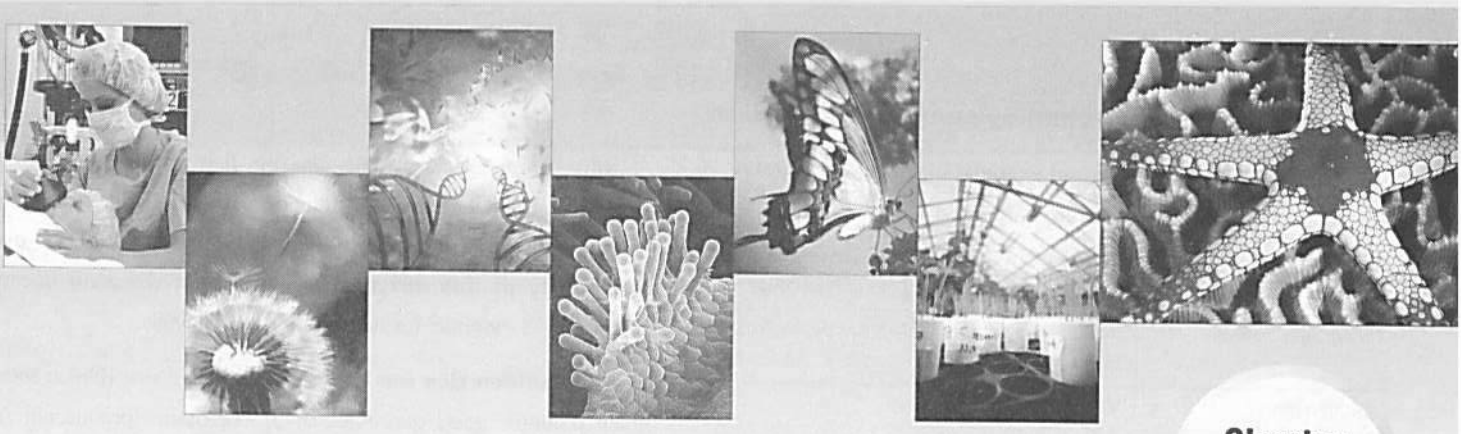


Chapter

9.2

Biotechnology and its Application

The applications of biotechnology include therapeutics, diagnostics, genetically modified crops for agriculture, processed food, bioremediation, waste treatment and energy production.

Biotechnological Applications In Agriculture

There are three options to increase the food production :

(i) Agrochemical based agriculture;

(ii) Organic agriculture ; and

(iii) Genetically engineered crop – based agriculture.

The **Green Revolution** succeeded in increasing the food production but it was not sufficient to feed the growing human population. One solution of this problem is use of **genetically modified crops**. Genes of plants, bacteria, fungi and animals have been changed by manipulations, therefore, these organisms are called **Genetically Modified Organisms (GMO).**

GM plants have been useful in many ways. Genetic modification has:

(i) Made crops more tolerant to **abiotic stresses** (cold, drought, salt, heat).

(ii) **Reduced reliance** on chemical pesticides (pest-resistant crops).

(iii) Helped to reduce **post harvest losses**.

(iv) Increased efficiency of **mineral usage** by plants (this prevents early exhaustion of fertility of soil).

Enhanced **nutritional value** of food, *e.g.*, vitamin 'A' enriched rice.

Genetic engineering in plants

The main steps in plant genetic engineering are given below :

(1) Agronomically important gene is identified and isolated.

(2) Plasmid is isolated from the bacterium, *Agrobacterium tumefaciens*.

(3) Plant DNA containing the gene of interest in integrated into the T DNA of the plasmid by using restriction endonuclease and ligase enzymes.

(4) Recombinant plasmid is introduced into the cultured plant cells.

(5) T DNA integrates into the plant cells chromosomes DNA.

(6) As the plant cells divide, each daughter cell receives a copy of T DNA and the gene of interest it carries.

(7) The cells give rise to a plantlet, which, when transferred into soil, grows into a new plant that may express the new gene.

Production of transgenic plants

Transgenic plants can be obtained by **combination of tissue culture** and **genetic engineering**. Transgenic plants have a **natural resistance** to **herbicides** and **pests**.

The vector used to introduce new genes into plant cells is most often a plasmid from the soil bacterium *Agrobacterium tumefaciens*. This is the **Ti plasmid** (tumour inducing plasmid), so called because in nature, it induces tumours in broad leaf plants.

For using Ti plasmid as a vector, researchers have eliminated its tumor causing properties while keeping its ability to transfer DNA into plant cells. Hence, for genetic engineering purposes, *Agrobacterium* strains are developed in which tumor-forming genes are deleted. These transformed bacteria can still infect plant cells.

The part of Ti plasmid transferred into plant cell DNA, is called the **T-DNA**. This T-DNA with desired DNA spliced into it, is inserted into the chromosomes of the host plant where it produces copies of itself, by migrating from one chromosomal position to another at random. Such plant cells are then **cultured**, induced to multiply and differentiate to form **plantlets**. Transferred into soil, the plantlets grow into mature plants, carrying the foreign gene, expressed throughout the new plant.

Table : 9.2-1 Some important example of transgenic plants

Transgenic plants	Useful application
Bt Cotton	Pest resistance, herbicide tolerance and high yield. It is resistant to boll worm infestation.
Flavr Savr Tomato	Increased shelf-life (delayed ripening) and better nutrient quality.
Golden rice	Vitamin A-rich
Potato	Higher protein content
Corn, Brinjal	Insect resistance
Soyabean, Maize	Herbicide resistance

Bt Cotton (Insect resistant plant)

Soil bacterium *Bacillus thuringiensis* produces proteins that kill certain insects like lepidopterans (tobacco budworm, armyworm), coleopterans (beetles) and dipterans (flies, mosquitoes). *B. thuringiensis* forms some protein crystals. These crystals contain a **toxic insecticidal protein**.

The Bt toxin protein exists as inactive **protoxin** but once an insect ingests the inactive toxin it is converted into an active form of toxin due to the alkaline pH of the alimentary canal which solubilise the crystals. The activated toxin binds to the surface of midgut epithelial cells and create pores that cause cell swelling and lysis and eventually cause death of the insect.

Bt toxin genes were isolated from *Bacillus thuringiensis* and incorporated into the several crop plants such as cotton.

The choice of genes depends upon the crop and targeted pest, as most **Bt toxins are insect-group specific**. The toxin is coded by a gene named *cry*. There are numerous genes. Two *cry* genes ***cryIAc*** and ***cryIIAb*** have been **incorporated in cotton**. This genetically modified crop is called **Bt cotton** as it contains **Bt toxin** genes against **cotton bollworms**. Similarly, ***cryIAb*** has been introduced in Bt corn to protect the same from corn borer.

Pest resistant plants

A nematode *Meloidogyne incognitia* infects the roots of **tobacco plants** and causes a great **reduction in yield**. A novel strategy was adopted to prevent this infection that was based on the process of **RNA interference (RNAi)**. RNA interference is the phenomenon of **inhibiting activity of a gene through production of sense and antisense RNA**.

This method involves a **specific *m*RNA** silencing. The result was that the parasite could not survive in a transgenic host expressing specific interfering RNA. The transgenic plants thus got itself protected from the parasite.

Some other **agricultural applications** are :

(i) The protein **hirudin** present in leech prevents blood clotting. Its gene was chemically synthesized and introduced in *Brassica napus*. The seeds of the latter came to have hirudin which could be extracted and purified.

(ii) **'Flavr Savr'** tomato was the first transgenic variety to reach the market. Here inactivation of gene which produces **polygalactouronase enzyme** has been done. The **non-availability of this enzyme prevents over-ripening** because the enzyme is essential for degradation of cell walls.

(iii) **Golden rice** is a transgenic variety of rice (*Oryza sativa*) which contains good quantities of β – carotene (provitamin A – inactive state of vitamin A).

(iv) Production of value added products like nutrition supplements, pharmaceuticals, fuels etc. using transgenic crops **(molecular farming).**

Biotechnological Applications in Health

The biotechnological processes have made great impact in the area of healthcare by mass production of safe and more effective **therapeutic drugs**. This is known as medical biotechnology or **red biotechnology**.

Cloning

Cloning is the process of producing many identical organisms or clones. In this process nucleus of ovum (n) is removed and replaced by nucleus of diploid cell of same organism. Now the egg with 2*n* nucleus is transferred to the uterus of mother to have normal pregnancy and delivers clone of itself.

Examples of organism cloning

(1) Cloning of sheep was done by Dr. Ian Wilmut (1995) of Roslin Institute, Edinberg U.K. and normal healthy lamb (DOLLY) was born in Feb, 1996. This lamb was exactly similar to her mother.

(2) The first cloned calves George and Charlie were born in January 1998.

(3) ANDI was the world's first genetically altered primate produced by inserting a jelly fish gene into the embryo of a rhesus monkey.

(4) Scientist at Scotland cloned POLLY and MOLLY. Unlike Dolly, polly and molly were transgenic (they carried human protein gene) polly and molly were born in july 1997.

(5) Brigitte Boissliar, a 46-year old French chemist announced the creation of the world's first cloned human baby nicknamed "Eve" (December 2002).

Few examples of applications of plant cloning in genetic engineering are given below where desired DNA has been introduced in plant genome for various purposes :

Table : 9.2-2

Applications	Examples
Herbicide resistant plants	Petunia, tobacco, tomato and corn
Insect resistant plants	Cotton, tobacco and mustard
Virus resistant plants	Tomato, potato, alfaalfa, cucumber, rice and papaya
Plants which improved storage proteins	French been and potato
Plants with improved oil and fats	Rapeseed (rich in oleic acids and sterates) and soyabean (rich in cocoa oil)
Stress tolerant plants	Tobacco

Steroids : Steroids are high molecular weight complex crystallisable fatty compounds. Which are having one 5-carbon ring and three 6-carbon rings. Steroids are of wide distribution in both plants and animals. Cholesterol is one of the most important steroids of animals, which is a precursor of animal hormones (steroid hormones) like progesterone and oestrogen (female sex hormones) and testosterone (male sex hormone).

Steroids are nowadays used as valuable drugs, *e.g.*, in treatment of hormonal disturbances, for suppressing immune response in auto immune diseases, used in formation of birth control pills or contraceptive pills (oestrogens and progesterones) and anit-inflammatories.

Rhizopus stolonifer is capable of hydroxylation, necessary for steroid synthesis. (Murray and Peterson, 1950).

Progesterone is precursor of 4 different useful steroids and the micro-organisms used in this conversion are *Rhizopus arrhizus, R. stolonifer* (*R. nigricans*), *Curvularia lunata* (all fungi) and a bacterium *Streptomyces argenteolus*.

Vaccines : The vaccines are preparations of infectious or toxic agents that have been altered so as not to cause disease. It is injected into an antibody producing organism to produce immunity in the body against diseases. The process of inoculation of vaccine is known as Vaccination and Louis Pasteur (1850) is responsible for understanding the basis of vaccination and immunization. (Edward Jenner 1790, however made earlier studies in relation to smallpox). A vaccine contains either weakened or attenuated (polio, smallpox and measles vaccines) or even killed pathogens (typhoid vaccine) which have still antigens to induce antibody production. In some cases (like botulism and tetanus), toxins produced by pathogens serve as vaccines. A large number of vaccines (called first generation vaccines) against different viral and bacterial diseases have been produced.

In recent years, some new vaccines called second generation vaccines and third generation vaccines have been developed. Second generation vaccines are produced by recombinant DNA technology or genetic engineering, *e.g.*, vaccines are for *Herpes* virus and *Hepatitis* B. Third generation vaccines are produced synthetically or are synthesized vaccines, *e.g.*, for feline leukemia virus and foot and mouth disease virus.

Table : 9.2-3

Vaccine	Function
Hepatitis B	Prevention of long term liver damage.
Hepatits A	Prevention of high fever, liver damage.
Herpes simplex virus	Genital ulcers
Rabies virus	Encephalitis, hydrophobia
Dengue virus	Hemorrhagic fever
Cytomegalo virus	Infection in infants and lummuno compromised patients
Mesels	Prevent of measels

Insulin : It is a hormone secreted by β-cells of islets of langerhans of pancreas in human body. Insulin is a hormone of protein nature (51 amino acids), made of 2 polypeptide chains having 21 and 30 amino acids respectively and joined by disulphide bonds. Deficiency of this insulin leads to a disease called *diabetes mellitus*. Insulin supplied from outside can cure this disease.

Sharpy-Shafer (1916) proposed that diabetes is due to failure pancreas to secrete a chemical named insulin. Banting and Best (1921) first of all isolated insulin from dog's pancreas and used it for curing diabetes patients. The injection of insulin from slaughtered pigs and cows is effective in patients of diabetes, but some patients produce a few undesirable side effect.

By using genetic engineering or recombinant DNA technology, insulin producing genes from human beings have been transferred into *E.coli* bacteria, which produce insulin called 'Humulin' for clinical use. In 1978 Genentech produced Human Insulin in *E. coli*. In 1998, Eli Lilly and Ranbaxy launched diabetic drugs like Humapen, Humalog and protein kinase *C*.

Monoclonal antibodies : Monoclonal antibodies (Mabs) are the specialized antibodies, which are specific to only one type of antigen. Antibodies are produced in lymph nodes, spleen and liver. Antibodies are often required for research in medicine. The concept of monoclonal antibodies was put forward by Georges Kohler and Cesal Milstein in 1974 and these antibodies are produced outside the body by hybrid cell culture technique, known as Hybridoma technology. For this technology Kohler and Milstein were awarded Nobel Prize in 1984. Lymphocytes and myeloma cells fuse together to form hybridoma cells (by somatogamous fusion).

These hybridoma cells have capacity of antibody production (of lymphocytes) and rapid cell division (of cancer cells). These hybridoma cells in culture conditions produce large quantities of specific and pure (monoclonal) antibodies, which are separated and used in cure of different diseases.

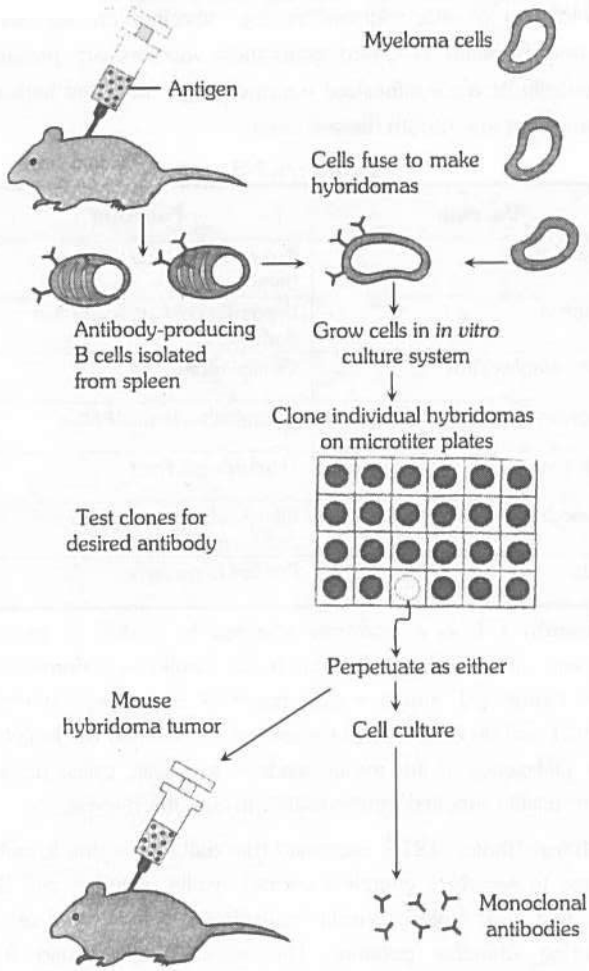


Fig : 9.2-1 Hybridoma technique and production of monoclonal antibodies

Biosynthesis of somatostatin : This hormone is secreted from front lobe of pitutary gland. It is made up of 191 amino acid units. Ross first isolated this hormone. The individual suffers dwarfness due to its deficiency. The gene or DNA of this hormone is introduced in *E.coli*, near the gene which codes for β-galactosidase.

Gene therapy

The use of bioengineered cells or other biotechnology techniques to treat human genetic disorders is known as gene therapy. Gene therapy is the transfer of normal genes into body cells to correct a genetic defect. It can be used to treat genetic diseases like sickle-cell anaemia and Severe Combined Immuno Deficiency (SCID). It (SCID) is caused by a defect in the gene for the enzyme adenosine deaminase (ADA). SCID patients have no functioning T lymphocytes and one treated with the injections of their white blood cells that have been engineered to carry the normal ADA alleles.

Transgenics Animals

A gene that has been introduced into a cell or organism is called a transgene (for transferred gene) to distinguish it from endogenous genes. The animal carrying the introduced foreign gene is said to be transgenic animal and the possessor called Genetically Modified Organisms (GMOs). Most of the transgenic animals studied to date were produced by microinjection of DNA into fertilized eggs. Prior to microinjection, the eggs are surgically removed from female parent and fertilized *in vitro* then DNA is microinjected into the male pronucleus of the fertilized egg through a very fine-tipped glass needle. The integration of injected DNA molecules appears to occur at random sites in the genome.

The first transgenic animal produced was the 'supermouse' by the incorporation of the gene for human growth hormone by Richard Palmiter and Ralph Brinster in 1981.

Table : 9.2-4 Some important example of transgenic animals

Transgenic animals	Useful application
Cow, Sheep, goat	Therapeutic human proteins in their milk.
Pig	Organ transplantation without risk of rejection.
Fish (Common Carp, Catfish, Salmon, gold fish)	They contain human growth hormone (hGH). They attain a size twice of that shown by nontransgenic fish.
Mouse	Contains a human gene that cause breast cancer. This enables the researchers to study the very early development of cancer.

Significance of Trangenic Animals

A transgenic animal contains in its genome, a gene or genes introduced by one or the other technique of transfection. The gene introduced by transfection is known as **transgene**. In animals, transfection specifies the introduction of a DNA segment, either naked or integrated into a vector, into an animal cell. The same phenomenon is known as **transformation** in all other organisms.

Transgenic animals can be specifically designed to allow the study of how genes are regulated, and how they affect the normal functions of the body and its development, *e.g.*, study of complex factors involved in growth such as insulin-like growth factor.

Many transgenic animals are designed to increase our understanding of how genes contribute to the development of disease.

Transgenic animals that produce useful **biological products** can be created by the introduction of the portion of DNA (or genes) which codes for a particular product such as human protein ($\alpha-1-$ antitrypsin) used to treat **emphysema**.

Similar attempts are being made for treatment of **phenylketonuria** (PKU) and **cystic fibrosis**.

In 1997, the first transgenic cow, **Rosie** produced human protein-enriched milk (2.4 grams per litre). The milk contained the human alpha-lactalbumin and was nutritionally more balanced product for human babies than natural cow milk.

Transgenic mice are being developed for use in testing the safety of vaccine before they are used on humans.

Transgenic animals are made that carry genes which make them more sensitive to toxic substances that non-transgenic animals. **Toxicity testing** in such animals will allow us to obtain results in less time.

Gene transfers have been successful in various **fish**, such as common carp, rainbow trout, Atlantic salmon, catfish, goldfish, zebra-fish etc. **Genetically modified salmon was the first transgenic animal obtained for food production.**

Rabbits are quite promising for **gene farming or molecular farming**, which aims at the production of recoverable quantities of **pharmaceutically** or **biologically** important **proteins encoded by the transgenes.**

Goats are being evaluated as **bioreactors**. Some human genes have been introduced in goats and their expression achieved in mammary tissues.

Transgenic sheep have been produced to achieve better growth and meat production. For example, human genes for blood clotting factor IX and for a l-antitrypsin have been transferred in sheep and expressed in mammary tissue.

Dogie is a transgenic dog with excellent smelling power.

Industrial Biotechnology

Use of microbes to obtain a product or service of economic value constitutes industrial biotechnology. It is also known as **white** or **grey biotechnology**.

Industrial production of useful products began as early as 1875 with the production of alcohol. At present, several chemicals, such as, **lactic acid, amylase, glycerine, citric acid, gluconic acid, acetic acid, acetone, butanol,** a variety of **enzymes, vitamins,** aminoacids, and all the **antibiotics** are produced using microorganisms.

Biosafety Issues

Measures taken to prevent any risk to plants, animals and microbes from transgenic organisms is known as biosafety. It was feared that genetically engineered microorganisms (GEMs) may disturb the ecosystem and its processes, in which they might be released. They may rapidly multiply and outcompete the native microbes. They may also transfer genes related to virulence of pathogenesis into bacterial population and, thereby increase their virulence. Similarly, genetically modified plants could pose biological and ecological risk.

The biosafety guidelines are developed to contribute to ensuring an adequate level of protection in the fields of safe transfer, handling and use of living modified organisms.

Bioethics

(1) Bioethics is the branch of ethics, philosophy and social commentary that deals with the biological sciences and their potential impact on society.

(2) The major bioethical concern pertaining to biotechnology are :

(i) Use of animals in biotechnology causes great suffering to them.

(ii) Introduction of a transgene from one species into another species violates the 'integrity of species'.

(iii) Transfer of human genes into animals (and *vice-versa*) dilutes the concept of 'humanness'.

Biopatent

(1) A patent is a monopoly granted to a person who has either.

(i) Invented a new and useful article.

(ii) Made an improvement of an existing article or

(iii) Invented a new process of making an article.

(2) The right of a patent holder include the right to make use, sell, offer for sale, export and license.

(3) A patent is granted by the legal system, therefore it is a subject which cannot be fully understood without knowing the law on the subject.

(4) Biopatent are awarded for the following :

(i) Strains of microorganism

(ii) Cell lines

(iii) Genetically modified strains of plants and animals

(iv) DNA sequences

(v) The proteins encoded by DNA sequences

(vi) Various biotechnological procedures

(vii) Production processes

(viii) Products and

(ix) Product applications

(5) In 1971. General Electric and one of its employees **Anan Mohan Chakravarty** applied to a US patent on a geneticall engineered *Pseudomonas.*

(6) The **human breast cancer gene** (BRCAl) was patente in the US once its base sequence had been determined an attempts are being made to patent the second breast cancer gen (BRCA2).

Biopiracy

(1) **Piracy** means the unauthorized publication c reproduction of another's material.

(2) **Intellectual Property Right** (IPR) claims by the form sector overt the work of the informal constitutes biopirarcy.

(3) Three aspects of biopiracy are :

Intellectual Piracy : This makes a false claim to novelty ar invention, even though the knowledge has evolved since ancie time.

Resource Piracy : This divests scarce biological resources monopoly control of corporations thus depriving communities ai indigenous practitioners.

Economic Piracy : It creates market monopolies ai excludes the original innovators from their rightful share to loc national and international markets.

(i) **Patenting of Neem**

(a) Indians have shared the knowledge of the properties of tl Neem with the entire world.

(b) Pirating this knowledge, the USDA and an American MNC **W.R. Grace** in the early 90s sought a patent (No. 0426257 B_1) from the European Patent Office (EPO) on the "method for controlling on plants by the aid of a hydrophobic extracted neem oil"

(c) The controversial patent on neem was revoked by EPO on 10th May 2000.

(d) An American university patented the healing properties of **turmeric powder,** cherished in India since ancient times for its power to cure the wound.

(ii) **Patenting of Basmati**

In 1997 the US Patent and Trademark Office (USPTO) granted a patent (No. 5663484) to a Texas based American company **Rice Tec Inc** for "Basmati rice line and grains".

(iii) **Rice Biopiracy**

(a) **Syngenta,** the biotech giant, tried to grab the precious collections of 22,972 varieties of paddy, India's rice diversity, from India's rice bowl, Chattisgarh in India.

(b) **Dr. Richharia,** the ex-director of Central Rice Research Institute (CRRI), Cuttack was the rice sage of India.

(iv) **ConAgra and the Biopiracy of Atta**

The US corporations have taken a patent on atta (wheat flour) chakkis through the patient no. 6,098,905, granted to Nebraska-based company, ConAgra on August 8,2000.

(v) **Brazzein**

Brazzein is a protein, which is produced by a W. African plant. *Pentadiplandra brazzeana* and is approximately **2,000 times** as sweet as sugar. It is used as a low calorie sweetener. Local people have been using the super-sweet berries of the plant for centuries. But the protein was patented in USA and the gene encoding brazzein was isolated, sequenced and patented in USA as well. It is proposed to transfer the brazzein gene into maize and express it in maize kernels. Such kernels will then be used for extraction of brazzein. This development could have serious implications for countries who export large quantities of sugar.

Biowar

(1) **Biowar** or **Biological war** or **bioterrorism** is the deployment of biological weapons against people, their crops and animals.

(2) Bioterrorism refers to the intentional or threatened use of viruses, bacteria, fungi or toxins from living organisms to produce death of disease in humans, animals and plants.

(3) The biological agent/toxin, called **bioweapon** agent, is kept in a suitable container so that it remains active and virulent during delivery.

(4) The first reported use of biological weapons was in 5th century BC, when **Assyrians** poisoned enemy wells with rye ergot.

(5) During many occasions, **smallpox** was used as a biological weapon, **Pizarro** is said to have presented South American natives with variola-contaminated clothing in the 15th century.

(6) Biological weapons were used after sep. 11, 2001 attack on USA.

(7) Anthrax spores were used against USA and her allied countries by Al-Qaeda activists.

(8) **Botulinum toxin,** the most potent one, enter nerve terminals before they block the release of neurotransmitters.

(9) The plant toxin **ricin** kills by blocking protein synthesis in many cells.

Table : 9.2-5 Biological Warfare Agents

Pathogens	Smallpox virus
	Viral encephalitides
	Viral hemorrhagic fevers
	Bacillus anthracis
	Brucella suis
	Coxiella burnetii
	Francisella tularensis
	Yersinia pestis
Toxins	Botulinum
	Ricin
	Stylococcal enterotoxin B
Anticrop agent	Rice blast
	Rice stem rust
	Wheat stem rust

DNA Chips or Biochips

They are single stranded DNA chains, genes, gene part repetitive DNA segments, etc. Firmly stuck to silica or glass chips for matching and studying DNA components to know about hereditary. Superiority, hereditary defects, presence of disease through hyperactivity or inactivation of specific genes and development of new gene based drug. For example biochips of healthy genes BRCA-I and BRCA-II have been 'developed to study proneness of woman for breast cancer'.

Tips & Tricks

- US patent "use of turmeric in wound healing is cancelled in 1998".
- Sabin et al prepared oral vaccine known as oral polio vaccine (OPV).
- Non rabies zone in India is Lakshadweep.

Ordinary Thinking

Objective Questions

Biotechnology and it's application

1. In plant biotechnology, root tumours are induced in plant using the bacterium **[Odisha JEE 2008]**
(a) *Agrobacterium rhizogenes* (b) *Agrobacterium basilis*
(c) *Rhizobium* (d) None of these

2. Lal Bahadur Shastri biotechnological centre is in
(a) Bombay (b) Calcutta
(c) Delhi (d) Kanpur

3. Human insulin is being commercially produced from a transgenic species of **[CBSE PMT 2008]**

Or

Genetically engineered human insulin is prepared by using **[BVP 2000]**
(a) *Rhizobium* (b) *Saccharomyces*
(c) Escherichia (d) *Mycobacterium*

4. Which of the following is/are true

A. Biowar	-	Biowar is the use of biological weapons against humans and or their crops and animals
B. Bioethics	-	Bioethics is the unauthorised use of bioresources and traditional knowledge related to bioresources for commercial benefits
C. Biopatent	-	Exploitation of bioresources of other nations without proper authorisation

[Kerala PMT 2007]
(a) *B* only (b) *A* only
(c) *A* and *B* only (d) *A* and *C* only
(e) *B* and *C* only

5. Monoclonal antibodies are produced from hybrid cells called hybridomas. The cells employed to obtain these hybridoma cells, are **[KCET 2006]**
(a) B-lymphocytes and myeloma cells
(b) Lymphoma cells and bone marrow cells
(c) T-lymphocytes and myeloma cells
(d) B-lymphocytes and carcinoma cells

6. Which of the following has been covered under the broad patent category **[DPMT 2007]**
(a) *Triticum* (b) *Oryza*
(c) *Pisum sativum* (d) *Brassica*

7. 'Gray biotechnology' is referred to **[AMU (Med.) 2010]**
(a) Medical process (b) Industrial process
(c) Agricultural process (d) Aquatic process

8. Dextran is used in
(a) Bleeding (b) Blood preservation
(c) Blood transfusion (d) Blood clotting

9. Utility of fungi for steroid conversion was demonstrated by
(a) Pasteur and Jaubert (b) Kohler and Milstein
(c) Murray and Peterson (d) Waksman and Woodruff

10. Humulin is **[CBSE PMT 1999]**
(a) A form of chitin (b) A powerful antibiotic
(c) A new digestive enzyme (d) Human insulin

11. Which of the following established the scientific basis of vaccination
(a) Louis Pasteur (b) Edward Jenner
(c) Cesar Milstein (d) George Kohler

12. Hybridomas are employed for **[NCERT; MP PMT 2003; Odisha JEE 2008]**
(a) Synthesis of antibiotics
(b) Killing cancer cells
(c) Synthesis of monoclonal (somaclonal) antibodies
(d) Production of somatic hybrids

13. Cells obtained from cancerous tumours are known as **[MP PMT 2012]**
(a) Hybridomas (b) Myelomas
(c) Lymphocyte (d) Monoclonal cells

14. Kohler and Milstein developed biotechnology for the production of **[MP PMT 2002; Odisha JEE 2008]**
(a) Myelomas (b) Steroid conversion
(c) Monoclonal antibodies (d) Immobilised enzymes

15. Which one of the following pairs is not correctly matched **[MP PMT 1993]**

(a) Plasmid	Small piece of extrachromosomal DNA in bacteria
(b) Interferon	An enzyme that interferes with DNA replication
(c) Cosmid	A vector for carrying large DNA fragments into host cells
(d) Myeloma	Antibody–producing tumour cells

16. Nuclear transplantation technique was discovered by **[VITEEE 2006]**
(a) Briggs (b) Ian Wilmut
(c) Gurdon (d) Griffith

17. Secondary metabolite is **[DPMT 2006]**
(a) Sugar (b) Glucose
(c) Antibiotics (d) All of these

18. In which field application of biotechnology occurs **[GUJCET 2015]**
(a) Bio-medicine (b) Agriculture
(c) Environment field (d) All of the above

19. Biopiracy is related to **[MH CET 2008]**
(a) Bioreasearches
(b) Traditional knowledge
(c) Biomolecules and genes discovered
(d) All of these

20. A genetically engineered micro-organism used successfully in bioremedication of oil spills is a species of **[NCERT; CBSE PMT 2007; BHU 2008; MP PMT 2009]**
(a) *Pseudomonas* (b) *Trichoderma*
(c) *Xanthomonas* (d) *Bacillus*

21. Choose the correct option for the toxic protein produced by *B. thuringiensis* **[GUJCET 2014]**
(a) It acts in acidic medium and binds to epithelial cells of foregut
(b) It acts in neutral medium and binds to epithelial cells of hindgut
(c) It acts in alkaline medium and binds to epithelial cells of foregut
(d) It acts in alkaline medium and binds to epithelial cells of midgut

22. The name of drug used in cancer treatment produced by biotechnology is **[MP PMT 1998]**
(a) Interferon (b) HGH
(c) TSH (d) Insulin

23. The main technique involved in agricultural biotechnology is called **[MP PMT 1998]**
(a) Tissue culture (b) Transformation
(c) Plant breeding (d) DNA replication

24. The new strain of bacteria produced by biotechnology in alcohol industry is **[MP PMT 1998, 2006]**
(a) *Escherichia coli*
(b) *Saccharomyces cerevisiae*
(c) *Bacillus subtilis*
(d) *Pseudomonas putida*

25. Important objective of biotechnology in agriculture section is **[MP PMT 1998]**
(a) To produce pest resistant varieties of plant
(b) To increase the nitrogen content
(c) To decrease the seed number
(d) To increase the plant weight

26. The vaccine of Hepatitis-B is a **[NCERT; MP PMT 2003, 12]**
(a) First generation vaccine
(b) Interferon
(c) Second generation vaccine
(d) Third generation vaccine

27. The illegal and unlawful development of biomaterials without payment to the inhabitants of their origin is called **[J & K CET 2010]**
(a) Biopatent (b) Biotechnology
(c) Bio-war (d) Biopiracy

28. In September 2001, Which of the following was used as a bioweapon agent in America **[MP PMT 2007]**
Or
Most widely used bioweapon is **[BHU 2006, 08; AFMC 2008]**
(a) Botulinum
(b) Anthrax (*Bacillus anthracis*)
(c) Polio virus
(d) AIDS virus

29. Which of the following is not used as bioweapon **[DUMET 2010]**
(a) *Bacillus anthracis*
(b) *Botulinum* toxin
(c) *Bacillus thuringiensis* toxin
(d) Smallpox

30. Which one of the following is now being commercially produced by biotechnological procedures **[CBSE PMT (Mains) 2010]**
(a) Nicotine (b) Morphine
(c) Quinine (d) Insulin

31. Some of the steps involved in the production of humulin are given below. Choose the correct sequence
(i) Synthesis of gene (DNA) for human insulin artificially
(ii) Culturing recombinant E.coli in bioreactors
(iii) Purification of humulin
(iv) Insertion of human insulin gene into plasmid
(v) Introduction of recombinant plasmid into E.coli
(vi) Extraction of recombinant gene product from E.coli **[KCET 2010]**
(a) (ii), (i), (iv), (iii), (v), (vi) (b) (i), (iii), (v), (vi), (ii), (iv)
(c) (i), (iv), (v), (ii), (vi), (iii) (d) (iii), (v), (ii), (i), (vi), (iv)

32. Monoclonal antibodies are **[AIIMS 2010]**
(a) Obtained from a cell and act on one antigen
(b) Obtained from a group of cells and act on more than one antigens
(c) Obtained from a group of same type of cells and act on single antigen
(d) Obtained from a group of same type of cells and act on more than one antigens

33. What is true about Bt toxin **[CBSE PMT 2009; AIPMT (Cancelled) 2015]**
(a) The inactive protoxin gets converted into active form due to acidic ph of the insect gut
(b) Bt protein exists as active toxin in the Bacillus
(c) The activated toxin enters the ovaries of the pest to sterilize it and thus prevent its multiplication
(d) The concerned Bacillus has antitoxins

34. Trade name of genetically engineered insulin is **[CPMT 2000; MP PMT 2003]**
(a) Anulin (b) Beta insulin
(c) Humilin (d) Gilbert's insulin

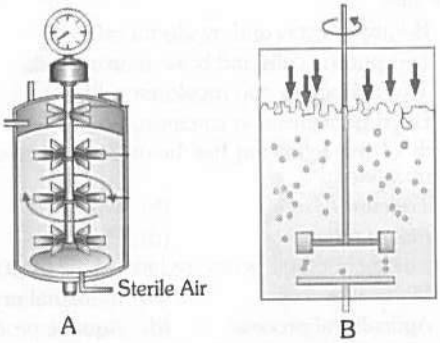
35. Consumption of which one of the following foods can prevent the kind of blindness associated with vitamin '*A*' deficiency **[DPMT 2007; CBSE PMT 2008; CBSE PMT (Pre.) 2012]**
(a) Bt Soybean (b) Golden rice
(c) Flavr Savr tomatoes (d) Starlink maize

36. Grafting between two members of same species is **[Kerala PMT 2006]**
(a) Allograft (b) Autograft
(c) Xenograft (d) None of the above

37. Isolation of ***Bt*** gene from bacterium (*Bacillus thuringiensis*) was taken up in the year **[AMU (Med.) 2009]**
(a) 1977 (b) 1980
(c) 1997 (d) 1990

38. "Tissue culture" means **[MP PMT 1993]**
(a) Cultivation of tissue in laboratory through formation of new cells
(b) Introduction of new tissue in an animal body
(c) A technique for maintaining fragments of cells alive after their removal from an organism
(d) Maintaining tissue alive by immersing it partially in a nutrient fluid

39. The following apparatus are used for fermentation process. Identify A and B respectively **[NCERT]**



(a) Stirred tank and sparged tank bioreactor
(b) Respirometer and sparged tank bioreactor
(c) Stirred tank and Gene gun
(d) None of these

40. An example of gene therapy is **[AIIMS 2004]**
(a) Production of injectable Hepatitis *B* vaccine
(b) Production of vaccines in food crops like potatoes which can be eaten
(c) Introduction of gene for adenosine deaminase in persons suffering from Severe Combined Immuno-deficiency (SCID)
(d) Production of test tube babies by artificial insemination and implantation of fertilized eggs

41. Find the incorrect statement **[Kerala CET 2005]**
(a) Gene therapy is a genetic engineering technique used to treat diseases at molecular level by replacing defective genes with normal genes
(b) Calcitonin is a medically useful recombinant product in the treatment of infertility
(c) Bt toxin is a biodegradable insecticide obtained from *Bacillus thuringiensis*
(d) *Trichoderma* species is a biocontrol agent for fungal diseases of plants
(e) Totipotency is the potential ability of a cell to develop into a complete plant

42. Which of the following is false for BT transgenic plant **[BCECE 2005]**
(a) Disease resistance
(b) Prepared by *Bacillus thuringiensis*
(c) It is recombinant type
(d) No such plant is known

43. A tumour inducing plasmid widely used in the production of transgenic plants is that of **[AIIMS 2005]**
(a) *Escherichia coli*
(b) *Bacillus thuringiensis*
(c) *Staphylococcus aureus*
(d) *Agrobacterium tumefaciens*

44. Crown gall disease in plants is caused by **[BHU 2005]**
(a) Ti-plasmid (b) Pi-plasmid
(c) Bacteria (d) Virus

45. In transgenics, expression of transgene in target tissue is determined by **[CPMT 2005]**
(a) Enhancer (b) Promotor
(c) Transgene (d) Reporter

46. Which of the following is correctly matched **[Kerala PMT 2011]**

(A)	*Agrobacterium tumefaciens*	-	Tumour
(B)	*Thermus aquaticus*	-	Bt-gene
(C)	*pBR322*	-	Enzyme
(D)	Ligase	-	Molecular scissors
(E)	*Hin d* II	-	Plasmid vector

47. This is not a GMO **[KCET 2012]**
(a) Bt brinjal (b) Golden rice
(c) Tracy (d) Dolly

48. The first clinical gene therapy was given for treating **[CBSE PMT(Mains) 2012]**
(a) Diabetes mellitus
(b) Chicken pox
(c) Rheumatoid arthritis
(d) Adenosine deaminase deficiency

49. Tobacco plants resistant to a nematode have been developed by the introduction of DNA that produced (in the host cells) **[CBSE PMT (Mains) 2012]**
(a) Both sense and anti-sense RNA
(b) A particular hormone
(c) An antifeedant
(d) A toxic protein

50. Cloning does not provide **[CPMT 2010]**
(a) Same morphological character
(b) Variation
(c) Same genetic character
(d) All of the above

51. This method of finding a gene is used when researchers know very little about the gene they are trying to find. This process results in a complete gene library : a collection of copies of DNA fragments that represent the entire genome of an organism **[AIIMS 2009]**
(a) Cloning (b) Shotgun cloning
(c) Gene synthesis cloning (d) PCR

52. Cloning gene is a process where **[DUMET 2010]**
(a) Gene is cloned in an animal
(b) Fragments of DNA are transferred from one organism to another, usually carried on a DNA vector
(c) Fragments of DNA cloned in the same organisms using carrier
(d) DNA is cloned in plants

53. First cloned animal is **[CBSE PMT 2000]**
(a) Dog (b) Molly
(c) Dolly sheep (d) Polly sheep

54. ANDI is cloned **[Kerala CET 2002]**
(a) Sheep (b) Bull
(c) Monkey (d) Cat

55. Choose the correct statement with reference to "Dolly" **[NCERT; Kerala CET 2005]**
(a) She was created by taking nucleus from unfertilised egg
(b) She was created by taking nucleus from udder cell and cytoplasm from unfertilised egg
(c) She was created by taking cytoplasm from udder cells and nucleus from fertilised egg
(d) She was created in the test tube

56. Which part of the tobacco plant is infected by *Meloidogyne incognita* **[NEET (Phase-I) 2016]**
(a) Flower (b) Leaf
(c) Stem (d) Root

NCERT Exemplar Questions

1. Bt cotton is not **[NCERT]**
(a) A GM plant
(b) Insect resistant
(c) A bacterial gene expressing system
(d) Resistant to all pesticides

2. C-peptide of human insulin is **[NCERT]**
(a) A part of mature insulin molecule
(b) Responsible for formation of disulphide bridges
(c) Removed during maturation of pro-insulin to insulin
(d) Responsible for its biological activity

3. GEAC stands for **[NCERT]**
(a) Genome Engineering Action Committee
(b) Ground Environment Action Committee
(c) Genetic Engineering Approval Committee
(d) Genetic and Environment Approval Committee

4. $\alpha-1$ antitrypsin is **[NCERT]**
(a) An antacid (b) An enzyme
(c) Used to treat arthritis (d) Used to treat emphysema

5. A probe which is a molecule used to locate homologous sequences in a mixture of DNA or RNA molecules could be **[NCERT]**
(a) A ssRNa (b) A ssDNA
(c) Either RNA or DNA (d) Can be ssDNA but not ssRNA

6. Choose the correct option regarding Retrovirus **[NCERT]**
(a) An RNA virus that synthesizes DNA during infection
(b) A DNA virus that synthesizes RNA during infection
(c) A ssDNA virus
(d) A dsRNA virus

7. The site of production of ADA in the body is **[NCERT]**
(a) Erythrocytes (b) Lymphocytes
(c) Blood plasma (d) Osteocytes

8. A protoxin is **[NCERT]**
(a) A primitive toxin
(b) A denatured toxin
(c) Toxin produced by protozoa
(d) Inactive toxin

9. Pathophysiology is the **[NCERT]**
(a) Study of physiology of pathogen
(b) Study of normal physiology of host
(c) Study of altered physiology of host
(d) None of the above

10. The trigger for activation of toxin of *Bacillus thuringiensis* is **[NCERT]**
(a) Acidic pH of stomach
(b) High temperature
(c) Alkaline pH of gut
(d) Mechanical action in the insect gut

11. Golden rice is **[NCERT]**
(a) A variety of rice grown along the yellow river in China
(b) Long stored rice having yellow colour tint
(c) A transgenic rice having gene for β – carotene
(d) Wild variety of rice with yellow coloured grains

12. In RNAi, genes are silenced using **[NCERT]**
(a) ss DNA (b) ds DNA
(c) ds RNA (d) ss RNA

13. The first clinical gene therapy was done for the treatment of **[NCERT]**
(a) AIDS
(b) Cancer
(c) Cystic fibrosis
(d) SCID (Severe Combined Immuno Deficiency resulting form deficiency of ADA)

14. ADA is an enzyme which is deficient in a genetic disorder SCID. What is the full form of ADA **[NCERT]**
(a) Adenosine deoxyaminase (b) Adenosine deaminase
(c) Aspartate deaminase (d) Arginine deaminase

15. Silencing of a gene could be achieved through the use of **[NCERT]**
(a) RNA only
(b) Antisense RNA only
(c) Both RNA and antisense RNA
(d) None of the above

Critical Thinking

Objective Questions

1. Hybridoma cells are **[CBSE PMT 1999]**
(a) Nervous cells are
(b) Hybrid cells resulting from myeloma cells
(c) Only cells having oncogenes
(d) Product of spore formation in bacteria

2. The prerequisites for biotechnological production of antibiotics is **[MP PMT 1998]**
(a) To search an antibiotic producing microorganism
(b) To isolate the antibiotic gene
(c) To join antibiotic gene with *E. coli* plasmid
(d) All of the above

3. Hybridomas are the result of fusion of **[NCERT; AIIMS 2007]**
(a) Male reproductive cells
(b) Female reproductive cells
(c) Normal antibody producing cells with myeloma
(d) Abnormal antibody producing cells with myeloma

4. Which of the following correctly defines a transgenic animal **[NCERT; CBSE PMT 1995]**
(a) An animal which has foreign DNA and RNA in some of its cells because of an injection of DNA and RNA into the nucleus of the zygote from which it is developed
(b) An animal which has foreign DNA in all its cells because of an injection of DNA into the nucleus of the zygote from which it is developed
(c) An animal which has foreign DNA in some of its cells because of an injection of DNA into the nuclei of some of the cells of the blastocyst
(d) An animal which has foreign DNA in all its cells because of an injection of DNA into the nuclei of some of the cells in adulthood

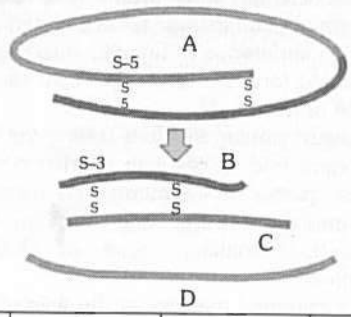
5. Which one of the following is a correct statement **[AIIMS 2005]**
(a) "Bt" in "Bt-cotton" indicates that it is a genetically modified organism produced through biotechnology
(b) Somatic hybridization involves fusion of two complete plant cells carrying desired genes
(c) The anticoagulant hirudin is being produced from transgenic *Brassica napus* seeds
(d) "Flavr Savr" variety of tomato has enhanced the production of ethylene which improves its taste

6. Which of the following Bt crops is being grown in India by the farmers **[NEET 2013]**
(a) Soyabean (b) Maize
(c) Cotton (d) Brinjal

7. Which of the following represents the action of insulin **[NEET (Karnataka) 2013]**
(a) Increases blood glucose levels by stimulating glucagon production
(b) Decreases blood glucose levels by forming glycogen
(c) Increases blood glucose level by promoting cellular uptake of glucose
(d) Increases blood glucose levels by hydrolysis of glycogen

8. Which one of the following vectors is used to replace the defective gene in gene therapy **[NEET (Karnataka) 2013]**
(a) Adenovirus (b) Cosmid
(c) Ri plasmid (d) Ti plasmid

9. Following is a diagrammatic representation of maturation of insulin. Select the correct set of the names labelled A, B, C and D **[NCERT]**



	A	B	C	D
(a)	Proinsulin	B - Peptide	A - Peptide	Free C Peptide
(b)	Proinsulin	A - Peptide	B - Peptide	Insulin
(c)	Proinsulin	A - Peptide	B - Peptide	Free C Peptide
(d)	Proinsulin	B - Peptide	A - Peptide	Insulin

10. Select the correct option for the given statements 'X', 'Y' and 'Z'
Statement 'X' – A transgenic cow, Rosie, produced human protein-enriched milk, which was nutritionally more balanced product for human babies than natural cow milk
Statement 'Y' – Milk produced by transgenic cow, Rosie, contain 2.4 gm protein/litre
Statement 'Z' – In the above mentioned milk in 'Y' statement, alpha lactalbumin is present **[GUJCET 2014]**
(a) Statements 'X', 'Y' and 'Z' are true and statement 'Z' gives correct explanation
(b) Statements 'X', 'Y' and 'Z' are true and statement 'Z' does not give correct explanation
(c) Statements 'X' and 'Y' are correct and statement 'Z' is wrong
(d) Statements 'X' and 'Y' are wrong and statement 'Z' is correct

11. The transgenic animals are generally produces for all of the following needs except **[MHCET 2015]**
(a) Testing of chemical safety
(b) Testing of vaccine safety
(c) Stimulation of pathogenicity
(d) Production of pharmacologically important proteins

12. Basic principle of developing transgenic plant and animals is to introduce the gene of interest into the nucleus of **[WB JEE 2012]**
(a) Somatic cell (b) Vegetative cell
(c) Germ cell (d) Body cell

A R Assertion & Reason

Read the assertion and reason carefully to mark the correct option out of the options given below :
(a) If both the assertion and the reason are true and the reason is a correct explanation of the assertion
(b) If both the assertion and reason are true but the reason is not a correct explanation of the assertion
(c) If the assertion is true but the reason is false
(d) If both the assertion and reason are false
(e) If the assertion is false but reason is true

1. Assertion : *Ti* plasmid obtained from *Agrobacterium tumefaciens* is effectively used as a vector for gene transfer in plant cells.
Reason : The part of Ti plasmid transferred into the DNA of plant cells is called as T-DNA.

2. Assertion : The transgenic food may cause toxicity and product allergy in human beings.
Reason : The bacteria present in alimentary canal of human beings may become resistant to the antibiotics by taking up the antibiotic resistant gene that is present in the GM food.

3. Assertion : GMO tomato 'Flavr Savr' has increased shelf life and better nutrient quality.
Reason : This is achieved by reducing the amount of cell wall degrading enzyme 'polygalacturonase' responsible for fruit softening.

4. Assertion : Transgenic mouse is termed as 'super mouse' because it is twice big in size than the normal mouse.
Reason : In 'super mouse', the gene for human growth factor has been introduced and expressed.

Answers

Biotechnology and it's application

1	a	2	c	3	c	4	b	5	a
6	b	7	b	8	c	9	c	10	d
11	a	12	c	13	b	14	c	15	b
16	a	17	c	18	d	19	d	20	a
21	d	22	a	23	a	24	d	25	a
26	c	27	d	28	b	29	c	30	d
31	c	32	c	33	a	34	c	35	b
36	a	37	b	38	a	39	a	40	c
41	b	42	d	43	d	44	a	45	d
46	a	47	d	48	d	49	a	50	b
51	b	52	b	53	c	54	c	55	b
56	d								

NCERT Exemplar Questions

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

Critical Thinking Questions

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

Assertion and Reason

1	b	2	b	3	a	4	a		

Answers and Solutions

Biotechnology and it's application

6. (b) *Oryza* has been covered under broad patent category.
8. (c) Dextran is a complex polysaccharide and dextran plays an important role in plasma transfusions.
9. (c) *Rhizopus stolonifer* is capable of hydroxylation, necessary for steroid synthesis, (Murray and Peterson 1950).
10. (d) The first commercial example of enzyme modification of a protein for human use is the conversion of pig insulin to human insulin called "humulin".
11. (a) The process of inoculation of vaccine is known as vaccination and Louis Pasteur (1850) is responsible for understanding the basis of vaccination.
12. (c) Monoclonal / Magic antibodies are pure antibodies against a particular antigen which are obtained through Clonal culture of hybridoma.
14. (c) In biotechnology monoclonal antibodies (Mabs) are the specialize antibodies, which are specific to only one type of antigen. The concept of monoclonal antibodies was put forward by Georges kohler and Cesal Milstein in 1974.
15. (b) Interferons are antiviral proteins which were produced by "Charles Weismann" (1980) by recombinant DNA technology in *E. coli*.
17. (c) The chemical compounds which are produced as by-products of cellular metabolism and are not essential for the survival and growth of organisms, which produce them are called secondary metabolites *e.g.*, alkaloids, steroids, tannis, cesins, antibiotic etc.
21. (d) Toxin produced by *Bacillus thuringiensis* acts in alkaline medium and binds to epithelial cells of midgut and causes pores that leads to death of the insects.
23. (a) The tissue culture is a latest method of crop improvement. Besides also used in manufacture of antibiotics, alkaloids and dyes.
24. (d) *Pseudomonas putida* is a new strain of bacteria produced by biotechnology in alcohol industry.
26. (c) Second generation vaccines are produced by recombinant DNA technology or genetic engineering *e.g.*, vaccine for *Herpes* virus and *Hepatitis – B*.
35. (b) Golden rice is vitamin A rich variety developed by *R. DNA* technology and used in the treatment of vitamin A deficiency.
36. (a) When transplant between individuals of same species but with different genetical background is done it is known as allograft.
40. (c) Gene therapy can be used to treat genetic diseases like sickle-cell anaemia and severe combined immuno deficiency (SCID). SCID patients are treated with the injections of their WBCs that have been engineered to carry the normal adenosine deaminase (ADA).
41. (b) Calcitonin is medically useful in the treatment of osteomalacia.
42. (d) Bt cotton is a transgenic plant, which have been genetically modified by incorporating foreign and other specific genes through recombinant DNA technology.
44. (a) One of the most interesting plasmids is the tumour-inducing (Ti) plasmid of Agrobacterium tumefaciens. Agrobacterium tumefaciens is a causative agent of a common plant disease termed crown gall disease.
49. (a) RNA interference technique, sense and Antisense RNA fused to form Ds RNA that silent the expression of m-RNA of nematode.
51. (b) Shotgun cloning involves cutting the DNA of the entire genome into pieces with restriction enzymes, inserting these pieces or fragments into bacteria or yeast with plasmids or viruses and allowing the organisms to reproduce making copies or clones of the DNA fragments.
53. (c) First mammal was cloned by *wilmut* etal (1997) when they successfully produced a cloned baby sheep named Dolly at Roslin Research Institute Scotland.
54. (c) The first genetically modified monkey, a baby rhesus called ANDI.
55. (b) Dolly has nuclear genes from the ewe who supplied the udder cell and mitochondrial genes from the egg cytoplasm of the second ewe.

Critical Thinking Questions

1. (b) A myeloma is a type of cancer associated with abnormal production of irregular antibodies. It occurs in antibody producing cells that have lost their normal control. Clones of the hybrid cell resulting from artificial fusion of a normal antibody producing *B* cell with myeloma cell are called hybridomas.
3. (c) Lymphocytes cells are mixed with myeloma cells (tumour cells isolated from cancer of bone marrow). Lymphocytes and myeloma cells fuse together to form hybridoma cells. These hybridoma cells have capacity of antibody production and rapid cell division.
5. (a) Insecticide producing gene of Bacillus thuringiensis has been transferred to cotton and other plants like corn, rice. It has helped the cotton growing farmers to some crore of rupees required for protection against boll worm infestation.
8. (a) Adenovirus is non-enveloped dsDNA virus which cause respiratory diseases. It is used to transfer a gene of interest in animal cells.
10. (a) The first transgenic cow, Rosie, produced human protein-enriched milk containing 2.4 gm protein per litre. The milk contained human alpha-lactalbumin and was nutritionally more balanced product for human babies than natural cow milk.

Assertion and Reason

1. (b) *Agrobacterium tumefaciens*, a pathogen of several dicot plants can transfer a piece of DNA called (T-DNA) to transform normal plant cell into a tumor cell. Ti plasmid of *Agrobacterium tumefaciens* and Ri plasmid of *A. rhizogens* are best known plant cloning vectors. *Agrobacterium* is natural genetic engineer of plants.
2. (b)
3. (a) Genetically modified tomato is called flavr savr with delayed ripening. By the use of antisense RNA technology the enzyme polygalacturonase, which causes damage to pectin is deactivated and the tomato is kept fresh for longer duration.
4. (a) Palmiter and Brinster (1981) developed the first transgenic animal 'supermouse'. It has human growth hormone gene. It has been intoroduced and expressed. Size of supermouse is big in size than the normal mouse.

Biotechnology and its Application

SET Self Evaluation Test

1. Product of biotechnology is **[MP PMT 2009]**
   (a) Transgenic crop (GM crop)
   (b) Humulin
   (c) Biofertilizer
   (d) All of these
2. Who was first to develop artificial skin by tissue culture **[MP PMT 2010]**
   (a) Harrison (b) Carrel
   (c) Maximov (d) Engene-Bell
3. Genetically engineered bovine (bST), sometimes calles rbST (recombinant bovine somatotropin) or rbGH (recombinant bovine growth hormone) are used in the **[AIIMS 2009]**
   (a) Therapeutic drugs (b) Agriculture
   (c) Dairy industry (d) DNA fingerprinting
4. The enzyme TPA is used to **[MH CET 2015]**
   (a) Maintain turgor pressure (b) Strengthen tissues
   (c) Increase plasma (d) Dissolve blood clots
5. Which transgenic animal have been given human genes for organ transplantation into human without risk of rejection **[MP PMT 2011]**
   (a) Cow (b) Sheep
   (c) Goat (d) Pig
6. Which of the following enzymes are used for manufacturing detergents
   (a) Proteases (b) Glucoamylases
   (c) Amylases (d) Lactases
7. Maximum number of existing transgenic animals is of **[CBSE PMT (Pre.) 2011; MH CET 2015]**

   Or

   Transgenic rates, rabbits, pigs, sheep, cows and fish have produced although over 95% of all existing transgenic animals are **[NCERT]**
   (a) Pig (b) Fish
   (c) Mice (d) Cow
8. The clot formation can be prevented by treatment with _____ in gene therapy **[MHCET 2015]**
   (a) DNase (b) Recombinant vaccine
   (c) TPA (d) TGF-B
9. Match List I with List II and select the correct option

List I		List II	
A.	*Bacillus thuringiensis*	1.	Production of chitinases
B.	*Rhizobium meliloti*	2.	Scavenging of oil spills
C.	*Escherichia coli*	3.	Incorporation of 'nif' gene
D.	*Pseudomonas putida*	4.	Production of Bt toxin
E.	*Trichoderma*	5.	Production of human insulin

[NCERT; Kerala PMT 2008]

   (a) A – 2, B – 4, C – 1, D – 5, E – 3
   (b) A – 2, B – 4, C – 5, D – 1, E – 3
   (c) A – 4, B – 3, C – 5, D – 2, E – 1
   (d) A – 3, B – 4, C – 5, D – 1, E – 2
   (e) A – 4, B – 2, C – 5, D – 3, E – 1
10. Maturation of genetically engineered proinsulin into insulin takes place after **[MP PMT 2011]**
    (a) Joining of C - peptide
    (b) Removal of C - peptide
    (c) Removal of Disulphide bridge
    (d) All of the above
11. Golden rice is a promising transgenic crop. When released for cultivation, it will help in **[CBSE PMT 2006; Odisha JEE 2012; AIPMT 2015]**
    (a) Herbicide tolerance
    (b) Producing a petrol-like fuel from rice
    (c) Alleviation of vitamin A deficiency
    (d) Pest resistance
12. An example of gene silencing is **[VITEEE 2006]**
    (a) *Bt* Cotton
    (b) Flavr savr tomato
    (c) Transgenic Maize
    (d) Transgenic rice

AS Answers and Solutions

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

3. (c) These hormones are used in the dairy industry, when injected into cows would increase their milk production.
4. (d) TPA (Tissue plasminogen activator) enzyme is specifically used in heart patients to dissolve blood clots.
6. (a) Proteases or proteolytic enzymes obtained from *Aspergillus oryzae* and *Bacillus subtilis* and are used in detergents to remove some proteinaceous stains on clothes.

* * *