CHAPTER

12 BIOTECHNOLOGY AND ITS APPLICATIONS

Syllabus

➢ ***Application of Biotechnology in health and agriculture :*** *Human insulin and vaccine production, stem cell technology, gene therapy; genetically modified organisms–Bt crops; transgenic animals; Biosafety issues, biopiracy and patents.*

Chapter Analysis

List of Topics		2016		2017		2018
		D	OD	D	OD	D/OD
Biotechnological applications in agriculture	• Bt cotton • Cry gene • Role of *Agrobacterium* as vector in Tobacco plant infestation			1 Q (3 M)	1 Q (1 M)	1 Q (3 M)
Biotechnological applications in Medicine	• Production of artificial insulin • Polymerase chain reaction • RNAi technology • Enzyme replacement therapy	2 Q (3 M)	1 Q (3 M)		1 Q (3 M)	1 Q (1 M)
Transgenic animals	• Advantages of GMO organisms • Transgenic animals	1 Q (3 M)	1 Q (1 M)			
Ethical issues	• Biopiracy			1 Q (1 M)		

- *On the basis of above analysis, it can be concluded that important topics from this chapter are cry genes, Bt cotton plant, steps of production of artificial insulin, role of Agrobacterium as vectors, RNAi technique, PCR, and advantages of GMO to farmers.*

TOPIC-1
Application of Biotechnology in Agriculture and Medicine

Revision Notes

- Biotechnology essentially deals with industrial scale production of biopharmaceuticals using genetically modified microbes, fungi, plants and animals.
- The applications of biotechnology include therapeutics, diagnostics, and genetically modified crops for agriculture, processed food, bioremediation, waste treatment and energy production.

- **Three 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)** Downstream processing technologies to purify the protein / organic compound.

➢ **Biotechnological Applications in Agriculture**

- **Three options for increasing food production are :**
  - **(a)** Agro-chemical based agriculture.
  - **(b)** Organic agriculture.
  - **(c)** Genetically engineered crop-based agriculture.
- The Green Revolution succeeded in tripling the food supply.
- Increased yields have partly been due to the use of improved crop varieties, but mainly due to the use of better management practices and use of agrochemicals (fertilisers and pesticides).
- Genetically Modified Organisms (GMO) or transgenic organisms are the plants, bacteria, fungi and animals whose genes are altered by manipulation.

➢ **Advantages of Genetic Modification in Plants**

- **(a)** It makes crops more tolerant to abiotic stresses (cold,drought, salt, heat, etc).
- **(b)** It helps to reduce post-harvest losses.
- **(c)** It increases efficiency of mineral usage by plants (this prevents early exhaustion of fertility of soil).
- **(d)** It enhances nutritional value of food *e.g*. Vitamin 'A' enriched rice.
- **(e)** GM is used to create tailor-made plants to supply alternative resources to industries in the form of starches, fuels and pharmaceuticals.

➢ **Pest Resistant Plants**

- Pest Resistant Plants reduce the use of chemical pesticide.
- It reduces the need for insecticides *e.g*. Bt cotton, Bt corn, rice, tomato, potato, soyabean, etc.

➢ **Bt Cotton**

- Some strains of *Bacillus thuringiensis* produce proteins that kill insects like coleopterans (beetles), lepidopterans (tobacco, budworm, armyworm) and dipterans (flies, mosquitoes).
- *B. thuringiensis* forms a toxic insecticidal protein (Bt toxin) crystal during a particular phase of their growth. It does not kill the *Bacillus* as it exists as inactive protoxins.
- When an insect ingests the inactive toxin, it is converted into active toxin due to the alkaline pH of the gut which solubilise the crystals.
- The toxin binds to the surface of midgut epithelial cells and creates pores.
- It causes cells to swell and undergo lysis and ultimately leading to the death of the insect.
- Bt toxin genes were isolated from *B. thuringiensis* and incorporated into crop plants such as cotton.
- Most Bt toxins are insect-group specific.
- The toxin is coded by a gene named cry *e.g*. the proteins encoded by the genes *cryIAc* and *cryIIAb* control the cotton bollworms and that of *cryI Ab* controls corn borer.

➢ **Nematode resistance in tobacco plant**

- A nematode *Meloidegyne incognitia* infects the roots of tobacco plants and causes a great reduction in yield.
- RNA interference (RNAi) strategy is used to prevent this infestation.
- RNAi is a method of cellular defense in all eukaryotic organisms.
- It prevents translation of a specific mRNA (silencing) due to a complementary dsRNA molecule.
- The source of this complementary RNA is from an infection by RNA viruses or mobile genetic elements (transposons) that replicate via an RNA intermediate.
- Using *Agrobacterium* vectors, nematode-specific genes (DNA) were introduced into the host plant.
- It produces both sense and anti-sense RNA in host cells.
- These two RNA's being complementary to each other form a double stranded RNA (dsRNA) that initiated RNAi and thus,silenced the specific mRNA of nematode.
- Thus, the parasite cannot survive in a transgenic host expressing specific interfering RNA.

➢ **Biotechnological Applications in Medicine**

- The recombinant DNA technology helps for the mass production of safe and more effective therapeutic drugs.
- The recombinant therapeutics does not induce unwanted immunological responses as is common in case of similar products isolated from non-human sources.
- At present, about 30 recombinant therapeutics have been approved for human-use in the world including India.
- In India, 12 of these are presently being marketed.

➢ **Genetically Engineered Insulin**

- The management of adult-onset diabetes is possible by taking insulin at regular time intervals.
- Now, it is possible to produce human insulin using bacteria.

- Insulin from the pancreas of animals (cattle and pigs) causes allergy or other types of reactions to the foreign protein.
- Insulin consists of two short polypeptide chains (chain A and chain B) that are linked together by disulphide bridges.
- In mammals, insulin is synthesized as a pro-hormone.
- The pro-hormone needs processing before it becomes a fully mature and functional hormone.
- The pro-hormone contains an extra stretch called the C peptide.
- This is removed during maturation into insulin.
- In 1983, Eli Lily an American company prepared two DNA sequences corresponding to A and B chains of human insulin and introduced them in plasmids of *E. coli* to produce insulin chains.
- The chains A and B were produced separately, extracted and combined by creating disulfide bonds to form human insulin.

➢ **Gene Therapy :**

- It is a method to correct a gene defect diagnosed in a child / embryo.
- Here, genes are inserted into a person's cells and tissues to treat a hereditary disease.
- It compensates for the non-functional gene.
- First clinical gene therapy was given in 1990 to a four year old girl with adenosine deaminase (ADA) deficiency.
- This disorder is caused due to the deletion of the gene for *Adenosine deaminase* (the enzyme crucial for the immune system to function).
- This can be cured by bone marrow transplantation or by enzyme replacement therapy (injection of functional ADA) but these approaches are not completely curative.
- In gene therapy, lymphocytes from the patient's blood are grown in a culture.
- Then, a functional ADA cDNA(using a retroviral vector) is introduced into these lymphocytes.
- Then, they are returned to the patient.
- This should be periodically repeated as these cells are not immortal.
- However, if the ADA gene (from bone marrow cells) is introduced into cells at early embryonic stages, it could be a permanent cure.

➢ **Molecular Diagnosis**

- Recombinant DNA technology, PCR and Enzyme Linked Immuno-sorbent Assay (ELISA) are some techniques for early diagnosis.
- The presence of a pathogen is normally suspected only when the pathogen has produced a symptom.
- By this time, the concentration of pathogen will be already very high in the body.
- However, very low concentration of a bacteria or virus can be detected by amplification of their nucleic acid by PCR.
- PCR is used to detect HIV in suspected AIDS patients.
- It is also used to detect mutations in genes in suspected cancer patients.
- It is a powerful technique to identify many other genetic disorders.
- A single stranded DNA or RNA, tagged with a radioactive molecule (probe) is allowed to hybridise to its complementary DNA in a clone of cells followed by detection using autoradiography.
- The clone having the mutated gene will hence not appear on the photographic film, because the probe will not have complementarity with the mutated gene.
- 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 synthesized against the pathogen.

Very Short Answer Type Questions (1 mark each)

AI **Q. 1. Suggest a molecular diagnostic procedure that detects HIV in suspected AIDS patients.**

R **[Foreign Set-I, 2016]**

Ans. PCR and ELISA. 1

Commonly Made Error

- Many students write incorrect name for the diagnostic test for AIDS i.e. they write Widal test, AIDS test, PAP smear test, LISA/ALIZA, etc.

Answering Tip

- Give regular practice in learning the acronyms with understanding.

Q. 2. Why do children cured by enzyme-replacement therapy for adenosine deaminase deficiency need periodic treatment ? U **[Outside Delhi Set-I, 2015]**

Ans. As this therapy does not cure the disease completely it requires periodic treatment. **1**

[CBSE Marking Scheme, 2015]

Detailed Answer :

They need periodic treatment because it is not a completely curative method. In this method, a functional ADA-cDNA is injected into the patient's lymphocytes using a retroviral vector. Since, lymphocytes have a definite life cycle, there is a need for periodic infusion of genetically engineered lymphocytes (having ADA) into the patient. **1**

Q. 3. Mention the chemical change that proinsulin undergoes, to be able to act as mature insulin.
[R] [Delhi/Outside Delhi, 2018]

Ans. Removal of C-peptide (from pro-insulin).
[CBSE Marking Scheme, 2018]

Detailed Answer:
Insulin is synthesized as a pro-hormone, which needs to be processed before it becomes a fully mature and functional hormone. The pro-hormone is a single polypeptide chain with an extra stretch called the C-peptide. This is removed during maturation.

[AI] Q. 4. State the role of C peptide in human insulin.
[R] [Outside Delhi Set-III, 2014]

Ans. C-peptide is an extra stretch of polypeptide. It makes the insulin inactive. **1**

Q. 5. Write the possible source of RNA interference (RNAi) gene. **[R] [Delhi Set-I, Comptt. 2014]**

Ans. The source of RNA gene could be from an infection by viruses having RNA genomes or mobile genetic elements (transposons) that replicate via an RNA intermediate. **1**

Q. 6. What happens when *Meloidogyne incognita* consumes cells with RNAi gene ?
[R] [Delhi Set-I, II, III, 2011]

Ans. Using *Agrobacterium* vectors, the nematode specific genes are introduced into the host plant. The introduction of DNA initiates RNAi and thus silences the specific mRNA of *Meloidogyne incognita*. As a consequence, the parasite can not survive in the transgenic host expressing specific interfering RNA. **1**

Q. 7. Biotechnologists refer to *Agrobacterium tumefaciens* as a natural genetic engineer of plants. Give reasons in support of the statement.
[U] [Outside Delhi, 2011]

Ans. *Agrobacterium tumefaciens* is referred to as the natural genetic engineer of plants because the genes which are carried by its plasmid bring out their effects in various parts of the plants. **1**

Q. 8. Name the specific type of gene that is incorporated in a cotton plant to protect the plant against cotton boll worm infestation.
[U] [Outside Delhi - 2017, Set - II]

Ans. *Cry I Ac / Cry II Ab* **1**
[CBSE Marking Scheme, 2017]

OR

3 The cry genes that code for toxic protein – cry protein, specifically cry II Ab and cry I Ac are incorporated in cotton plants to protect it against cotton boll worm infestation.

[Topper's Answer, 2017]

Q. 9. What are *Cry* genes ? In which organism are they present ? **[R] [Outside Delhi - 2017, Set - I]**

Ans. The genes which code for Bt toxin / Cry proteins (toxic proteins), *Bacillus thuringiensis.*
½ + ½
[CBSE Marking Scheme, 2017]

Answering Tip
- The mechanism of action of Bt-toxin must be explained with reference to "Cry protein". The reason for calling it "cry protein" should also be explained.

Q. 10. List the type of *cry* genes that provide resistance to corn plants and cotton plants respectively against lepidopterans. **[R] [Foreign - 2017, Set - I, II, III]**

Ans. *cryIAc / cryIIAb* - cotton. ½
cryIAb - corn. ½
[CBSE Marking Scheme, 2017]

Q. 11. Bt-toxins are released as inactive crystals in the bacterial body. What happens to it in the cotton boll worm body that it kills the boll worm.
[U] [Outside Delhi - 2017, Set - III]

Ans. It is converted into an active protein (due to alkaline pH of the gut of the boll worm). The toxin binds to midgut cells / create pores / causes cell swelling and lysis that kills the bollworm.
½ + ½ = **1**
[CBSE Marking Scheme, 2017]

Q. 12. Name the technique by which Gene expression can be controlled with the help of RNA molecule.
[R] [CBSE SQP, 2018]

OR

State a method of cellular defense which works in all eukaryotic organisms. **[SQP 2016-17]**

Ans. RNA interference.
[CBSE Marking Scheme, 2018] 1

Commonly Made Error
- RNA Interference is spelt incorrectly by number of students.

[AI] Q. 13. What is Gene therapy ?
[R] [Outside Delhi Comptt. - 2017, Set - II]

Ans. Correction of genetic defect / involves delivery of a normal gene to take over the function of non-functional gene.

[CBSE Marking Scheme, 2017] 1

Q. 14. Why do toxic insecticides proteins secreted by *Bacillus thuringiensis* kill insects ? U [Foreign 2012]

Ans. It is because of Cry proteins produced by the spores of *Bacillus thuringiensis* which are toxic when ingested by some insects. **1**

Short Answer Type Questions-I (2 marks each)

Q. 1. Write the function of –

(i) *Cry 1 AC* gene

(ii) RNA interference (RNA)

R [Outside Delhi Set-I, Comptt., 2015]

Ans. **(i)** It produces inactive pro-toxin in the host cell / produces proteins to control cotton bollworms.

(ii) It produces dsRNA which silences host m-RNA / cellular defence mechanism / prevents infestation by nematodes. **1 + 1**

Commonly Made Error

- Students often write vague answers. Most of them are clueless about RNAi. They explain RNA as Interfering with RNA or interference of RNA with DNA.

AI Q. 2. Why does the Bt toxin not kill the bacterium that produces it but kills the insect that ingests it ?

U [Delhi Set-II, 2014]

Ans. Exists as inactive protoxins. 1
Becomes active in the gut of insect due to alkaline pH.

[CBSE Marking Scheme, 2014] 1

Detailed Answer :

Bt toxin does not kill the bacteria because when it is present in the bacteria, it is in an inactive and crystalline form. It becomes active and toxic when it is consumed by insects such as lepidopterans (armyworm), coleopterans (beetles) and dipterans (flies / mosquitoes) due to alkaline pH in their gut.

2

Q. 3. Explain how Eli Lily an American company produced insulin by recombinant DNA technology. R [Delhi Set-I, II, 2014]

Ans. In 1983, Eli Lily and American company prepared two DNA sequences corresponding to A and B chains of human insulin, introduced them in plasmids of *E. coli* to produce insulin chains. Chains A and B were produced separately, extracted and combined by creating disulfide bonds to form human insulin. **½ × 4 = 2**

Q. 4. What is gene therapy ? Name the first clinical case where it was used. R [Delhi Set-II, 2014]

Ans. **(i)** Collection of methods that allows correction of a gene defect that has been diagnosed in a child / embryo. **1**

(ii) Adenosine deaminase (ADA) deficiency. **1**

[CBSE Marking Scheme, 2014]

Detailed Answer :

Gene therapy is the method of inserting genes into an individual 's cell or tissue to cure various genetic disorders. It is used to replace a defective gene with a functional one. The first gene therapy method was used to cure the adenosine deaminase deficiency. **2**

Q. 5. Why is proinsulin called so ? How is insulin different from it ?

R [Outside Delhi Set-I, II, III, 2013]

Ans. It is like a proenzyme or prohormone. It contains an extra stretch of C-peptide. It needs to be processed to become fully mature and functional hormone like insulin. **2**

Q. 6. Write the function of adenosine deaminase enzyme. State the cause of ADA deficiency in humans. Mention a possible permanent cure for a ADA deficiency patient.

R [Delhi Set-I, II, III, 2013]

Ans. Adenosine deaminase enzyme is involved in purine metabolism. It is needed for the breakdown of adenosine from food. The disease is caused by a mutation in a gene on chromosome 20. The gene codes for the enzyme ADA. It is an inherited disorder that damages the immune system.

Treatment : (i) Bone marrow transplantation.

(ii) Transfusion of RBC.

If the gene isolated from bone marrow cells producing ADA is introduced in to cells at early embryonic stages, it could be a permanent cure.

½ + 1 + ½ = 2

Q. 7. (i) State the role of DNA ligase in biotechnology.

(ii) What happens when *Meloidogyne incognita* consumes cells with RNAi gene ?

R [Outside Delhi Set-III, 2012]

Ans. **(i)** Linking of DNA fragment is done by DNA ligase / linking of Okazaki fragments or discontinuous synthesis fragments / linking of desired gene with plasmid to form recombinant DNA.

(Any one) 1

(ii) Specific mRNA of the nematode silenced, parasite dies. **½ + ½**

[CBSE Marking Scheme, 2012]

Detailed Answer :

(i) The linking of antibiotic resistance gene with the plasmid vector became possible with the enzyme DNA ligase, which acts on cut DNA molecules and

joins their ends. This makes a new combination of circular autonomously replicating DNA created in vitro and is known as recombinant DNA.

(ii) When *Meloidogyne incognita* (parasite) consumes cells with RNAi gene, parasite cannot survive and this prevents infestation. The introduced RNAi gene DNA forms both sense and anti-sense RNA. Two strands being complementary to each other bind and form ds RNA, leading to RNAi. Thus, the mRNA of nematode is silenced and the parasite cannot survive there. **2**

Q. 8. (i) Mention the cause and the body system affected by ADA deficiency in humans.

(ii) Name the vector used for transferring ADA-DNA into the recipient cells in humans. Name the recipient cells. U **[Outside Delhi Set-II, 2012]**

Ans. **(i)** Defective gene not producing ADA, immune system is affected. ½ + ½

(ii) A retroviral vector is used. Recipient cells are lymphocytes. ½ + ½

[CBSE Marking Scheme, 2011]

AI **Q. 9. Why does a patient of ADA-deficiency requires repeated infusion of genetically engineered lymphocytes ? Suggest a possible permanent remedy.** R **[Outside Delhi Comptt., 2011]**

OR

Why is the introduction of genetically engineering lymphocytes into a ADA deficiency patient not a permanent cure ? Suggest a possible permanent cure. [CBSE SQP 2013, 2010]

OR

Why is the introduction of genetically engineered lymphocytes into an ADA deficiency patient not a permanent cure ? Suggest a possible permanent cure. U **[Delhi Set-I, 2010]**

Ans. **(i)** ADA patients lacks functional T-lymphocytes and so fails to fight infectious pathogens.

(ii) The therapy includes reactivation of patient's immune system by introduction of functional ADA gene.

(iii) The cells are not immortal and requires repeated infusions.

(iv) Introduction of ADA gene into early embryonic stages is the permanent cure.

[CBSE Marking Scheme, 2011]

Detailed Answer :

Adenosine deaminase (ADA) deficiency is associated with Severe Combined Immuno Deficiency (SCID).

(i) ADA is very crucial for the immune system to function. The deficiency of ADA causes severe combined immuno deficiency disease. The patient lack functional T-lymphocytes and fails to fight the infectious pathogens.

(ii) Using gene therapy, lymphocytes are extracted from the patient's bone marrow and a normal functional gene for ADA is introduced into these lymphocytes with the help of the retrovirus.

(iii) The lymphocytes of bone marrow contain the functional ADA gene and reactivate the patient's immune system.

(iv) 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. But the problem is that they are not completely curable. If the gene isolated from marrow cells producing ADA is introduced into cells at early embryonic stages, it could be a permanent cure.

½ × 4 = 2

Q. 10. Explain the process of RNA interference.

R **[Delhi Set-I, 2011]**

Ans. This method involves silencing of a specific mRNA of the parasite due to complementary dsRNA molecule that binds to and prevents translation of the mRNA (silencing). The source of this complementary RNA could be from an infection from viruses having RNA genomes or mobile genetic elements (transposons) that replicate via RNA intermediate. **2**

Answering Tip

- Learn RNAi in terms of inhibiting gene expression.

Q. 11. Explain how a hereditary disease can be corrected. Give an example of first successful attempt made towards correction of such diseases.

U **[Delhi Set-I, 2011]**

Ans. Introduction of required genes into cells and tissues to treat diseases / by delivery of normal gene to take over the function of non-functional gene / by gene therapy. First gene therapy was given to four year old girl with Adenosine deaminase deficiency. 2

[CBSE Marking Scheme, 2011]

Detailed Answer :

Gene therapy is an attempt to deal with hereditary or genetic or congenital diseases. This aims at correction of a genetic defect by delivery of a normal gene into an individual or embryo to take over or compensate the function for a non-functional gene. The first disease to have a gene therapy is ADA (Adenosine deaminase) deficiency. In this, the gene coding for enzyme ADA gets deleted leading to deficiency of ADA and problems in immune system. Gene therapy for ADA deficiency includes-

Isolation of lymphocytes from patient's blood and culturing them *in-vitro*.

Functional ADA cDNA are then introduced into the cultured lymphocytes.

These lymphocytes are returned back to the patient's body.

Permanent cure for this problem is the introduction of gene isolated from bone marrow cells producing ADA into cells at early embryonic stages. **2**

Commonly Made Error

- Most of the students mis-spelled adenosine deaminase as adenosine diaminase.
- They just write that genetically altered cells are re-introduced in patient's body without mentioning the use of proper vector (i.e., disarmed retro-virus).

AI Q. 12. How did Eli Lily synthesise the human insulin ? Mention one difference between this insulin and the one produced by the human pancreas. R **[Delhi Set-I, 2010]**

Ans. **(i)** In 1983, Eli Lily an American company prepared two DNA sequences corresponding to A and B chains of human insulin and introduced them in plasmids of *E. coli* to produce insulin chains.

(ii) Chains A and B were produced separately, extracted and combined by creating disulphide bonds to form human insulin. **½ × 3 = 1½**

Insulin produced by human pancreas has an additional C peptide. **½**

Q. 13. How is Bt cotton made to attain resistance against bollworm ? R **[Delhi Comptt. 2010]**

Ans. **(i)** Specific 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 the targeted pest, as most Bt toxins are insect-group specific.

(ii) The toxin is coded by a gene named *cry*. There are a number of them for example, the proteins encoded by the genes *cryIAc* and *cryIIAb* control the cotton ballworms and that of *cryIAb* controls corn borer. **1 + 1 = 2**

Q. 14. Name the insect pest that is killed by the product of cry IAc gene. Explain how the gene makes the plant resistant to the insect pest.

R **[Outside Delhi 2010]**

Ans. Cotton bollworms

The protein coded by *cryIAc* gene control the cotton bollworms. CryIAc is responsible for producing a toxic crystalline protein known as cry protein (Bt toxin). It is non-toxic to the bacterium because it exist as an inactive protoxin.

When this toxin enters the insect, it get converted into active form due to the alkaline pH of the gut. The activated toxin binds to the surface of the midgut epithelial cells and create pores and causes cell to swell, lyse and hence causing the death of the insect. **2**

Q. 15. Name the source and types of cry genes isolated from it for incorporation into crops by biotechnologies. Explain how have these genes brought beneficial change in the genetically modified crops ? R **[Outside Delhi, 2009]**

Ans. *Bacillus thuringiensis* is the source of cry gene.

Types of crygenes isolated from it are *cryIAc*, *cryIIAb*, *cryIAb*.

These genes act as biopesticides when introduced. They produce toxic insecticidal protein which, when activated cause death of the insects.

½ + ½ + 1

Q. 16. Why is functional insulin produced considered better than the ones used earlier by diabetic patient ?

R **[Outside Delhi, 2009]**

Ans. The functional protein is produced by rDNA. It does not produce allergic reaction and complication while earlier insulin was produced or extracted from pancreas of cattle and pig. It caused allergy and many complication to the diabetic patients. **2**

Short Answer Type Questions-II

(3 marks each)

AI Q. 1. How has RNAi technique helped to prevent the infestation of roots in tobacco plants by a nematode *Meloidegyne incognitia* ?

R **[Delhi Set-I, 2016]**

Ans. RNAi technique is helpful in preventing the infestation of roots in tobacco plants. This can be done by introduction of nematode-specific genes using the *Agrobacterium* vectors into the host plant. The introduction of DNA was such that it produced both sense and anti-sense RNA in the host cells. These two RNA's being complementary to each other formed a double stranded (dsRNA) that initiated RNAi and thus, silenced the specific mRNA in the nematode. The consequence was that the parasite could not survive in transgenic host expressing specific interfering RNA. The transgenic plant therefore got itself protected from the parasite. **3**

Q. 2. Explain enzyme-replacement therapy to treat adenosine deaminase deficiency. Mention two disadvantages of this procedure.

R **[Outside Delhi Set-I, 2016]**

Ans. Functional adenosine deaminase is given to the patient by injection. **1**

Disadvantages :

Therapy is not completely curative, periodic infusion of enzyme required. **1 + 1**

[CBSE Marking Scheme, 2016]

Detailed Answer :

Adenosine deaminase deficiency is a genetic disorder. The disorder is caused due to the deletion of the gene for *adenosine deaminase,* the enzyme crucial for the immune system to function.

Adenosine deaminase deficiency in patients can be treated by enzyme replacement therapy. In this treatment, patients are regularly injected with the functional ADA enzyme.

Disadvantages of this process :

(i) It does not completely eradicate the disease.

(ii) The requirement of repeated doses of the enzymes makes it expensive.

OR

(8) Enzyme Replacement Therapy refers to a method in which a functional Adenosine Deaminase (ADA) enzyme is introduced in the lymphocytes of the patient in order to compensate for the absence of ADA in the patient.
Its disadvantages are –
→ Enzyme Replacement Therapy is not completely curative.
→ Since lymphocytes have a fixed life span, a patient will hence requires periodic infusions of ADA enzyme into the cells, which will increase the cost of treatment.

[Topper's Answer, 2016]

Q. 3. *CrylAb* is introduced in a plant to prevent infestation by corn borer.

(i) What is the resultant plant referred as ?

(ii) Summarize the action of the gene introduced ?

R **[CBSE SQP, 2016-17]**

Ans. **(i)** Bt corn. ½

(ii) *Cry I Ab* / Bt toxin gene codes for crystal protein, the Bt toxin protein exists as an inactive protein, but once an insect ingests it, it gets converted into an active form due to the alkaline pH of the gut which solubilizes the crystal. The activated toxin binds to the surface of mid gut and creates pores that cause swelling, lysis and eventually death of the insect. ½ × 5 = 2½

[CBSE Marking Scheme, 2017]

Q. 4. Explain the various steps involved in the production of artificial insulin.

U **[Outside Delhi, 2017, Set - I, II, III]**

Ans. Two DNA sequences corresponding to A and B polypeptide chains of human insulin were prepared, these were introduced into E.coli to produce A and B chains separately, these chains were extracted and combined by creating disulphide bonds. **1 + 1 + 1 = 3**

[CBSE Marking Scheme, 2017]

OR

Artificial insulin / Cumulin was first produced by Eli Lily Company.
The various steps involved are :-
i) production of 2 DNA sequences corresponding to chain A and chain B of human insulin
ii) introduction of the sequences into a host such as E. coli
iii) synthesis of the 2 chains separately in the host
iv) extraction of the 2 polypeptide chains from the host
v) joining the 2 chains by forming disulphide bonds between them to create mature insulin.

[Topper's Answer, 2017]

Q. 5. What was the challenge for production of insulin using rDNA techniques ? How did Eli Lily produce insulin using rDNA technology ?

U **[Outside Delhi Comptt. - 2017, Set - I, II, III]**

Ans. The challenge for production of insulin using rDNA technique was getting insulin assembled into a mature form. **1**

(i) Prepared two DNA sequence corresponding to A and B chains of human insulin.

(ii) Introduced them in plasmids of *E. coli* to produce insulin chains.

(iii) Chains A and B were produced separately.

(iv) Extracted and combined by creating disulfide bonds to form human insulin ½ × 4

[CBSE Marking Scheme, 2017]

Q. 6. Name the organism from which the 'cry' genes are isolated. Mention with the help of suitable example why and how bio-technologists have made use of 'cry' genes ?

R **[Outside Delhi Comptt. 2017]**

Ans. *Bacillus thuringiensis* **1**

(i) Source of insecticidal (crystal) protein that control the cotton bollworms / corn borer. **1**

(ii) Specific Bt toxin genes were isolated from *Bacillus thuringiensis*, incorporated into several crop plants such as cotton. **½ × 2**

[CBSE Marking Scheme, 2017]

Q. 7. Why do lepidopterans die when they feed on Bt cotton plant ? Explain how does it happen.

U **[Delhi - 2017, Set - I, II, III]**

Ans. Bt cotton contains inactive toxin protein / protoxin / insecticidal protein / crystal protein, once the insect ingest it, the inactive protoxins are converted into active form due to alkaline pH in gut, which solubilise the crystals, activated toxins binds to surface of midgut (epithelial cells), create pores, causes cell swelling, lysis eventually leading the death of the insect pest. **½ × 6 = 3**

[CBSE Marking Scheme, 2017]

Q. 8. GM plants are useful in many ways. How would you convince farmers to grow GM plants on their field ? Explain giving three reasons.

A **[Delhi Comptt. - 2017, Set - I, II]**

Ans. Make crop more tolerant to abiotic stresses / Reduce reliance on chemical pesticides / Help to reduce post harvest loses / Increase efficiency of mineral usage / Enhance nutritional value of food.

(Any three) 1 × 3 = 3

[CBSE Marking Scheme, 2017]

Q. 9. What is GMO? List any five possible advantages of a GMO to a farmer. A **[Delhi Set-I, 2016]**

OR

People are quite apprehensive to use GM crops. Give three arguments in support of GM crops so as to convince the people in favour of such crops.

A **[Outside Delhi, Set-I, II, Comptt., 2016]**

Ans. Plants / bacteria / fungi / animals whose genes have been altered by manipulation. ½

Tolerance to abiotic stresses / like cold / drought / salt / heat, reduced reliance on chemical pesticides / pest resistant crops, reduce post harvest losses, increased efficiency of mineral usage by plants, enhanced nutritional value to create tailor made plant. **(Any five) ½ × 5 = 2½**

[CBSE Marking Scheme, 2016]

Detailed Answer :

Genetically modified organisms are living organisms whose genes have been altered by biotechnological manipulation.

Advantages :

(i) It makes crops more tolerant to abiotic stresses which can be in the form of cold, drought, salt or heat.

(ii) It reduces the reliance on chemical pesticides (pest-resistant crops).

(iii) It helps to reduce post harvest losses.

(iv) It increases the efficiency of mineral usage by plants. This prevents early exhaustion of fertility of soil.

(v) In enhances the nutritional value of food *e.g.* genetically modified variety of rice is rich in vitamin A. **1 + 2 = 3**

AI **Q. 10. (i) What is Gene therapy?**

(ii) Describe the procedure of such a therapy that could be a permanent cure for a disease. Name the disease. R **[Foreign Set-I, 2016]**

Ans. **(i)** Collection of methods that allows correction of gene defect that has been diagnosed in a child / embryo. Here, the genes are inserted into a person's cells and tissues to treat a hereditary disease. It compensate the non-functional gene. This involves delivery of a normal gene into the individual / embryo to take over the function of non-functional / defective gene. 1

(ii) If the desired gene is isolated and introduced into cells at early embryonic stages, it can provide a permanent cure. 1

ADA/Adenosine deaminase deficiency. 1

[CBSE Marking Scheme, 2016]

Q. 11. How has the study of biotechnology helped in developing pest resistant cotton crop? Explain.

U **[Delhi Set-I, II, III, Comptt., 2016]**

Ans. Some strains of *Bacillus thuringiensis* produce proteins that kill insects (pests), these crystals contain a toxic insecticidal protein, once the insect ingests this (inactive) toxin, it is converted into an active form, due to alkaline pH of the gut, activated toxin binds to surface of midgut epithelial cells and creates pores, causing swelling and lysis leading to death of pest. **½ × 6 = 3**

[CBSE Marking Scheme, 2016]

Q. 12. A person is born with a hereditary disease with a weakened immune system due to deficiency of an enzyme. Suggest a technique for complete cure for this disease. Identify the deficient enzyme and explain the technique used for cure.

U **[CBSE SQP, 2017]**

Ans. Gene Therapy.

ADA (Adenosine deaminase) deficiency.

Lymphocytes from the blood of the patient are grown in a culture, a functional ADA cDNA is introduced into these lymphocytes, which are subsequently returned to the patient. The permanent cure is done by introducing ADA cDNA into cells at early embryonic stages. **3**

[CBSE Marking Scheme, 2017]]

Q. 13. Why is molecular diagnosis preferred over conventional methods ? Name any two techniques giving one use of each.

U **[Delhi Set-I, II Comptt., 2016]**

Ans. To allow early detection. **1**

Example : rDNA technology / PCR / ELISA / Probe (Any two). **½ + ½ = 1**

PCR-to detect low concentration of bacteria / virus (HIV).

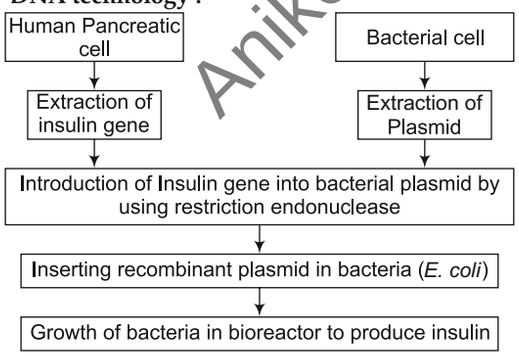
ELISA–to detect antigen / to detect antibodies produce by those antigens / to detect HIV.
Probe-to detect a mutated gene from a normal one (any two corresponding functions).
½ + ½ = 1
[CBSE, Marking Scheme, 2016]

Q. 14. Explain how Eli Lily, an American company produced insulin by recombinant DNA technology.
R **[Delhi/Outside Delhi, Comptt, Set 1,2,3, 2018]**
OR
How did an American Company, Eli Lily use the knowledge of r-DNA technology to produce human insulin ? [Outside Delhi Set-I, 2015]
OR
Explain how the company Eli lily was able to produce human insulin using rDNA technique.
[Outside Delhi Set-I, Comptt., 2016]
OR
Recombinant DNA-technology is of great importance in the field of medicine. With the help of a flow chart, show how this technology has been used in preparing genetically engineered human insulins. [Delhi Set-I, 2015]

Ans. Prepared two DNA sequences, corresponding to A and B chains of human insulin, introduced in the plasmids of E.coli, to produce insulin chains, chains A and B were produced separately and extracted and combined by creating disulphide bonds ½ × 6
[CBSE Marking Scheme, 2018]

Detailed Answer :

Preparation of human insulin using recombinant DNA technology :



3

Commonly Made Error
- Many students do not write the steps in proper sequence. Key terms like vector, host, use of restriction enzymes, ligase etc. are missed. Many students forget to mention about polypeptide chains- alpha and beta and cloning of their respective genes.

Q. 15. Mention the cause of ADA deficiency in humans. How has genetic engineering helped patients suffering from it ?
U **[Outside Delhi Set-I, Comptt. 2015]**

Ans. Deletion / mutation of the gene which forms the enzyme – adenosine deaminase. 1
Lymphocytes from the blood of the patient, can be grown in a culture outside the body, ADA cDNA gene can be inserted into the lymphocyte using retroviral vector, then lymphocytes can be returned to the patient. (They can start producing ADA).
½ × 4 = 2
[CBSE Marking Scheme, 2015]

Q. 16. Rearrange the following in the correct sequence to accomplish an important biotechnological reaction : R **[Outside Delhi Set-I, 2015]**
(a) *In vitro* synthesis of copies of DNA of interest
(b) Chemically synthesized oligonucleotides
(c) Enzyme DNA-polymerase
(d) Complementary region of DNA
(e) Genomic DNA template
(f) Nucleotides provided
(g) Primers
(h) Thermostable DNA-polymerase (from *Thermus aquaticus*)
(i) Denaturation of ds-DNA

Ans. Correct sequence is

$$\underbrace{i \rightarrow e \rightarrow b/g}_{=1} \rightarrow \underbrace{g/b \rightarrow c/h \rightarrow h/c}_{=1} \rightarrow \underbrace{f \rightarrow d \rightarrow a}_{=1}$$

//

$$\underbrace{a \rightarrow i \rightarrow e}_{=1} \rightarrow \underbrace{b/g \rightarrow g/b \rightarrow c/h}_{=1} \rightarrow \underbrace{h/c \rightarrow f \rightarrow d}_{=1}$$

3
[CBSE Marking Scheme, 2015]

Detailed Answer :

The correct sequence of the steps involved in biotechnological reaction is:
(e) Genomic DNA template
(i) Denaturation of ds-DNA
(g) Primers
(b) Chemically synthesised oligonucleotides
(c) Enzyme DNA polymerase
(h) Thermostable DNA polymerase
(f) Nucleotide provided
(d) Complementary region of DNA
(a) In *vitro* synthesis of copies of DNA of interest
3

Commonly Made Error
- Many students misplaced the terms and hence could not write in correct logical sequence.

Q. 17. (i) Tobacco plants are damaged severely when infested with *Meloidogyne incognita*. Name and explain the strategy that is adopted to stop this infestation.
(ii) Name the vector used for introducing the nematode specific gene in tobacco plant.
U **[Outside Delhi Set-II, 2014]**

Ans. **(i)** Nematode specific gene introduced into host plant (using *Agrobacterium*), produced dsRNA, RNAi initiated, specific mRNA of the nematode silenced and parasite dies. ½ × 4=2
(ii) *Agrobacterium tumefaciens.* 1

Q. 18. Name the nematode that damages the roots of tobacco plants. How is a transgenic tobacco plant made resistant to nematode using biotechnology ?

R [Outside Delhi Set-I, Comptt., 2014]

Ans. (i) Nematode – *Meloidogyne incognita.*

A nematode *Meloidogyne incognita* infect the roots of tobacco plants and causes a great reduction in yield. RNAi takes place in all eukaryotic organisms as a method of cellular defence. This method involves silencing of a specific mRNA due to a complementary dsRNA molecule that builds to and prevents translation of the mRNA (silencing).

(ii) Using *Agrobacterium* vectors, nematode-specific genes were introduced into the host plant. The introduction of DNA was such that it produces both sense and anti-sense RNA in the host cells. These two RNAs being complementary to each other formed a double-stranded RNA (dsRNA) that initiated RNAi and thus silenced the specific mRNA of the nematode. As a consequence the parasite could not survive in a transgenic host expressing specific interfering RNA.

1½ + 1½=3

Q. 19. How is the Bt cotton plant created as a GM plant ? How is it protected against bollworm infestation ?

U [Delhi Set-I, Comptt., 2013]

OR

(i) Why are certain cotton plants called Bt cotton plants ?

(ii) Explain how Bt cotton is resistant to pests.

R [Delhi Comptt. 2011; Outside Delhi Comptt. 2010]

Ans. (i) Certain cotton plants are called Bt cotton because specific Bt toxin genes were isolated from *Bacillus thuringiensis* and incorporated into these cotton plants.

The proteins encoded by the genes *cryIAc* and *cryIIAb* control the cotton bollworms and that for *cryIAb* controls corn borer.

(ii) Specific Bt toxin genes were isolated from *Bacillus thuringiensis* and incorporated into several crop plants such as cotton. The choice of genes depends upon the crop and the targeted pest, as most Bt toxin is insect-group specific. The toxin is coded by a gene named *cry.* There are a number of them, for example, the proteins encoded by the genes *cryIAc* and *cryIIAb* control the cotton boll worms, that of *cryIAb* controls corn borer. **1 + 2 = 3**

Q. 20. (i) How has biotechnology helped in producing *Meloidogyne incognita* resistant tobacco plant ?

(ii) Why does this nematode die on eating such a GM plant ? **U [Delhi Comptt. 2010]**

Ans. (i) Nematodes like *Meloidgyne incognitia* infects the roots of tobacco plants and causes reduction in yield. The infestation of these nematodes can be prevented by the process of RNA interference (RNAi). RNAi is present in all eukaryotic organisms as cellular defence by silencing of specific mRNA due to complementary dsRNA molecules that bind to and prevents translation of the mRNA.

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

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

1½ + 1½ = 3

Q. 21. How has the use of *Agrobacterium* as vectors helped in controlling *Meloidogyne incognitia* infestation in tobacco plants ? Explain in correct sequence.

R [Delhi/Outside Delhi, 2018]

OR

How did the process of RNAi interference help to control the nematode from infecting the roots of tobacco plants ? **U [Delhi Set-I, 2014]**

OR

How is a transgenic tobacco plant protected against *Meloidogyne incognita* ?

R [Outside Delhi Set-I, II, III, 2010]

Ans. (a) Using *Agrobacterium* vector, nematode specific genes are introduced into host plant.

(b) Sense and antisense strands of mRNA are produced.

(c) ds RNA is formed.

(d) ds RNA initiates RNAi.

(e) Prevents translation of mRNA / Silencing of mRNA of parasite / nematode.

(f) Parasite will not survive. **½ × 6**

[CBSE Marking Scheme, 2018]

Answering Tip

- The principles of RNAi and its application should be discussed properly with reference to the scope of the syllabus.

Q. 22. Expand 'ELISA'. Why is this method preferred over conventional method of diagnosis of disease ?

R [Delhi Comptt. 2017, Set - I, II, III]

Ans. Enzyme Linked Immunosorbent Assay. **1**

Infection by pathogen detected by the presence of antigens (protein, glycoprotein etc.), antibodies synthesised against the pathogen. **1**

Conventional methods cannot provide early diagnosis which is made possible by ELISA. **1**

[CBSE Marking Scheme, 2017]

Q. 23. How does *Agrobacterium tumefaciens* act as a suitable vector in the biotechnological experiments? Cite an example where it has been successfully used as a vector.

A [Outside Delhi Set-I, III, Comptt., 2016]

Ans. *Agrobacterium tumefaciens* (a pathogen of several dicot plants) is able to deliver a piece of DNA known as 'T DNA' to transform normal cells into tumor cells. The tumor inducing (Ti) plasmid of *Agrobacterium* (cloning vector) is no more used for pathogenic purposes, but the mechanism is used to deliver gene of interest, into plant where it multiplies.
Agrobacterium vector is used to transfer Nematode specific gene in the host plant (Tobacco) to develop Nematode resistant plant. **6×½=3**
[CBSE Marking Scheme, 2016]

Q. 24. Plasmid is a boon to biotechnology. Justify this statement quoting the production of human insulin as an example. E & A **[Outside Delhi 2009]**

Ans. The plasmids is a boon to biotechnology. It is a good vector in production of human insulin. It has a specific restriction site, where restriction endonuclease enzymes make a cut and a segment of DNA which codes for human insulin is inserted there. The recombinant plasmid so formed is introduced into E. coli and host cell where it replicates and produces insulin in large amount. The plasmid has number of origin of replication (ori) where replication starts. **3**

Long Answer Type Questions **(5 marks each)**

Q. 1. Explain the application of biotechnology in producing Bt cotton. [Delhi Set-I, Comptt. 2015]
U **[CBSE SQP, 2015]**

Ans. Bt toxin gene has been cloned from the bacteria and has been expressed in plants, to provide resistance to insects (without the need for synthetic insecticide). Bt toxin gene forms protein crystals. These crystals contain a toxic insecticidal protein. Bt toxin protein exists as inactive protoxin in the host, but once the insect ingests the inactive toxin, it is converted into active form of toxin, due to alkaline pH of the gut which solubilises the crystals, causing death of the insect. **5**

Q. 2. Explain the application of rDNA technology to produce insulin.
A **[Outside Delhi Set-I, Comptt. 2015]**

Ans. Human insulin is synthesised as a pro-hormone. The pro-hormone contains an extra C-peptide. The C-peptide is not present in mature insulin and is removed during maturation. Eli-Lilyan American company prepared two DNA sequences, corresponding to A and B chains of human insulin and introduced them in plasmids of *E. coli* to produce insulin chains. Chain A and B were produced separately, extracted and combined by creating disulphide bonds. **5**

AI **Q. 3. (i) Name the source from which insulin was extracted earlier. Why is this insulin no more in use by diabetic people ?**
(ii) Explain the process of synthesis of insulin by Eli Lily company. Name the technique used by the company.
(iii) How is the insulin produced by human body different from the insulin produced by the above-mentioned company ?
U **[Outside Delhi Set-I, II, III, 2011]**

Ans. **(i)** Insulin from an animal source, though it caused some patients to develop allergy or other types of reactions to the foreign protein. Insulin consists of two short polypeptide chains : chain A and chain B, which are linked together by disulphide bridges. In mammals, including humans, insulin is synthesized as a pro-hormone, which contains an extra stretch called the C-peptide.
(ii) In 1983, Eli Lily, an American company, prepared two DNA sequences corresponding to A and B chains of human insulin and introduced them in plasmids of *E.coli* to produce insulin chains. Chains A and B were produced separately, extracted and combined by creating disulphide bonds to form human insulin.
(iii) The insulin produced by human body is different from the insulin produced by the above mentioned company. Insulin is synthesized as a prohormone (like a proenzyme, the prohormone also needs to be processed before it becomes a fully mature and functional hormone), which contains an extra stretch called the C peptide. This C peptide is not present in the mature insulin and is removed during maturation into insulin. The main challenge for production of insulin using rDNA techniques was getting insulin assembled into a mature form.
1 + 2 + 2

Q. 4. (i) What is a plasmid ?
(ii) What is meant by ADA deficiency ? How is gene therapy a solution to this problem ? Why is it not a permanent cure ?
U **[Delhi Set-III, 2010]**

Ans. **(i)** Plasmids are extra-chromosomal, self-replicating, usually circular double-stranded DNA molecules found in bacteria and in some yeast.
(ii) ADA is adenosine deaminase deficiency, this enzyme is crucial for the immune system to function. The patient lacks functional T-lymphocytes and fails to fight the infecting pathogens.
Children with ADA deficiency are cured by bone marrow transplantation or enzyme

replacement therapy, where ADA is given by injection. By using gene therapy techniques, lymphocytes are taken from the patient's bone marrow and the normal gene for ADA is introduced into the lymphocytes using retrovirus. These cells are re-introduced in the patient's immune system.

As these cells are not immortal, the patient requires periodic infusion of such genetically engineered lymphocytes. Hence, it is not a permanent cure.

If the functional gene is introduced into the bone marrow cells at early embryonic stage, it would be a permanent cure. **1 + 4 = 5**

TOPIC-2
Transgenic Animals and Bioethical Issues

Revision Notes

- **Transgenic Animals**
  - These are the animals whose genome has been altered by introduction of an extra (foreign) gene by manipulation. *E.g.* Transgenic rats, rabbits, pigs, sheep, cows and fish.
  - Over 95% of all existing transgenic animals are mice.
- **Advantages or Benefits of Transgenic Animals**
  - **To study normal physiology and development :**
    - **(a)** Transgenic animals are used to study how genes are regulated and how they affect the normal body functions and its development.
    - **(b)** *E.g.* study of complex factors such as insulin-like growth factor. Genes (from other species) that alter the formation of this factor are introduced and the biological effects are studied. This gives information about the biological role of the factor in the body.
  - **To Study the contribution of genes in the development of a disease :**
    - **(a)** Transgenic models help for investigation of new treatments for human diseases.
    - **(b)** *E.g.* transgenic models for many human diseases such as cancer, cystic fibrosis, rheumatoid arthritis and Alzheimer's.
  - **Biological products :**
    - **(a)** Some medicines contain biological products, but they are often expensive.
    - **(b)** Transgenic animals are used to produce useful biological products by introducing genes which codes for a particular product. *e.g.* human protein (α-1-antitrypsin) used to treat emphysema, products for treatment of phenylketonuria (PKU) and cystic fibrosis etc.
    - **(c)** In 1997, *Rosie* (first transgenic cow) produced human protein-enriched milk (2.4 gm per litre).
    - **(d)** It contains the human alpha-lactalbumin and is nutritionally more balanced product for human babies than natural cow-milk.
  - **Vaccine safety testing:** Transgenic mice are being developed and used in testing the safety of vaccines before they are used for humans. Polio vaccine was tested in mice.
  - **Chemical safety testing (toxicity testing) :** Transgenic animals are made to know the effect of toxic chemicals. This is also known as toxicity / safety testing.
- **Ethical Issues**
  - **Problem of unpredictable results**
    - **(a)** Genetic modification may cause unpredictable results when such organisms are introduced into the ecosystem.
    - **(b)** Therefore, Indian Government has set up organizations like **GEAC** (Genetic Engineering Approval Committee), which makes decisions about the validity of GM research and the safety of GM-organisms for public services.
  - **Problems of patent**
    - **(a)** Certain companies have got patents for products and technologies that make use of the genetic materials, plants etc. that have been identified, developed and used by farmers and indigenous people of a specific country.
    - **(b)** *E.g.* Basmati rice, herbal medicines like turmeric, neem, etc.
    - **(c)** Basmati rice has unique aroma and flavour.

(d) India has 27 varieties of Basmati.
(e) In 1997, an American company got patent rights on Basmati rice through the US Patent and Trademark Office.
(f) This allowed the company to sell a 'new' variety of Basmati which had actually been derived from Indian farmer's varieties.
(g) Indian Basmati was crossed with semi-dwarf varieties and claimed as a novelty.
(h) Other people selling Basmati rice could be restricted by the patent.

- **Biopiracy :**
  (a) It is the use of bio-resources by multinational companies and other organizations without proper authorization from the countries and people concerned.

Very Short Answer Type Questions (1 mark each)

Q. 1. What is biopiracy ? R **[Delhi Set-I, 2015]**

Ans. Illegal / non authorized / non compensated use of bioresources by organisations.
[CBSE Marking Scheme, 2015] 1

Detailed Answer :

Some organisation and multinational companies exploit patent biological resources or bio-resources of other nations without proper authorisation from the countries concerned is called biopiracy. **1**

Commonly Made Error

- Many of the students get confused between *bio patent* and *bio piracy*.

AI **Q. 2.Mention two objectives of setting up GEAC by our government.**

R **[Outside Delhi Set-II, 2016] [KVS]**

OR

GEAC is one of the organization set up by Indian Government. Write it's full form. Give it's two objectives. [DDE]

Ans. Indian Government has set up organisations like GEAC (Genetic Engineering Approval Committee), which make decision about the validity of GM research and the safety of GM-organisms for public services. **1**

Q. 3. What are transgenic animals. Give an example.

U **[Outside Delhi Set-III, 2016]**

Ans. Animals whose DNA is manipulated to possess and express an extra (foreign) gene *e.g.* Rosie - transgenic cow. **½ × 2 = 1**
[CBSE Marking Scheme, 2016]

Detailed Answer :

Transgenic animals are animals whose genes are altered by manipulation (recombinant DNA technology). Example includes Transgenic mouse, silk producing goats, sheep, Rosie - a transgenic cow etc. **1**

Answering Tip

- Understand definitions, importance, significance and applications of transgenics in detail.

Q. 4. Can you suggest a method to remove oil (hydrocarbon) from seeds based on your understanding of rDNA technology and chemistry of oil ?

A **[Outside Delhi Set-I, II, III, 2016]**

Ans. It is possible to remove gene for oil synthesis from seeds by recombinant DNA technology or genetic engineering. **1**

Q. 5. What was the speciality of milk produced by the transgenic cow-Rosie.

R **[Outside Delhi Set, 2008]**

Ans. Rosie was the first transgenic cow. The milk produced by it was protein rich. It contained human alpha lactalbumin. This milk was nutritionally richer and balanced as compared to that of normal cow. **1**

Q. 6. Name the Indian variety of rice patented by an American Company. R **[Delhi Set, 2008]**

Ans. The Indian variety of rice patented by American Company—Rice Tec inc. in 1997 was basmati rice. **1**

AI **Q. 7. A multinational company outside India tried to sell new varieties of turmeric without proper rights, what is such an act referred to ?**

A **[Outside Delhi, 2008]**

Ans. Biopiracy.

Short Answer Type Questions-I (2 marks each)

Q. 1. What is Biopiracy ? State the initiative taken by the Indian Parliament towards it.

R **[Delhi Set-II, 2014]**

Ans. **(i)** Use of bio resources without authorisation, compensation. **½ + ½**

(ii) The govt. has cleared patent terms, emergency provisions, research and development initiative.
(Any two) ½ + ½
[CBSE Marking Scheme, 2014]

Detailed Answer :

(i) Bio-piracy is defined as the illegal commercial utilization of biological material of a country by organisations or multinational companies without proper authorisation from the concerned countries.

Q. 2. How have transgenic animals proved to be beneficial in :

(i) Production of biological products.

(ii) Chemical safety testing. R **[Delhi Set-III, 2014]**

Ans. **(i)** Rosie - transgenic cow produced human protein / alpha lactalbumin enriched milk, alpha-1 antitrypsin used to treat emphysema. ½ + ½

(ii) Toxicity Testing - more sensitive to toxic substances, results obtained in less time. ½ + ½

[CBSE Marking Scheme, 2014]

Detailed Answer :

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, phenylketonuria (PKU) and cystic fibrosis.

Transgenic animals are made that carry genes which make them more sensitive to toxic substances than non-transgenic animals. They are then exposed to the toxic substances and the effects are studied. Toxicity testing in such animals will allow us to obtain results in less time.

Q. 3. How is 'Rosie' considered different from a normal cow ? Explain. U **[Delhi Set-I, 2011]**

Ans. Rosie is a transgenic cow. **1**

Rosie produced human protein enriched milk, containing human alpha - lactalbumin. **1**

AI **Q. 4. Biopiracy should be prevented. State why and how ?** U **[Outside Delhi Set-I, II, III, 2011]**

Ans. Biopiracy is the term used to refer to the use of bioresources by multinational companies and other organizations without proper authorization from the countries and people concerned without compensatory payment.

There has been growing realization of the injustice, inadequate compensation and benefit sharing between developed and under developed countries. Therefore, some nations have developing laws to prevent such unauthorized exploitation of their bioresources and traditional knowledge. **1 + 1 = 2**

Q. 5. (a) While cloning vectors, which of the two will be preferred by biotechnologists - bacteriophages or plasmids. Justify with reason.

(b) Name the first transgenic cow developed and state the improvement in the quality of the product produced by it. **[CBSE SQP, 2018]**

Ans. **(a)** Bacteriophages, because they have very high copy numbers of their genome within the bacterial cells whereas some plasmids may have only one or two copies per cell and others may have 15-100 copies per cell. **1**

(b) Rosie, it produced human protein-enriched milk (2.4 gms per litre). **1**

[CBSE Marking Scheme, 2018]

Short Answer Type Questions-II

(3 marks each)

Q .1. The Indian Government refuted the attempt by a multinational company (MNC) to patent the antiseptic property of curcumin derived from Turmeric. Analyze the unethical practice adopted by the MNC, state its implications and suggest provisions in the Indian Law to prevent such malpractices A **[CBSE SQP, 2018]**

Ans. **(i)** MNC wanted to encash on our rich legacy by biopiracy. **1**

(ii) It leads to injustice, inadequate compensation and unauthorized exploitation of traditional knowledge of the country. **1**

(iii) Second amendment of the Indian Patents Bill takes into consideration issues related with patent terms, emergency provisions and research and development initiative. **1**

[CBSE Marking Scheme, 2018]

Q. 2. (a) What are transgenic animals ?

(b) Name the transgenic animal having the largest number amongst all the existing transgenic animals.

(c) Mention any three purposes for which these animals are produced.

R **[Delhi/Outside Delhi, Comptt, Set 1,2,3, 2018]**

Ans. **(a)** Animals that have had their DNA manipulated to possess and express an extra / foreign gene. **1**

(b) Mice. ½

(c) **(i)** Normal physiology and development.

(ii) Study of disease.

(iii) Biological products.

(iv) Vaccine safety.

(v) Chemical safety testing. **(Any three)**

½ × 3

[CBSE Marking Scheme, 2018]

Answering Tip

- Understand definitions, importance, significance and applications of transgenics in detail.

Q. 3. What is GEAC ? What are its objectives ?

Ans. GEAC stands for Genetic Engineering Approval Committee. It is an Indian Government organization. **It has following objectives :**

(i) To examine the validity of GMO i.e. genetic modification of organisms research.

(ii) Safety of introducing GMOs for public use. **1+2**

Know the Terms

- **ELISA :** Enzyme linked immunosorbent Assay.
- **GEAC :** Genetic Engineering Approval Committee.
- **ADA :** Adenosine deaminase deficiency. This enzyme is crucial for the functioning of the immune system.
- **Probe :** A probe is a piece of single-stranded DNA that is tagged with a radioactive molecule.
- **Vaccines :** It is a liquid containing dead or attenuated pathogen or it is an antigen that provides temporary or permanent immunity to a disease.
- **Transgenic animals :** Animals that have their DNA manipulated to possess and express an extra or a foreign gene are known as transgenic animals.
- **Biopatent :** A patent is the right granted by a government to an inventor to prevent others from commercially using his invention. When patents are granted for biological entities and for products derived from them, these patents are called biopatents.
- **Biopiracy :** Some organizations and multinational companies exploit biological resources or bioresources of other nations, without proper authorization from the countries concerned. This is called biopiracy.
- **SCID :** Severe Combined Immuno-deficiency. It is caused by a defect in the gene for the enzyme adenosine deaminase (ADA).
- **GMO :** Genetically modified organisms.
- **RNAi :** RNA Interference.

❐❐❐