes
(c) Changes in genes
(d) Polyploidy

25. Which of the following is most effective chemical mutagene
(a) Methane (b) Guanine
(c) Carbon tetrasulphide (d) Caffeine

26. Four inbreed lines of maize are crossed. The cross is
(a) Tetraploid cross (b) Double cross
(c) Dihybrid cross (d) Tetrahybrid cross

27. The process of removing stamens from the flower bud during hybridization is called **[MP PMT 1993, 95, 2001, 05; MHCET 2000, 03, 04; CBSE PMT 2001; JIPMER 2002; DPMT 2004; BHU 2002, Wardha 2005]**
(a) Crossing (b) Selfing
(c) Emasculation (d) Caping

28. The hybrids are generally found to be superior to their parents, it is because of **[MP PMT 1993; BVP 2004]**
(a) Homozygosity (b) Hybrid vigour
(c) Parents are generally weak (d) None of these

Genetic engineering and Tissue culture

1. Somaclones are obtained by **[NCERT; MHCET 2001; AIIMS 2003; CBSE PMT 2009]**
(a) Tissue culture (b) Plant breeding
(c) Irradiation (d) Genetic engineering

2. Which one of the following is commonly used in transfer of foreign DNA into crop plants **[DPMT 2003; BVP 2004; CBSE PMT 2009; Kerala PMT 2010; WB JEE 2011]**

Or

Insect tolerant gene from Bacillus thuringiensis is introduced using T_i plasmid of **[AUM (Med.) 2010]**

Or

Which of the following has been used as cloning vector **[NCERT]**
(a) *Trichoderma harzianum*
(b) *Meloidogyne incognita*
(c) *Agrobacterium tumefaciens*
(d) *Penicillium expansum*

3. Transgenic plants are the ones **[NCERT; Odisha PMT 2002; AMU (Med.) 2006; CBSE PMT 2009; MP PMT 2010, 12]**
(a) Produced by a somatic embryo in artificial medium
(b) Generated by introducing foreign DNA in to a cell and regenerating a plant from that cell
(c) Produced after protoplast fusion in artificial medium
(d) Grown in artificial medium after hybridization in the field

4. Cellular totipotency was first demonstrated by **[WB JEE 2009]**
(a) F.C. Steward (b) Robert Hooke
(c) T. Schwann (d) A.V. Leeuwenhoek

5. The crops engineered for glyphosate are resistant/tolerant to **[AIPMT (Cancelled) 2015]**
(a) Bacteria (b) Insects
(c) Herbicides (d) Fungi

6. Crop plants grown in monoculture are **[CBSE PMT 2006]**
(a) Characterised by poor root system
(b) Highly prone to pests
(c) Low in yields
(d) Free from intraspecific competition

7. In order to obtain virus-free plants through tissue culture the best method is **[CBSE PMT 2006; CBSE PMT (Pre.) 2012]**

Or

In Crop Improvement Programmer Virus Free clones can be obtained Through **[KCET 2009]**

Or

Which of the following methods is/are used in recovery of healthy plants from diseased plants **[NCERT]**
(a) Anther culture (b) Meristem culture
(c) Protoplast culture (d) Embryo rescue

8. The technique that was employed to produce haploids of Datura was **[NCERT; Kerala PMT 2006]**

Or

For production of haploids, we culture **[BVP 2001, 02; BHU 2006]**

(a) Meristem culture (b) Anther culture
(c) Embryo culture (d) Protoplast culture
(e) callus culture

9. The tumor inducing capacity of *Agrobacterium tumefaciens* is located in large extra-chromosomal plasmids called **[NCERT; KCET 2007; Kerala PMT 2009]**

(a) *Ri* plasmid (b) Lambda phage
(c) *pBR* 322 (d) *Ti* plasmid

10. Callus is **[NCERT; Wardha 2005; AIIMS 2010]**

(a) Undifferentiated mass of tissue
(b) Root formation in culture media
(c) Plant hormones
(d) Plant byproduct

11. Somatic hybrids are produced by **[Manipal 2005]**

(a) Protoplast fusion (b) Tissue culture
(c) Pollen culture (d) Hybridoma process

12. The process in which mature differentiated cells reverse to meristematic activity to form callus is called **[KCET 2007]**

(a) Dedifferentiation (b) Differentiation
(c) Cyto-differentiation (d) Redifferentiation

13. Sterilization of tissue culture medium is done by **[KCET 2007]**

(a) Autoclaving of medium at 120°C for 15 minutes
(b) Filtering the medium through fine sieve
(c) Mixing the medium with antifungal agents
(d) Keeping the medium at – 20°C

14. Protoplasts of two different species are fused in **[MHCET 2004]**

(a) Micropropagation (b) Somatic hybridization
(c) Clonal propagation (d) Organography

15. Somatic hybridization is a technique of **[BHU 2004]**

(a) Natural breeding (b) Natural pollination
(c) Artificial pollination (d) Somatic cells hybridization

16. Bt toxin is obtained from **[DPMT 2007]**

(a) Prokaryotes (b) Eukaryotes
(c) Both (a) and (b) (d) None of these

17. A cybrid is a hybrid carrying **[NCERT; Kerala PMT 2004]**

(a) Cytoplasms of two different plants
(b) Genomes and cytoplasms of two different plants
(c) Cytoplasms of two different plants and genome of one plant
(d) Genomes of two different plants
(e) Cytoplasms of several plants and genomes of two plants

18. In transgenics, expression of transgene in target tissue is determined by **[CBSE PMT 2004]**

(a) Promoter (b) Reporter
(c) Enhancer (d) Transgene

19. To obtain virus-free healthy plants from a diseased one by tissue culture technique, which part/parts of the diseased plant will be taken **[CBSE PMT 2014]**

(a) Both apical and axillary meristems
(b) Epidermis only
(c) Apical meristem only
(d) Palisade parenchyma

20. Restriction enzyme was discovered by

(a) Berg (b) Smith and North
(c) Waksman (d) Alexander Fleming

21. The technique of obtaining large number of plantlets by tissue culture method is called **[NCERT; CBSE PMT 2004]**

Or

To meet the demands of the society, in vitro production of a large number of plantlets in a short duration is practised in floriculture and hoticulture industry today. This is called..... **[KCET 2010; MH CET 2015]**

Or

A novel technique devised to produce vast quantities of strong and healthy plantlets by rapid vegetative multiplication under controlled conditions **[NCERT]**

(a) Micropropagation (b) Macropropagation
(c) Plantlet culture (d) Organ culture

22. In tissue culture roots can be induced by **[KCET 2007]**

(a) Lower concentration of cytokinin and higher concentration of auxins
(b) Only cytokinin and no auxins
(c) No cytokinin and only auxins
(d) Higher concentration of cytokinin and lower concentration of auxins

23. Which enzyme is used for the separation of genetic material **[AFMC 2004]**

Or

"Molecular scissors" used in genetic engineering is **[KCET 2000; WB JEE 2009; MP PMT 2013]**

(a) Ligase (b) Restriction endonuclease
(c) Hydrolase (d) Amylase

24. Which body of the Government of India regulates GM research and safety of introducing GM organisms for public services **[AIPMT (Cancelled) 2015]**

(a) Indian Council of Agricultural Research
(b) Genetic Engineering Approval Committee
(c) Research Committee on Genetic Manipulation
(d) Bio-safety committee

25. Which of the following is incorrectly matched **[NCERT; Kerala PMT 2007; WB JEE 2011]**

(a) Explant - Excised plant part used for callus formation
(b) Cytokinins - Root initiation in callus
(c) Somatic embryo - Embryo produced from a vegetative cell
(d) Anther culture - Haploid plants
(e) Callus - Undifferentiated mass of cells

26. DNA probes are used in human for **[MP PMT 1996]**
(a) Disease diagnosis (b) Disease control
(c) Disease resistance (d) Disease tolerance

27. 'Cloning' is meant for **[AFMC 1997]**
(a) Production of *HGH* gene in *E. coli*
(b) To preserve the genotype of organism
(c) To replace the original gene
(d) All of these

28. Two bacteria found to be very useful in genetic engineering experiment are **[CBSE PMT 1998, 2000, 06]**
(a) *Nitrosomonas* and *Klebsiella*
(b) *Escherichia* and *Agrobacterium*
(c) *Nitrobacter* and *Azotobacter*
(d) *Rhizobium* and *Diplococcus*

29. The latest trend in plant disease control is **[Pb. PMT 1999; CBSE PMT 2000]**
(a) Chemical control
(b) Biological control
(c) Use of fertilizers
(d) Use of disease resistant varieties

30. Who amongst the following received Nobel Prize in 1970 for his outstanding research contribution **[HP PMT 2005]**
(a) Robert W. Holley (b) Waston and Crick
(c) Norman E. Borlaug (d) Avery

31. The technique involving insertion of a desired gene into the DNA of plasmid vector is known as **[KCET 1999; CBSE PMT 2003]**
(a) Dressing (b) Splicing
(c) Cloning (d) Drafting

32. The introduction of t – DNA into plants involves **[AIPMT 2015]**
(a) Altering the pH of the soil, then heat shocking the plants
(b) Exposing the plants to cold for a brief period
(c) Allowing the plant roots to stand in water
(d) Infection of the plant by *Agrobacterium tumefaciens*

33. Some of the characteristic of Bt cotton are **[CBSE PMT (Pre.) 2010]**
(a) High yield and resistance to bollworms
(b) Long fibre and resistance to aphids
(c) Medium yield, long fibre and resistance to beetle pests
(d) High yield and production of toxic protein crystals which kill dipteran pests

34. Abnormal gene is replaced by normal genes through **[DPMT 2004]**
(a) Gene therapy (b) Medicines
(c) Cloning (d) Radiation

35. Plants in comparison to animals are more rapidly manipulated by genetic engineering. Select out the most probable reason for this **[Odisha JEE 2010]**
(a) Totipotency shown by plant cells
(b) Single somatic cell can regenerate a whole plant body
(c) Genetic engineering is supplemented with plant tissue culture techniques
(d) All of the above

36. Micropropagation is a technique **[WB JEE 2010; AIPMT (Cancelled) 2015]**
(a) Somatic embryogenesis for production of true type plants
(b) For production of haploid plants
(c) For production of somatic hybrids
(d) For production of somaclonal plants

37. Insect resistance transgenic cotton has been produced by inserting a piece of DNA from **[CPMT 2004]**
(a) An insect (b) A bacterium
(c) A wild relative of cotton (d) A virus

38. Cryobiology deals with **[BVP 2002]**
(a) Temperature effect
(b) Physiology
(c) Anatomy
(d) Characteristics of biomolecule

39. Introduction of foreign genes for improving genotype is **[AIIMS 2002; Odisha JEE 2011]**

Or

Insertion or deletion of one or more new genes which are absent in an organism by artificial method (not by reproduction) is called as **[NCERT; CBSE PMT 1996]**
(a) Biotechnology (b) Tissue culture
(c) Vernalization (d) Genetic engineering

40. In plant tissue culture, the callus tissues can be regenerated into complete plantlets primarily by altering the concentration of **[WB JEE 2012]**
(a) Sugars (b) Vitamins
(c) Amino acids (d) Hormones

41. Hybrid vigour is mostly due to **[NCERT; Pb. PMT 2000; MHCET 2003, 04; DPMT 2004]**
(a) Superiority of all the genes
(b) Homozygosity of pure characters
(c) Heterozygosity
(d) None of these

42. Plants are genetically engineered with novel genes by **[AIEEE Pharmacy 2003]**
(a) Protoplast fusion
(b) Recombinant DNA technology
(c) Embryo rescue technique
(d) Recombination breeding

43. Two plants growing in different seasons and different geographical area, can produce hybrid by **[BHU 2003]**
(a) Pollen culture (b) Tissue culture
(c) Somatic embryogenesis (d) Invitro synthesis

44. A human gene product can be produced by genetically engineered bacteria. This is possible because the **[AIEEE Pharmacy 2003]**
(a) Genetic code is universal
(b) Human chromosome can replicate in bacterial cell
(c) Bacterial cell can carry out the splicing reaction
(d) Mechanism of gene regulation is identical in humans and bacteria

45. The genetically engineered crop which has been recently introduced in India is **[AIEEE Pharmacy 2003]**
(a) Herbicide tolerant maize (b) Bt cotton
(c) Slow ripening tomato (d) Golden rice

46. Cultivation of Bt Cotton has been much in the news. The prefix "Bt" means **[Kerala PMT 2004; AIIMS 2004, 08; AFMC 2009; KCET 2011]**
(a) "Barium-treated" cotton seeds
(b) "Bigger thread" variety of cotton with better tensile strength
(c) Production by "biotechnology" using restriction enzymes and ligases
(d) Carrying an endotoxin gene from *Bacillus thuringiensis*

47. Which of the following is a transgenic plant **[Odisha JEE 2010, 12]**
(a) Flavr savr (b) *Ashbya gossypii*
(c) *Meloidogyne incognita* (d) *Gluconobacter oxidans*

48. Widely used tool in genetic engineering of crop plants involves **[AIEEE Pharmacy 2004]**
(a) Protoplast fusion (b) *Agrobacterium* mediation
(c) Transposon mediation (d) Microinjection

49. An improved variety of transgenic basmati rice **[CBSE PMT (Pre.) 2010]**
(a) Gives high yield but has no characteristic aroma
(b) Does not require chemical fertilizers and growth hormones
(c) Gives high yield and is rich in vitamin A
(d) Is completely resistant to all insect pests and diseases of paddy

50. The genetically-modified (GM) brinjal in India has been developed for **[CBSE PMT (Pre.) 2010]**
(a) Drought-resistance
(b) Insect-resistance
(c) Enhancing shelf life
(d) Enhancing mineral content

51. Salt tolerant transgenic has been developed for **[AMU (Med.) 2010]**
(a) Brinjal (b) Grape
(c) Potato (d) Tomato

52. The process of RNA interference has been used in the development of plants resistant to **[CBSE PMT (Pre./Mains) 2011]**
(a) Insects (b) Nematodes
(c) Fungi (d) Viruses

53. Which one of the following is a case of wrong matching **[CBSE PMT (Pre.) 2012]**
(a) Somatic hybridization–Fusion of two diverse cells
(b) Vector DNA-Site for t–RNA synthesis
(c) Micropropagation – In vitro production of plants in large numbers
(d) Callus–Unorganised mass of cells produced in tissue culture

54. Totipotency is the basic principle of **[Odisha JEE 2012]**
(a) Tissue culture (b) Sericulture
(c) Pisciculture (d) Silviculture

NCERT Exemplar Questions

1. Sonalika and Kalyan Sona are varieties of **[NCERT]**
(a) Wheat (b) Rice
(c) Millet (d) Tobacco

2. Which one of the following is not a fungal disease **[NCERT]**
(a) Rust of wheat (b) Smut of Bajra
(c) Black rot of crucifers (d) Red rot of sugarcane

3. In virus-infected plants the meristematic tissues in both apical and axillary buds are free of virus because **[NCERT]**
(a) The dividing cells are virus resistant
(b) Meristems have anti viral compounds
(c) The cell division of meristems are faster than the rate of viral multiplication
(d) Viruses cannot multiply within meristem cell(s).

4. Several South Indian states raise 2-3 crops of rice annually. The agronomic feature that makes this possible is because of **[NCERT]**
(a) Shorter rice plant (b) Better irrigation facilities
(c) Early yielding rice variety (d) Disease resistant rice variety

5. Which one of the following combination would a sugarcane farmer look for in the sugarcane crop **[NCERT]**
(a) Thick stem, long internodes, high sugar content and disease resistant
(b) Thick stem, high sugar content and profuse flowering
(c) Thick stem, short internodes, high sugar content, disease resistant
(d) Thick stem, low sugar content, disease resistant

6. Fungicides and antibiotics are chemical that **[NCERT]**
(a) Enhance yield and disease resistance
(b) Kill pathogenic fungi and bacteria, respectively
(c) Kill all pathogenic microbes
(d) Kill pathogenic bacteria and fungi respectively

7. Use of certain chemicals and radiation to change the base sequences of genes of crop plants is termed **[NCERT]**
(a) Recombinant DNA technology
(b) Transgenic mechanism
(c) Mutation breeding
(d) Gene therapy

8. The scientific process by which crop plants are enriched with certain desirable nutrients is called **[NCERT]**
(a) Crop protection (b) Breeding
(c) Bio-fortification (d) Bio-remediation

9. The term 'totipotency' refers to the capacity of a **[NCERT]**
(a) Cell to generate whole plant
(b) Bud to generate whole plant
(c) Seed to germinate
(d) Cell to enlarge in size

10. Given below are a few statements regarding somatic hybridization. Choose the correct statements
(i) Protoplasts of different cells of the same plant are fused
(ii) Protoplasts from cells of different species can be fused
(iii) Treatment of cells with cellulase and pectinase is mandatory
(iv) The hybrid protoplast contains characters of only one parental protoplast
Options **[NCERT]**
(a) (i) and (iii) (b) (i) and (ii)
(c) (i) and (iv) (d) (ii) and (iii)

11. An explant is **[NCERT]**
(a) Dead plant
(b) Part of the plant
(c) Part of the plant used in tissue culture
(d) Part of the plant that expresses a specific gene

12. The biggest constraint of plant breeding is **[NCERT]**
(a) Availability of desirable gene in the crop and its wild relatives
(b) Infrastructure
(c) Trained manpower
(d) Transfer of genes from unrelated sources

13. Lysine and tryptophan are **[NCERT]**
(a) Proteins (b) Non-essential amino acids
(c) Essential amino acids (d) Aromatic amino acids

14. Micro-propagation is **[NCERT]**
(a) Propagation of microbes in vitro
(b) Propagation of plants in vitro
(c) Propagation of cells in vitro
(d) Growing plants on smaller scale

15. Protoplast is **[NCERT]**
(a) Another name for protoplasm
(b) An animal cell
(c) A plant cell without a cell wall
(d) A plant cell

16. To isolate protoplast, one needs **[NCERT]**
(a) Pectinase
(b) Cellulase
(c) Both pectinase and cellulase
(d) Chitinase

17. The agriculture sector of India employs about **[NCERT]**
(a) 50 per cent of the population
(b) 70 per cent of the population
(c) 30 per cent of the population
(d) 60 per cent of the population

18. 33 per cent of India's Gross Domestic Product comes from **[NCERT]**
(a) Industry
(b) Agriculture
(c) Export
(d) Small-scale cottage industries

19. A collection of all the alleles of all the genes of a crop plant is called **[NCERT]**
(a) Germplasm collection
(b) Protoplasm collection
(c) Herbarium
(d) Somaclonal collection

CT Critical Thinking

Objective Questions

1. Cellular totipotency is demonstrated by **[CPMT 2009]**
(a) Only gymnosperm cell (b) All plant cells
(c) All eukaryotic cell (d) Only bacterial cells

2. Genetic counsellors can identify heterozygous individuals by **[BHU 2004]**
(a) Height of individuals (b) Colour of individuals
(c) Screening procedures (d) All of these

3. Hardening in tissue culture is **[DPMT 2006; KCET 2012]**
(a) Keeping at 30-50°C temperature for about 30 minutes
(b) Acclimatisation of tissue culture plants slowly before growing in the field
(c) Plunging the vials into water at 37–40°C
(d) None of the above

4. In protoplast fusion which chemical is used **[DPMT 2006]**
(a) DMSO (b) Liquid N_2
(c) Pectinase (d) PEG

5. Vavilov's centres of origin of crop plants are located in
(a) Mountains of tropical areas
(b) Mountains of temperate areas
(c) Mountains of both tropical and temperate areas
(d) Plains of tropical areas

6. In high yielding 'hybrid crop varieties', to exploit hybrid vigour, the farmers need to purchase fresh hybrid seed every year, because **[NCERT; BHU 1994]**
(a) They are not allowed to grow their own seed
(b) The hybrid vigour is lost due to inbreeding depression
(c) The government of India has accepted Dunkel's proposals
(d) It is cheaper to purchase fresh seed

7. Parasexual hybridization means **[MP PMT 1995]**
(a) Fusion of male gamete with female gamete
(b) Fusion of male gamete with synergid nucleus
(c) Fusion of somatic protoplasts
(d) Fusion of male gamete with protoplasts

8. Genetic engineering is possible, because **[CBSE PMT 1998; AFMC 1999]**
(a) The phenomenon of transduction in bacteria is well understood
(b) We can see DNA by electron microscope
(c) We can cut DNA at specific sites by endonucleases like DNAase–I
(d) Restriction endonucleases purified from bacteria can be used in *vitro*

9. It shows correct chronological order of the events occurring during callus culture **[NCERT; GUJCET 2007]**
(a) Callus → Cell division → Explant → Addition of cytokinin → Acqire meristematic property
(b) Explant → Callus → Cell division → Addition of cytokinin → Cells acquire meristematic property
(c) Explant → Cell division → Callus → Addition of cytokinin → Cells acquire meristematic property
(d) Callus → Explant → Cell division → Addition of cytokinin → Cells acquire meristematic property

10. The shifting cultivation method called jhum belongs to the category of **[Kerala PMT 2006]**
(a) Industrial forestry (b) Agro–forestry
(c) Commercial forestry (d) Social forestry
(e) Conservation forestry

11. Breeding of crops with high levels of minerals, vitamins and proteins is called **[CBSE PMT (Pre.) 2010; Kerala PMT 2012]**
(a) Micropropagation (b) Somatic hybridisation
(c) Biofortification (d) Biomagnification

12. Pollen tablets are available in the market for **[CBSE PMT 2014]**
(a) Supplementing food
(b) *Ex situ* conservation
(c) In vitro fertilization
(d) Breeding programmes

AR Assertion & Reason

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.
(c) If assertion is true but reason is false.
(d) If the assertion and reason both are false.
(e) If assertion is false but reason is true.

1. Assertion : Haploids can be artificially produced.
Reason : Morphologically they are similar to diploids.

2. Assertion : Hybridization is done between two genetically different types of plants.
Reason : Hybridization is intraspecific.

3. Assertion : In case of vegetatively propagated crops, pure-line selection is not required.
Reason : Hybrid vigour is mostly used in vegetatively propagated plants.

4. Assertion : Aneuploidy may be of hypoploidy or hyperploidy type.
Reason : Monosomy lacks one pair of chromosomes.

5. Assertion : Interspecific hybridization often fails to form normal embryos.
Reason : Such embryos can germinate in culture conditions.

Answers

Domestication of plants

1	b	2	d	3	c	4	a	5	a
6	b	7	b	8	a	9	c	10	a
11	c	12	c	13	c	14	c	15	d
16	a	17	b	18	c	19	b		

Plant Breeding-Introduction

1	b	2	a	3	d	4	a	5	a
6	a	7	a	8	a	9	d	10	b
11	c	12	a	13	b	14	b	15	a
16	d	17	b	18	b	19	d	20	d
21	a	22	a	23	b	24	b	25	c
26	d	27	c	28	b				

Methods and application of plant breeding

1	c	2	d	3	c	4	c	5	b
6	c	7	d	8	a	9	d	10	a
11	a	12	c	13	d	14	b	15	d
16	c	17	a	18	b	19	a	20	a
21	b	22	d	23	c	24	c	25	c
26	b	27	c	28	b				

Genetic engineering and Tissue culture

1	a	2	c	3	b	4	a	5	c
6	b	7	b	8	b	9	d	10	a
11	a	12	a	13	a	14	b	15	d
16	a	17	c	18	b	19	a	20	b
21	a	22	a	23	b	24	b	25	b
26	a	27	b	28	b	29	d	30	c
31	b	32	d	33	a	34	a	35	d
36	a	37	b	38	a	39	d	40	d
41	c	42	b	43	b	44	a	45	b
46	d	47	a	48	b	49	c	50	b
51	d	52	b	53	b	54	a		

NCERT Exemplar Questions

1	a	2	c	3	c	4	c	5	a
6	b	7	c	8	c	9	a	10	d
11	c	12	a	13	c	14	b	15	c
16	c	17	d	18	b	19	a		

Critical Thinking Questions

1	b	2	c	3	b	4	d	5	a
6	b	7	c	8	d	9	c	10	b
11	c	12	a						

Assertion and Reason

1	c	2	b	3	b	4	c	5	b

Answers and Solutions

Domestication of plants

12. (c) Origin of agriculture dates back to 7000–13000 years ago in high and well watered lauds of Indus, Tigris, Nile and Euphrates.

14. (c) Dr. M.S. Swaminathan is pioneer mutation breeder and responsible for green revolution in India. Dr. Swaminathan is called "Father of green revolution in India.

15. (d) Nikolai Ivanovitch Vavilov (1926) proposed different centres of origin for various crop plants on two criteria
(i) Occurrence of wild relatives.
(ii) Occurrence of maximum variations in the crop. They are 11 in number.

17. (b) Sonora-64 and Lerma Rojo-64 is dwarf variety of wheat, which were brought to India, modified through mutations and integrated to Indian Agriculture.

Plant breeding-Introduction

3. (d) In wheat total number of chromosomes is – $6 \times 7 = 42$. Thus $n = 21$ and $x = 7$

7. (a) Introduction, hybridization and mutations are methods of plant breeding.

9. (d) Haploid production through pollen culture was first made in *Datura innoxia* (Jimson weed) by Guha and Maheshwari (1964).

11. (c) In hybridization, two or more plants of unlike genotypes are crossed together to get offsprings with new desirable combinations of characters as a result of genetic recombinations.

13. (b) The improved variety Indore-2 is obtained by mutation breeding and belongs to cotton crop.

19. (d) The earliest human civilizations around the river Nile in Egypt, the Chinese river valleys and the northern Indian plains are linked with crop cultivation.

22. (a) The method of producing thousands of plants through tissue culture is called micro-propagation. Each of these plants will be genetically identical to the original plant from which they were grown, i.e. they are somaclones. Many important food plants like tomato, banana, apple have been produced on commercial scale using this method.

23. (b) Selection is the oldest method of plant breeding and is the base of all crop improvement programmes.

24. (b) *Japonica* is disease resistant because it is a wild variety.

25. (c) Allopolyploid means a mixture of two different genetic forms. Intergeneric hybridization of cereal crops *i.e. Secale cereale* and *Triticum* froms Triticale (man made)

26. (d) The aims of plant breeding are increase in yield of seeds, resistance to diseases, insects, pests and earliness or lateness in maturity period or change in maturity behaviour.

27. (c) In intravarietal hybridization, the crosses are made between the plants of same variety.

28. (b) Tissue culture technique is based on totipotent nature of plant cell or phenomenon of totipotency, *i.e.*, each and every plant cell has inherent capacity to develop into complete plant.

Methods and application of plant breeding

3. (c) Gamma rays (from cobalt 60) is generally used for induced mutation in crops plants.

4. (c) Now a days PCR and RAPD technique are used for the characterization of *in vitro* clonal propagation in plants.

8. (a) Selection and hybridization is method of crop improvement or new varieties production of plants.

9 (d) Vegetative reproduction does not involve meiosis, hence no recombination and no loss of heterozygosity.

14. (b) The term Single Cell Protein (SCP) was coined at Massachusetts institute of technology (MIT) by a group of scientist in 1966. It is dried cell of micro-organisms or microbes (algae, bacteria, actinomycetes and fungi) used as food.
SCP is rich in highly quality protein and is poor in fats.

27. (c) Removal of stamens from a bisexual flower before anthesis is called emasculation. Emasculation is useful for preventing the self pollination in female parent which is concerned with hybridization.

28. (b) Breeding usually takes place between members of different varieties or strains, and in certain plants of closely related species. The progeny is known as hybrid and have phenotypes showing characteristics which are superior to either of the parents stock. This phenomenon is known as hybrid vigour or heterosis.

Genetic engineering and Tissue culture

3. (b) Transgenic plants are those plants in which a foreign gene has been introduced and stably integrated into host DNA.

8. (b) Haploids have a single genome as found in the gametes of the species. A haploid has only one copy of each chromosome and is highly sterile.

9. (d) *Agrobacterium tumefaciens* is a gram-negative soil bacterium that infects a wide range of plants and causes tumorous growths (galls), especially at the root/stem junction (crown gall).

10. (a) By culturing explant in culture medium, an undifferentiated mass of cells is obtained, which is known as callus.

11. (a) Protoplast technology refers to protoplast fusion or somatic hybridization. The two protoplast are fused by PEG (Polyethylene glycol) and thus somatic hybrid are obtained.

12. (a) Dedifferentiation is a phenomenon of reversion of differentiated cells or nuclei to non-differentiated (often meristematic) cells or nuclei.

14. (b) Somatic hybridization or parasexual hybridization involves the fusion of isolated protoplast of two different species.

15. (d) Somatic hybridization is a technique of somatic cells hybridization which involve the fusion of protoplasts. Cell formed by the fusion of protoplast of the same genotype are called homokaryotes and fused cells which contain non-identical nuclei are called heterokaryotes.

16. (a) Bt toxin gene is obtained from bacteria, *Bacillus thuringiensis*. This gene has been incorporated into cotton to provide resistance to corn borer.

19. (a) Apical and axillary meristems are free of virus.

20. (b) Restriction endonuclease was discovered by Smith and North. It is used in genetic engineering as a bioscissors.

21. (a) Micropropagation, means rapid vegetative multiplication of valuable plant material for agriculture, horticulture and forestry.
Propagation through tissue culture is called micropropagation.

23. (b) A specific restriction endonuclease enzyme is used for a cutting of specific part of DNA strand. Therefore they are also known as molecular scissors or biological scissors.

24. (b) GEAC – Genetic engineering approval Committee.

28. (b) Till today, the most important in genetic engineering of plants has been the Ti plasmid of soil bacterium. *Agrobacterium tumefaciens*. *E.Coli* has been extensively used as "Work horse" for genetic engineering *e.g.*, production of humulin, somatotropin.

30. (c) N.E. Borlaug was famous Mexican plant breeder, who was awarded Nobel Peace Prize (1970) for developing high yielding dwarf wheat varieties like sonora-64, Lerma rojo-64, etc.

34. (a) Gene therapy is a technique of treating genetic diseases by the replacement of faulty genes with normal genes.

36. (a) Raising of new plantlets through tissue culture technique producing similar plants (true type plants).

37. (b) Insect (*i.e.*, Boll worm) resistant transgenic cotton has been produced through genetic engineering by inserting a piece of DNA from bacterium *Bacillus thuringiensis*.

38. (a) Cryobiology deals with the study of effect of low temperature on organisms including their preservation.

41. (c) Hybrid vigour is also called heterosis. It results from the union of genetically different gametes (heterozygosity).

45. (b) In India only one transgenic crop, Bt cotton has so far been released for cultivation. Recently in March 2002. This has been developed by Maharastra hybrid seeds company (MAHYCO) in collaboration with USA company Monsanto.

52. (b) RNAi *i.e.*, RNA interference is used in the development of plants resistant to nematode like *Meloidegyne incognita*.

Critical Thinking Questions

2. (c) Genetic counselling is the giving of information and advice about the risks of genetic diseases and their outcomes. Genetic screening is a part of genetic counselling which includes prenatal diagnosis, carrier diagnosis and predictive diagnosis.

3. (b) The acclimatisation of plant formed by tissue culture before growing in the field to make it strong to adapt in new environment.

4. (d) Polyethylene glycol is the most commonly used chemical in protoplast fusion as it induce reproducible high frequency fusion accompanied with low toxicity to most cell types.

7. (c) Parasexual hybridization means fusion of somatic protoplast. It is found in fungus.

8. (d) Genetic engineering is the manipulation of genetic material of an organism using enzyme restriction endonuclease. Nathans and Smith (1970) isolated the first restriction endonuclease. Jackson, symons and Paul Berg (1972) successfully generated recombinant DNA molecules *in vitro*.

9. (c) Callus culture is a type of *in vitro* plant tissue culture. The process is carried out under controlled conditions. The selected cell, tissue or organ is called-explant. The number of cells increases through cell division. However, these cells are unorganized and collectively constitute a callus. They are maintained on agar-agar gel. Growth promoters like auxin and cytokinins are added to the culture. Under these condition, the cells become meristematic and begin to divide. Callus is obtained within 2 to 3 weeks.

12. (a) Pollen grains are rich in nutrients and it has become a fashion in recent years to use pollen tablets as food supplements.

Assertion and Reason

1. (c) Haploids can be artificially produced by any one of the following methods. (i) X-ray treatment, (ii) delayed pollination, (iii) temperature shocks, (iv) colchicine treatment, (v) distant hybridization, (vi) anther or pollen culture. Haploids are characterised morphologically by a reduction in size of all vegetative and floral parts.

2. (b) Hybridization is the obtaining of progeny after crossing two or more types of plants which differ genetically from one another on one or more traits. Hybridization may be intravarietal, intervarietal, interspecific and intergeneric. Interspecific hybridization is rare because species are genetically and reproductively isolated.

3. (b) In case of vegetatively propagated crops, pure line selection is not required. Pure-line selection is useful only for sexually reproducing plants. Hybrid vigour is most profitably used in vegetatively propagated crops because they do not involve sexual reproduction and hence loss of hybrid superiority.

4. (c) Aneuploidy can be either due to loss of one or more chromosomes (hypoploidy) or due to addition of one or more chromosomes to complete chromosome complement (hyperploidy). hypoploidy is mainly due to loss of a single chromosomes, monosomes $(2n-1)$ or due to loss of one pair of chromosomes, nullisomes $(2n-2)$.

5. (b) Interspecific hybridization often fails because the embryo dies quite early or fails to reach maturity. In such cases the embryo is taken out of the fertilized ovule and cultured over nutrient medium under controlled conditions.

Strategies for Enhancement in Food Production

SET Self Evaluation Test

1. Study the following lists

List-I		List-II	
(A)	Usage of bisexual flowers as female parents	(I)	Clonal selection
(B)	Incorporation of several desirable characters into a single variety	(II)	Pure line selection
(C)	Exploiting hybrid vigour for many generation	(III)	Emasculation
(D)	Improving local varieties of self-pollinated crops	(IV)	Hybridization
		(V)	Polyploidy breeding

The correct match is **[EAMCET 2009]**

	A	B	C	D
(a)	IV	V	III	I
(b)	II	III	IV	V
(c)	III	IV	I	II
(d)	I	V	II	IV

2. Indian Sugarcane Breeding Research Institute was established **[MP PMT 2013]**

(a) In Coimbatore of Tamil Nadu during 1912
(b) In Coimbatore of Tamil Nadu during 1937
(c) In Punjab Agricultural University, Ludhiana during 1912
(d) In Punjab Agricultural University, Ludhiana during 1937

3. As a general rule, inbreeding is possible between

(a) Any two members of a order
(b) Any two members of a family
(c) Any two members of a genus
(d) Any two members of a species

4. Axenic culture is best defined as **[CPMT 1993; AFMC 2000]**

(a) Cell cultures
(b) Cell cultures free from micro-organisms
(c) Cell cultures of insectivorous plants
(d) Cell cultures free from other micro-organisms

5. For the formation of diploid cells from haploid cells, colchicine is used to **[CBSE PMT 1996]**

(a) Stop the spindle fibres formation
(b) Replicate DNA twicely in one cell cycle
(c) Stop the formation of centromere
(d) Stop the mitotic division

6. The greatest threat to genetic diversity in agricultural crops is **[KCET 2009]**

(a) Extensive use of insecticides and pesticides
(b) Extensive mixed cropping
(c) Introduction of high yielding varieties
(d) Extensive use of fertilizers

7. Nucleic acid segment which is used to find the position of a gene and it forms a hybrid with this gene would be **[RPMT 2002]**

(a) Retrovirus (b) Probe
(c) Vector (d) Clone

8. Manipulation of DNA in genetic engineering became possible due to the discovery of **[CBSE PMT 2002]**

(a) Primase
(b) Transcriptase
(c) DNA ligase
(d) Restriction endonuclease

AS Answers and Solutions

1	c	2	a	3	d	4	d	5	a
6	c	7	b	8	d				

7. (b) Probes are DNA or RNA strands with specific nucleotide sequences complementary to VNTR (Variable Number Tendem Repeats) sequences which are used to find the position of a gene and it form a hybrid with this gene.

8. (d) Isolation of restriction endonucleases by Nathans and Smith (1970) made it possible to cut DNA at specific sites.

* * *