CHAPTER – 12

BIOTECHNOLOGY AND ITS APPLICATIONS

Biotechnology mainly deals with industrial-scale production of biopharmaceuticals and biologicals using genetically modified microbes, fungi, plants and animals, its applications include:

- Therapeutics
- Diagnostics
- Genetically modified crops for agriculture
- Processed food
- Bioremediation
- Waste water treatment and
- Energy production

Three critical research areas of biotechnology are:

(i) Providing the best catalyst in the form of improved organism usually a microbe or pure enzyme.

(ii) Creating optimal conditions through engineering for a catalyst to act, and

(iii) Downstream processing technologies to purify the protein/organic compound.

Application of Biotechnology in Agriculture

Food production can be increased by:

(i) Agro-chemical based agriculture

(ii) Organic agriculture

(iii) Genetically engineered crop based agriculture

Genetically Modified Organisms: organisms like bacteria, fungi, plants and animals whose genes have been altered by manipulation is called genetically modified organisms (GMO).

Genetic modification made plants and crops:

- More resistant to abiotic factors
- Reduced the use of chemical-based fertilisers
- Increased nutritional value of food. E.g. golden rice, i.e., Vitamin 'A' enriched rice
- helped to reduce post harvest losses.
- increased efficiency of mineral usage by plants
- Additionaly, GM has been used to create tailor-made plants to supply alternative resources to industries, in the form of starches, fuels and pharmaceuticals.

Application of Biotechnology in the production of Pest-resistant plants

Pest-resistant plants reduce the need for insecticides. *Bacillus thuringiensis* is a bacterium that produces Bt toxin. The Bt toxin gene was cloned from bacteria and produced in plants to give insect resistance without the use of pesticides, thereby creating a bio-pesticide.

Bt cotton, Bt corn, rice, tomato, potato, and soyabean are a few examples.

Bt Cotton-An overview: *Bacillus thuringiensis* produces proteins that kill insects such as **lepidopterans, coleopterans (beetles), and dipterans (flies, mosquitoes).**

B. thuringiensis generates crystals containing a poisonous insecticidal protein. This toxic protein exists in bacteria as inactive protoxins, but when an insect consumes the inactive form due to the alkaline pH of the gut, it converts into an active form of toxin and binds to the surface of midgut epithelial cells, creating pores that cause cell swelling and lysis, and eventually death of the insect.

The *Bt. thuringiensis* gene has been introduced into a variety of agricultural species, including cotton, maize, and rice. The toxin is encoded by the *cry* gene. Cotton bollworms are controlled by the protein coded by the genes *crylAb* and *cryIIAb*, while corn borer is controlled by *cryIAb*.

Brush Up Your Understanding

Q1. Which of the following bacteria is used in genetic engineering?
(a) Lactobacillus *(b) Agrobacterium*
(c) Salmonella (d) All of the above

S1. **(b)**

Q2. Which among the following Bt crop is extensively being grown by the Indian farmers?
(a) Maize (b) Cotton
(c) Rice (d) Wheat

S2. **(b)**

Pest Resistant Plants

Meloidegyne incognitia, a nematode, infects the roots of tobacco plants and reduces output. The method of RNA interference can be used to prevent the invasion of these worms (RNA*i*). RNA*i* is found in all eukaryotic creatures and serves as a cellular defence mechanism by silencing certain mRNA molecules **via complementary dsRNA** molecules that bind to and impede mRNA translation.

The source of complementary dsRNA may be from an infection by viruses having RNA genomes or mobile genetic elements (transposons) that replicate through RNA intermediate.

Nematode-specific genes were introduced into host plant using *Agrobacterium* vectors. The parasite could not survive in a transgenic host expressing specific interfering RNA.

Application of Biotechnology in Medicine

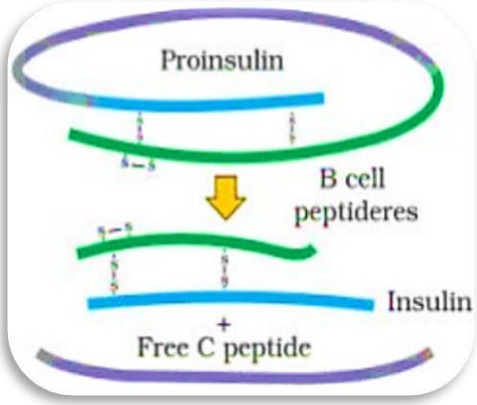
The rDNA technology procedures have had a huge influence on healthcare by allowing for the mass manufacturing of safer and more effective medicinal medications. **Currently, over 30 recombinant medicines have been authorised for human use worldwide. In India, 12 of these are currently on the market.**

Genetically Engineered Insulin: An overview

Adult-onset diabetes can be managed by using insulin at regular intervals. The extraction of insulin from animals was the primary source of this insulin. Insulin may now be produced from bacteria utilising biotechnology processes.

Previously, insulin was extracted from the pancreas of slaughtered cattle and pigs, but insulin derived from these sources causes allergy or other sorts of responses to the foreign protein.

Insulin is made up of two short polypeptide chains, A and B, that are joined together by disulphide bridges.

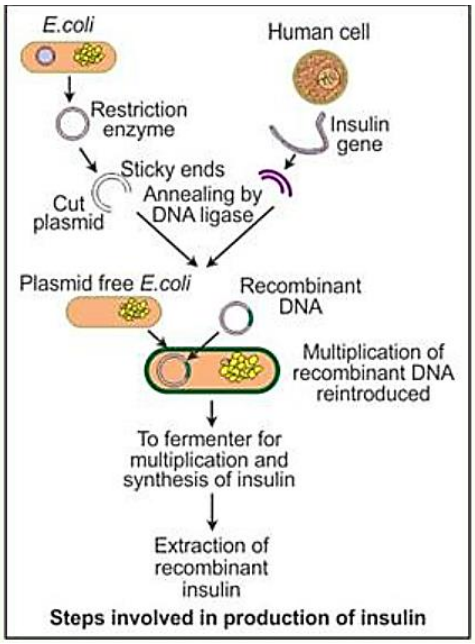


Structure of Human Insulin

In humans, insulin is synthesised as a prohormone that has an additional stretch known as C-peptide that is missing in mature insulin.

The biggest problem in producing insulin with the rDNA approach was assembling insulin into a mature state.

In 1983, an American corporation, Eli Lilly, synthesised two DNA sequences matching to the A and B chains of human insulin and put them into *E.coli* plasmids to create insulin chain. Chain A and Chain B were created independently, extracted and then combined to make human insulin by forming disulphide linkages.



Synthesis of Human Insulin

Brush Up Your Understanding

Q1. Which of the following field has used the techniques of biotechnology the most?
(a) Agriculture (b) Medicine
(c) Both (a) and (b) (d) None of the above

S1. **(b)**

Q2. *Meloidegyne incognitia*, a nematode, infects the roots of.

(a) Cotton plant (b) Tobacco plant
(c) Money plant (d) All of the above

S2. (b)

Gene Therapy: It is a collection of methods for correcting a gene abnormality that has been identified in a kid or embryo. In the case of a hereditary illness, this procedure is used. Here genes are inserted into a person's cells and tissues to treat a disease. Correction of a genetic defect involves delivery of a normal gene into the individual or embryo to take over the function of and compensate for the non-functional gene.

The first clinical gene therapy was performed on a four-year-old child with adenosine deaminase (ADA) deficiency in 1990. This condition is caused by the loss of the adenosine deaminase gene, which is required for the immune system to operate. The disorder is caused due to the deletion of the gene for adenosine deaminase. In some children ADA deficiency can be cured by bone marrow transplantation; in others it can be treated by enzyme replacement therapy, in which functional ADA is given to the patient by injection. This method is not completely curative hence, lymphocytes from the patient's blood are cultured in culture media outside the body then the lymphocytes are implanted with functioning ADA cDNA and returned to the patient. In this procedure, such genetically altered lymphocytes must be infused on a regular basis. If a gene derived from bone marrow cells that produces ADA is injected into cells during the early embryonic stages, it might lead to a permanent cure.

Molecular Diagnosis: Conventional methods of diagnostics, such as serum or urine analysis, are incapable of detecting disease-causing bacteria or viruses early. The following methods can be used for early diagnosis:

(i) rDNA technology: The method uses the extraction of a gene, cloning it and then amplifying it by PCR. The method uses polymerases, ligases, vectors, and hosts.

(ii) PCR : Symptoms of illness develop only after the pathogen concentration is sufficiently raised. Amplification of nucleic acid by PCR can identify low concentrations of bacteria and viruses. The technique detects gene mutations in cancer patients. In suspected AIDS patients, PCR is regularly employed to detect HIV. The PCR method can also be used to detect genetic disorders also.

(iii) ELISA: The antigen-antibody interaction concept underpins ELISA. Pathogen infection can be identified by identifying antigens such as proteins, glycoproteins, and so on, or by detecting antibodies synthesised against the pathogen.

Transgenic Animals

Transgenic animals are those that have had their DNA manupilated in order to possess and express a foreign gene. There have been transgenic mice, rats, rabbits, pigs, sheep, cows, and fish developed.

What is the need of creation of transgenic animals?

- To study gene regulation and its effect on normal functions of the body.
- Understand how the genes contribute to the development of a disease.
- Transgenic animals help in production of useful biological products. E.g. human protein (α-1-antitrypsin) used to treat emphysema.
- The first transgenic cow, Rosie, produced human protein-enriched milk (alpha-lactalbumin – 2.4 gm / litre).
- Such animals are useful in the testing of vaccines before human trials.

Note: Today transgenic models exist for many human diseases such as cancer, cystic fibrosis, rheumatoid arthritis and Alzheimer's.

Note: Transgenic mice are being used to test the safety of the polio vaccine.

Brush Up Your Understanding

Q1. The technique that can be used for the early diagnosis of a disease is.

(a) ELISA (b) Recombinant DNA technology
(c) PCR (d) All of the above

S1. (d)

Q2. Rosie was a transgenic.

(a) Sheep (b) Cow
(c) Mice (d) All of the above

S2. (b)

Ethical Issues

The Indiagovernment has established bodies such as the GEAC (Genetic Engineering Approval Committee) to make judgements on the legitimacy of GM research and the safety of integrating GM-organisms into public services.

Biopatent: A patent is government-granted protection that allows an inventor to restrict others from commercialising his creation.

Through the US Patent and Trademark Office, an American corporation obtained patent rights on Basmati rice in 1997. This 'new' variety of Basmati had actually been derived from Indian farmer's varieties. Indian Basmati was crossed with semi-dwarf varieties and claimed as an invention or a novelty. The patent extends to functional equivalents, implying that other people selling Basmati rice could be restricted by the patent. This enabled the business to offer a "new kind of Basmati" in the United States and elsewhere.

Biopiracy: It is the phrase used to describe the utilisation of bio-resources by multinational corporations and other organisations without legal licence from the nations and people involved and without compensation.

SUMMARY

The use of biology to develop technologies and products for the welfare of human beings is known as biotechnology. It has various applications in different fields such as therapeutics, diagnostics, processed food, waste management, energy production, genetically modified crops etc.

Biotechnology has different application in agriculture. It can be used in agro-chemicals, organic agriculture, and genetically engineered crop-based agriculture. It can be used to produce genetically modified organisms. The most important application in the field of biotechnology is the formation of pest resistant plants like *Bacillus thuringiensis* produces certain proteins that can kill insects such as lepidopterans, coleopterans, and dipterans.

Biotechnology has contributed a lot in medicine industry. The use of biotechnology in medicine is known as medicinal biotechnology. They provide methods for the formation of genetically modified insulin known as humulin. This helps in treatment of large number of diabetes patients.

The correction of gene defects is known as gene therapy. A normal gene is inserted into the individual or in an embryo to replace the abnormal gene.

Biotechnology helps in disease diagnosis by various techniques such as ELISA, PCR, and recombinant DNA technology.

Animals that have their DNA manipulated are known as transgenic animals. They can be used to study how genes are responsible for the development of various diseases. They can be used to manufacture chemicals that are useful. They can also be used for testing of drugs and vaccines.

Genetic Engineering Approval Committee is a committee set up by the Indian Government to oversee all decisions regarding GM research and the safety of GMOs for public use.

IMPORTANT POINTERS

- Specific Bt toxin genes were isolated from Bacillus thuringiensis and incorporated into the several crop plants such as cotton.
- The toxin is coded by a gene *cryIAc* named cry.
- RNA interference involves silencing of a specific mRNA due to a complementary dsRNA molecule that binds to and prevents translation of the mRNA (silencing).
- The first clinical gene therapy was given in 1990 to a 4-year old girl with adenosine deaminase (ADA) deficiency.
- Recombinant DNA technology, Polymerase Chain Reaction (PCR) and Enzyme Linked Immuno-sorbent Assay (ELISA) are some of the techniques that serve the purpose of early disease diagnosis.
- Biological product alpha 1 anti-trypsin is used for the treatment of emphysema.
- The Indian Government has set up organisations such as GEAC (Genetic Engineering Approval Committee), which will make decisions regarding the validity of GM research and the safety of introducing GM-organisms for public services

MULTIPLE CHOICE QUESTIONS

Q1. What is the full form of GEAC?
(a) Genetic Engineering Approval Committee
(b) General Engineering Approval Committee
(c) Global Engineering Approval Committee
(d) Genius Engineering Approval Committee

Q2. Earlier insulin was extracted from.
(a) Slaughtered cattle
(b) Slaughtered pigs
(c) Slaughtered cats
(d) Both (a) and (b)

Q3. How many polypeptide chains are present in insulin?
(a) 1 (b) 2
(c) 3 (d) 4

Q4. Which of the following bond is present between the polypeptide Chains of insulin?
(a) Hydrogen bonds
(b) di sulphide bridge
(c) Double bond
(d) Triple bond

Q5. Which of the following will not present in mature insulin?
(a) A-peptide (b) B-peptide
(c) C-peptide (d) D-peptide

Q6. How is a genetic defect corrected?
(a) by the delivery of a normal gene into the individual or foetus to take over the function of and compensate for the non-functional gene
(b) by the delivery of a normal gene into the individual or embryo to take over the function of and compensate for the non-functional gene
(c) by the delivery of a DNA molecule into the individual or embryo to take over the function of and compensate for the non-functional gene
(d) by the delivery of an RNA into the individual or embryo to take over the function of and compensate for the non-functional gene

Q7. When was the first gene therapy implemented?
(a) 1970 (b) 1980
(c) 1990 (d) 2000

Q8. What is biopiracy?
(a) it refers to the use of chemical resources by multinational companies and other organisations without proper authorisation from the countries and people concerned without compensatory payment
(b) it refers to the use of bioresources by multinational companies and other organisations without proper authorisation from the countries and people concerned without compensatory payment
(c) it refers to the use of plant resources by multinational companies and other organisations without proper authorisation from the countries and people concerned without compensatory payment
(d) it refers to the use of conventional resources by multinational companies and other organisations without proper authorisation from the countries and people concerned without compensatory payment

Q9. Which of the following is the first human hormone produced by Recombinant DNA technology?
(a) Thyroxin (b) Insulin
(c) Adrenalin (d) Oxytocin

Q10. Where is ADA produced inside the body?
(a) Erythrocytes (b) Thrombocytes
(c) Lymphocytes (d) Leucocytes

Q11. What is the source of *Ti* plasmid that is used for the production of transgenic?
(a) Clostridium (b) Agrobacterium
(c) Staphylococcus (d) None of the above

Q12. Which of the following is the correct form of GMO?
(a) Genetically Modified Organisms
(b) Globally Modified Organisms
(c) Genetically Made Organisms
(d) None of the above

Q13. What is/are the advantages of genetic modification?
(a) makes crops more tolerant to abiotic stresses
(b) reduces reliance on chemical pesticides
(c) helps to reduce post-harvest losses
(d) All of the above

Q14. Which of the following in *Bascillus thuringiensis* skills tobacco budworm armyworms l flies and mosquitoes?
(a) An enzyme (b) A protein
(c) A toxin (d) None of the above

Q15. Which of the following is responsible for converting the inactive *Bt* toxin into active form inside an insect?
(a) Acidic pH of the gut of the insect
(b) Neutral pH of the gut of the insect
(c) Alkaline pH of the gut of the insect
(d) None of the above

Q16. Where does the activated toxins inside the body of the insect bind that eventually causes the death of the insect?
(a) Mid-gut of endothelial cells
(b) Mid-gut of the epithelial cells
(c) Mid-gut of the mesothelial cells
(d) All of the above

Q17. Which of the following genes codes for *Bt* toxin?
(a) cryIAc (b) cry
(c) cryI (d) Both (a) and (b)

Q18. Which of the following genes control cotton boll worms?
(a) *cryIAc* (b) *cryIIAb*
(c) *cryIAb* (d) Both (a) and (b)

Q19. What are transposons?
(a) They are also called as jumping genes
(b) They can change their position within a genome
(c) They are very useful in research
(d) All of the above

Q20. Which of the following strategy was adopted to reduce *Meloidegyne incognitia* infestation in tobacco plants?
(a) DNA interference
(b) RNA interference
(c) Protein interference
(d) Transposons interference

Q21. RNA interference involves the silencing of which of the following RNA to prevent nematode infestation in tobacco plants?
(a) hn-RNA
(b) sn-RNA
(c) m-RNA
(d) All of the above

Q22. How many recombinant products have been approved for human use worldwide?
(a) 30 (b) 29
(c) 28 (d) 27

Q23. What were the main challenge that the scientists faced in the production of insulin using r-DNA techniques?
(a) Getting insulin assembled in a mature form
(b) Development of polypeptide chains of insulin
(c) Development of the C-peptide
(d) All of the above

Q24. The diagnostic test used for identification of AIDS is.
(a) Western Blot (b) Southern Blot
(c) ELISA (d) Widal test

Q25. Normally how is the presence of a pathogen inside a body suspected?
(a) Early detection
(b) Symptoms
(c) Diagnostic tests
(d) All of the above

Q26. Which of the following technique can be used to detect very low concentration of bacteria or virus inside the body?
(a) ELISA (b) PCR
(c) WIDAL test (d) Blood test

Q27. Which of the following test is based upon antigen antibody reaction?
(a) COVID 19 test
(b) CBC test
(c) ELISA test
(d) Southern blot

Q28. What are transgenic animals?
(a) They are the animals that have their DNA manipulated so that they possess and express an extra foreign gene
(b) They are the animals that have their DNA removed so that they possess and express an extra foreign gene
(c) They are the animals that have their RNA manipulated so that they possess and express an extra foreign gene
(d) They are the animals that have their protein manipulated so that they possess and express an extra foreign gene

Q29. What is the advantage of producing transgenic animals?
(a) Helps in study of normal physiology and development
(b) Helps in study of diseases
(c) Helps in the production of biological products
(d) All of the above

Q30. Which of the following is used to treat emphysema?
(a) Beta 1 anti-trypsin
(b) Alpha 1 anti-trypsin
(c) Gamma 1 anti-trypsin
(d) All of the above

Q31. Which among the following was the first transgenic cow?
(a) Jersey (b) Rosie
(c) Dolly (d) None of the above

Q32. What is the advantage of transgenic mice?
(a) they are successful and reliable
(b) can be used to test the safety of polio vaccine
(c) they can replace the use of monkeys to test the safety of batches of vaccines
(d) All of the above

ASSERTION AND REASON

Direction: in the following questions, a statement of assertion (A) is followed by a statement of reason (R). Choose the correct option among a, b, c and d.

Q1. **Assertion (A):** RNAi takes place in all the eukaryotic organism as a method of cellular defense.
Reason (R): Complementary ds RNA molecule binds to specific mRNA and prevents its translation.
(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A)
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A)
(c) Assertion (A) is true but reason(R) is false
(d) Assertion (A) is false but reason(R) is true

Q2. **Assertion (A):** Bt toxin are protein crystals containing insecticidal protein
Reason (R): *Bascillus thuringiensis* forms these protein crystals throughout continuously during their growth period.
(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A)
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A)
(c) Assertion (A) is true but reason(R) is false
(d) Assertion (A) is false but reason(R) is true

Q3. **Assertion (A):** ELISA can enable very easy detection of infection through antigen antibody reaction.
Reason (R): It is a nucleic acid based diagnostic tool that can confirm the prescence of infectious microbe at early stages.

Q4. **Assertion (A):** Animals that have had their DNA manipulated to possess and express an extra (foreign) gene are known as transgenic animals.
Reason (R): Transgenic rats, rabbits, pigs, sheep, cows and fish are animals that have been produced by this technology.
(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A)
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A)
(c) Assertion (A) is true but reason(R) is false
(d) Assertion (A) is false but reason(R) is true

TRUE AND FALSE

Q1. Transgenic animals serve as models for human diseases so that investigation of new treatments for diseases is made possible.

Q2. Biological product α-1-antitrypsin is used for the treatment of cancer.

Q3. Correction of a genetic defect involves delivery of a normal gene into the individual or embryo to take over the function of and compensate for the non-functional gene.

Q4. The Bt toxin protein exist as inactive protoxins but once an insect ingest the inactive toxin, it is converted into an active form of toxin due to the alkaline pH of the gut which solubilise the crystals.

PRACTICE QUESTIONS (MCQ)

Q1. Production of a human protein in bacteria by genetic engineering is possible because.
(a) Bacterial cell can carry out the RNA splicing reactions
(b) The mechanism of gene regulation is identical in humans and bacteria
(c) The human chromosome can replicate in bacterial cell
(d) The genetic code is universal

Q2. Transgenic tobacco which is developed through RNA interference, prevents the infection of.
(a) A nematode - *Meloidegyne incognitia*
(b) A bacterium - *Pseudonomonas putida*
(c) A fungi - *Tricoderma*
(d) An insect

Q3. The first transgenic cow was 'Rosie', produces.
(a) Human protein-enriched milk (α-lactabumin)
(b) Human protein α-1 antitrypsin rich milk
(c) Human protein enriched milk (insulin)
(d) All the above

Q4. Transgenic mice are being developed for use in.
(a) Testing the safety of polio vaccines before they are used on human
(b) Molecular diagnosis of diseases
(c) Production of human protein enriched milk
(d) Production of human insulin

Q5. *Meloidegyne incognitia* infects the root of which plant?
(a) Potato (b) Soyabean
(c) Tobacco (d) Tomato

Q6. Critical research areas of biotechnology are:
(a) providing the best catalyst in the form of improved organism usually a microbe or pure enzyme.
(b) Creating optimal conditions through engineering for a catalyst to act.
(c) Down stream processing technologies to purify the protein/organic compound.
(d) All the above

Q7. Over 95 percent of all existing transgenic animals are.
(a) Pigs (b) Cows
(c) Fish (d) Mice

Q8. Which one of the following statements are true regarding genetic modifications?
(a) Genetic modifications reduced reliance on chemical pesticides
(b) Genetic modifications has enhanced nutritional value of food.
(c) Genetic modifications made crops more tolerant to abiotic stresses.
(d) All are correct

Q9. Golden rice is enriched in.
(a) Vitamin C (b) Vitamin D
(c) Vitamin A (d) Vitamin E

Q10. The first transgenic cow, which produced human protein enriched milk was named.
(a) Andy
(b) Dolly
(c) Rosie
(d) Dumpy

Q11. Which of the following method of vectorless gene transfer is suitable for plants?
(a) Biolistics method
(b) Micro injection
(c) Liposome mediated
(d) Electroporation

Q12. Bacterium *Bacillus thuringiensis* is widely used in contemporary biology as.
(a) Source of industrial enzyme
(b) Indicator of water pollution
(c) Insecticide
(d) Agent for production of dairy products.

Q13. You have three copies of a particular DNA molecule what technique would you use to make more copies of the molecule?
(a) Gel electrophoresis
(b) Sequencing
(c) PCR
(d) Restriction fragment analysis

Q14. Extraction, purification and packaging of products is collectively known as.
(a) Upstream processing
(b) Distillation
(c) Downstream processing
(d) Genetic engineering

Q15. RNA interference is used for which of the following purposes in the field of biotechnology?
(a) to develop a plant tolerant to abiotic stresses
(b) to develop a pest resistant plant against infestation by nematode
(c) to enhance the mineral usage by the plant
(d) to reduce post harvest losses

Q16. In RNAi, the genes are silenced using.
(a) ds-RNA (b) ss-DNA
(c) ss-RNA (d) ds-DNA

Q17. Which of the following is true for Golden rice?
(a) It is Vitamin A enriched, with a gene from daffodil
(b) It is pest resistant, with a gene from Bacillus thuringiensis
(c) It is drought tolerant, developed using Agrobacterium vector
(d) It has yellow grains, because of a gene introduced from a primitive variety of rice

Q18. The introduction of T-DNA into plants involves.
(a) Allowing the plant roots to stand in water
(b) Infection of the plant by Agrobacterium tumefaciens
(c) Altering the pH of the soil, then heat shocking the plants
(d) Exposing the plants to cold for a brief period

Q19. Some of the characteristics of Bt cotton are.
(a) High yield and production of toxic protein crystals which kill dipteran pests
(b) High yield and resistance to bollworms
(c) Long fibre and resistance to aphids
(d) Medium yield, long fibre and resistance to beetle pests

Q20. The genetic defect - adenosine deaminase (ADA) deficiency may be cured permanently by.
(a) Enzyme replacement therapy
(b) Periodic infusion of genetically engineered lymphocytes having functional ADA cDNA
(c) Administering adenosine deaminase activators
(d) Introducing bone marrow cells producing ADA into cells at early embryonic stages

Q21. Two microbes found to be very useful in genetic engineering are.
(a) Escherichia coli and Agrobacterium tumefaciens
(b) Vibrio cholerae and a tailed bacteriophage
(c) Diplococcus sp. and Pseudomonas sp.
(d) Crown gall bacterium and Caenorhabditis elegans

Q22. Lepidopterans among the following are.
(a) Tobacco budworm (b) Armyworm
(c) Both (a) and (b) (d) None of the above

Q23. Transposons are.
(a) Genetic elements
(b) Mobile genetic elements
(c) Immobile genetic elements
(d) None of the above

Q24. Insulin used for diabetes was earlier extracted from.
(a) Cows (b) Cattle
(c) Pigs (d) Both (b) and (c)

Q25. Eli Lilly that worked on the preparation of insulin for diabetics was an.
(a) Australian company
(b) American company
(c) Indian company
(d) None of the above

Q26. The first clinical gene therapy was given to a.
(a) 2 year old girl (b) 3 year old girl
(c) 4 year old girl (d) 5 year old girl

Q27. Transgenic models for which of the following human diseases are available?
(a) Cystic fibrosis (b) Cancer
(c) Alzheimer's (d) All of the above

Q28. Number of rice varieties in India account for.
(a) 100,000 (b) 200,000
(c) 300,000 (d) 400,000

Q29. Rosie is a transgenic.
(a) Mice (b) Rabbit
(c) Cow (d) None of the above

Q30. A test that is based on the principle of antigen and antibody interaction is.

(a) PCR (b) Widal test
(c) ELISA (d) CVC

ASSERTION AND REASON

Direction: in the following questions, a statement of assertion (A) is followed by a statement of reason (R). Choose the correct option among a, b, c and d.

Q1. **Assertion(A):** At present, about 30 recombinant therapeutics have been approved for human-use.
Reason (R): In mammals, including humans, insulin is synthesised as a pro-hormone.
(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A)
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A)
(c) Assertion (A) is true but reason(R) is false
(d) Assertion (A) is false but reason(R) is true

Q2. **Assertion (A):** Gene therapy is a collection of methods that allows correction of a gene defect that has been diagnosed in a child/embryo.
Reason (R): The first clinical gene therapy was given in 1890 to a 7-year old girl.
(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A)
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A)
(c) Assertion (A) is true but reason(R) is false
(d) Assertion (A) is false but reason(R) is true

Q3. **Assertion (A):** Medicines required to treat certain human diseases can contain biological products, but such products are often expensive to make.
Reason (R): Transgenic animals that produce useful biological products can be created by the introduction of the portion of DNA (or genes) which codes for a particular product such as human protein (α-1-antitrypsin) used to treat emphysema.
(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A)
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A)
(c) Assertion (A) is true but reason(R) is false
(d) Assertion (A) is false but reason(R) is true

Q4. **Assertion (A):** Polymerase Chain Reaction (PCR) and Enzyme Linked Immuno-sorbent Assay (ELISA) are some of the techniques that serve the purpose of early diagnosis.
Reason (R): Insulin consists of two short polypeptide chains: chain A and chain B, that are linked together by disulphide bridges.
(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A)
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A)
(c) Assertion (A) is true but reason(R) is false
(d) Assertion (A) is false but reason(R) is true

SOLUTIONS MULTIPLE CHOICE

S1. **(a)** the committee decides for research and market launch of any genetically modified product

S2. **(d)** insulin from any animal source causes some patients to develop an allergy or other types of reactions to the foreign protein

S3. **(b)** insulin has two short polypeptide chains chain A and chain B

S4. **(b)** the A and the B polypeptide chains of insulin are connected by di-sulfide linkages

S5. **(c)** in mammals including human's insulin is synthesized as a prohormone which contains an extra stretch called the c-peptide this C-peptide is not present in mature insulin

S6. **(b)** diseases are corrected by inserting correct genes into a person's cells and tissues

S7. **(c)** the first clinical gene therapy was given to a 4-year-old girl who was suffering from adenosine deaminase deficiency

S8. **(b)** traditional knowledge related to bi resources can be exploited to develop modern applications and can also be used to save time effort and expenditure during that commercialization

S9. **(b)** in 1983 Eli Lilly, an American company prepared the first human hormone insulin

S10. **(c)** the first clinical gene therapy was given in 1990 to a 4-year-old girl suffering from ADA deficiency

S11. **(b)** Source of *Ti* plasmid is Agrobacterium.

S12. **(a)** plants bacteria fungi and many animals whose genes have been altered by manipulation are called as generic genetically modified organisms

S13. **(d)** Genetic modification has been used to create tailor made plants to supply alternative resources to industries in the form of starches, fuels and Pharmaceuticals

S14. **(b)** this protein is very effective in killing certain worms like bud worms. armyworms etc.

S15. (c) *Bt* toxin exists as inactive prototoxin, but once an insect ingests the inactive toxin, it is converted into an active form of toxin due to the alkaline pH of the gut

S16. (b) activated toxins bind to the surface of the midgut epithelial cell and creates pores that causes swelling and lysis of the cell and causes the death of the insect

S17. (d) the choice of genes depends on the crop and the targeted pest as most of the *Bt* toxin are insect - group specific

S18. (d) the *Bt* toxins are very insect specific, cry1Ab controls corn borers while *cryIAc* and *cryIIAb* controls cotton ball worms

S19. (d) transposons are mobile genetic elements that are very useful in to research and development Industry

S20. (b) RNA interference is a novels strategy that was adopted to prevent this infestation. RNA interference takes place in all eukaryotic organisms as a method of cellular defence

S21. (c) the method of RNA interference is based on the silencing of a specific m-RNA due to a complementary double stranded RNA molecule that binds to and prevents translation of the m-RNA

S22. (a) Recombinant therapeutic do not induce and wanted immunological responses as is common in case of similar products isolated from non-human's sources, till now 30 recombinant therapeutics have been approved for human use worldwide

S23. (a) The above issue was also solved by the scientists as they prepared two DNA sequences corresponding to A and B the polypeptide chains of insulin and introduced them into *E.coli* to produce insulin chains. The chains were combined by creating di sulphide bonds tp create human insulin.

S24. (c) ELISA stands for enzyme linked immune sorbent assay, and is used for detection of AIDS

S25. (b) using conventional methods of diagnosis early detection is not possible, recombinant DNA technology, PCR can be used for the purpose of early diagnosis but presence of a pathogen is normally suspected only when the pathogen has produced a disease symptom

S26. (b) PCR can be used for the detection of very low concentration of bacteria or virus by the amplification of the nucleic acids

S27. (c) Elisa is based on the principle of antigen antibody interaction infection by pathogen can be detected by the presence of antigens or by detecting the antibody synthesized against pathogens

S28. (a) transgenic rats, rabbits, pigs, sheep, cows and fishes are some examples of transgenic animals

S29. (d) transgenic animals are very useful in research, other than there they are very useful in development of vaccines and very useful in chemical safety testing

S30. (b) Alpha 1 anti-trypsin is a biological product to treat emphysema

S31. (b) in 1997 the first transgenic cow Rosie produced human protein enriched milk that contain the human alpha lactalbumin and was nutritionally a more balanced product for human babies and natural cow milk

S32. (d) Transgenic mice has proved to be a boon in RD industry.

ASSERTION AND REASON

S1. (b)

S2. (c) *B. thuringiensis* forms protein crystals during a particular phase of their growth.

S3. (c) ELISA is based on the principle of antigen-antibody interaction. Infection by pathogen can be detected by the presence of antigens (proteins, glycoproteins, etc.) or by detecting the antibodies synthesised against the pathogen.

S4. (a)

TRUE AND FALSE

S1. (True)

S2. (False) Biological product α-1-antitrypsin is used for the treatment of emphysema.

S3. (True)

S4. (True)

PRACTICE SOLUTIONS

S1. (d) Production of a human protein in bacteria by genetic engineering is possible because the genetic code is universal.

S2. (a) A nematode *Meloidegyne incognitia* infects the roots of tobacco plants which reduce the production of tobacco. The infection can be prevented using RNA interference process which is checked by silencing of specific mRNA due to a complementary ds RNA.

S3. (a) Rosie was the first transgenic cow and it was produced in 1997. The gene for human protein alpha-lactalbumin was introduced in this cow. Thus, the cow could produce protein-enriched milk.

S4. **(a)** transgenic mice are being formed for the use in testing the safety of vaccines before they are used on human beings. These mice are being used to test the safety of polio vaccines.

S5. **(c)** it infects the root of tobacco plant.

S6. **(d)**

S7. **(d)** Transgenic rats, rabbits, pigs, sheep, cows and fish have been produced, althrough 95% of all existing transgenic animals are mice.

S8. **(d)**

S9. **(c)** Golden rice is a variety of rice produced through genetic engineering to biosynthesize beta-carotene, a precursor of vitamin A, in the edible parts of rice.

S10. **(c)** In 1997, the first transgenic cow, Rosie, produced human protein-enriched milk (2.4 grams per litre). The milk contained the human alpha-lactalbumin and was nutritionally a more balanced product for human babies than natural cow-milk.

S11. **(a)** the method is suitable for plants, in this the cells are bombarded with high velocity micro-particles of gold or tungsten coated with DNA, the method is known as biolistics or gene gun.

S12. **(c)** It is used as an insecticide as it can produce toxins.

S13. **(c)** PCR is a gene amplification technique that uses a suitable protocol to generate multiple copies of a particular gene.

S14. **(c)** Downstreaming process helps in the recovery and purification of biosynthetic product. It is mainly used during large scale production of metabolites.

S15. **(b)**

S16. **(a)** RNAi takes place in all eukaryotic organisms as a method of cellular defense. This method involves silencing of a specific mRNA due to a complementary dsRNA molecule that binds to and prevents translation of the mRNA (silencing).

S17. **(a)** Golden rice is vitamin A enriched rice, with a gene from daffodil and is rich in carotene.

S18. **(b)** introduction of t-DNA into the plants causes infection of *Agrobacterium tumefaciens* in the plant and causes crown gall disease.

S19. **(a)** B*acillus thuringiensis* (Bt) is a Gram-positive bacterium that produces crystals during sporulation. These crystals comprise of one or a small number of ~130 kDa protoxins called as crystal proteins and exists as inactive protoxin in the *Bacillus*. These proteins are potent and highly specific insecticides (bollworms).

S20. **(d)** if the gene isolate from marrow cells producing ADA is introduced into cells at early embryonic stages, it could be a permanent cure.

S21. **(a)**

S22. **(c)** strains of *Bacillus thuringiensis* produce proteins that kill certain insects such as lepidopterans (tobacco budworm, armyworm) so it is useful in Biotechnology.

S23. **(b)** The source of complementary RNA in RNA interference could be from an infection by viruses having RNA genomes or mobile genetic elements (transposons) that replicate via an RNA intermediate.

S24. **(d)** Insulin used for diabetes was earlier extracted from pancreas of slaughtered cattle and pigs but insulin from an animal source caused some patients to develop allergy or other types of reactions to the foreign protein.

S25. **(b)** it was an American company.

S26. **(c)** The first clinical gene therapy was given in 1990 to a 4-year old girl with adenosine deaminase (ADA) deficiency.

S27. **(b)** Animals that have had their DNA manipulated to possess and express an extra (foreign) gene are known as transgenic animals. Today transgenic models exist for many human diseases such as cancer, cystic fibrosis, rheumatoid arthritis and Alzheimer's.

S28. **(b)**

S29. **(c)**

S30. **(c)** ELISA is based on the principle of antigen-antibody interaction. Infection by pathogen can be detected by the presence of antigens (proteins, glycoproteins, etc.).

ASSERTION AND REASON

S1. **(b)**

S2. **(c)** The first clinical gene therapy was given in 1990 to a 4-year old girl.

S3. **(a)**

S4. **(b)**