NCERT Exercise Answer Key

Chapter 10: Biotechnology and Its Applications

Medium Detailed Solutions

---

1. Which part of... ...virus-free plants and why?

Answer: Meristem (apical and axillary) is best suited for making virus-free plants.

Reasons:

- Meristematic tissues remain virus-free even when the plant is infected
- Viruses cannot penetrate rapidly dividing meristematic cells
- High metabolic activity in meristem prevents viral establishment
- Small size allows easy isolation and culture
- Totipotent nature enables regeneration of complete plant

Process: Remove meristem → Culture in vitro → Obtain virus-free plants

---

2. What is the... ...producing plants by micropropagation?

Answer: Major advantages:

1. **Rapid multiplication:** Thousands of plants produced in short time
2. **Disease-free plants:** Pathogen elimination through controlled conditions
3. **Year-round production:** Independent of seasonal variations
4. **Genetic uniformity:** All plants genetically identical (somaclones)

5. **Space efficiency:** Large numbers in small laboratory space
6. **Cost-effective:** Reduced field space and maintenance costs
7. **Quality plants:** Healthy, vigorous plants with better survival rates

---

3. Find out what... ...explant in vitro are?

Answer: Components of tissue culture medium:

Inorganic components:

- Macronutrients: N, P, K, Ca, Mg, S
- Micronutrients: Fe, Mn, Zn, Cu, B, Mo

Organic components:

- Carbon source: Sucrose (2-4%)
- Vitamins: Thiamine, pyridoxine, nicotinic acid
- Amino acids: Glycine, glutamine
- Growth regulators: Auxins (IAA, NAA), Cytokinins (BAP, kinetin)

Physical conditions:

- pH: 5.5-6.5
- Temperature: 25±2°C
- Light: 16-hour photoperiod
- Sterile environment

---

4. Crystals of Bt... ...because – (MCQ)

Answer: (c) toxin is inactive

Explanation:

- Bt toxin exists as **inactive protoxin** in bacterial crystals
- Protoxin is harmless to the bacterium producing it
- Becomes active only in insect's alkaline gut (pH 8-10)
- Alkaline conditions solubilize crystals and activate toxin
- Active toxin then binds to insect gut epithelial cells causing death
- Bacterial gut is not alkaline, so toxin remains inactive

---

5. What are transgenic... ...using any one example?

Answer: Transgenic bacteria: Genetically modified bacteria containing foreign genes to produce desired proteins.

Example: E. coli producing Human Insulin

Process:

1. **Gene isolation:** Human insulin gene isolated
2. **Vector preparation:** Plasmid vectors prepared
3. **Gene insertion:** Insulin gene inserted into plasmid
4. **Transformation:** Recombinant plasmid introduced into E. coli
5. **Selection:** Transformed bacteria selected using markers
6. **Production:** Bacteria cultured to produce human insulin
7. **Purification:** Insulin extracted and purified

Advantages:

- Large-scale production
- Cost-effective
- No immune reactions (human protein)
- Consistent quality

---

6. Compare and contrast... ...genetically modified crops.

Answer:

Advantages of GM Crops:

Agricultural benefits:

- Higher yield and productivity
- Pest and disease resistance
- Tolerance to herbicides and abiotic stress
- Reduced post-harvest losses
- Enhanced nutritional value (Golden rice)
- Reduced chemical pesticide use

Economic benefits:

- Cost-effective for farmers
- Reduced input costs
- Better market value

Disadvantages of GM Crops:

Environmental concerns:

- Potential ecosystem disruption
- Development of resistant pests
- Loss of biodiversity
- Gene flow to wild relatives

Health concerns:

- Allergenicity potential
- Antibiotic resistance genes
- Long-term health effects unknown

Socio-economic issues:

- Farmer dependency on companies
- Patent issues and biopiracy
- Traditional variety displacement

---

7. What are Cry... ...to his benefit?

Answer: Cry proteins: Insecticidal proteins produced by *Bacillus thuringiensis* bacteria.

Producing organism: *Bacillus thuringiensis* (Bt)

Human exploitation:

Mechanism:

1. Cry genes isolated from Bt bacteria
2. Genes inserted into crop plants (cotton, corn, rice)
3. Plants produce Cry proteins continuously
4. When insects eat plant tissue, proteins activated in alkaline gut
5. Proteins bind to gut receptors causing cell lysis and insect death

Benefits:

- **Bio-pesticide:** Crops act as living pesticides
- **Targeted action:** Specific to certain insect groups
- **Reduced chemical use:** Less environmental pollution
- **Cost-effective:** Farmers save on pesticide costs
- **Sustained protection:** Continuous protection throughout crop cycle

Examples: Bt cotton (bollworm control), Bt corn (corn borer control)

---

8. What is gene... ...deaminase (ADA) deficiency.

Answer: Gene therapy: Technique to treat genetic diseases by introducing normal/functional genes into patient's cells.

ADA Deficiency Example:

Disease details:

- **Cause:** Deletion/mutation of ADA gene
- **Effect:** Immune system dysfunction due to ADA enzyme deficiency
- **Symptoms:** Severe Combined Immunodeficiency (SCID)

Gene therapy approach (1990):

1. **Cell isolation:** Patient's lymphocytes extracted from blood
2. **Ex vivo culture:** Cells grown in laboratory culture
3. **Gene delivery:** Functional ADA cDNA introduced using retroviral vector
4. **Gene integration:** ADA gene integrates into lymphocyte genome
5. **Cell return:** Genetically modified lymphocytes reintroduced into patient
6. **Expression:** Modified cells produce functional ADA enzyme

Limitations:

- Temporary effect (cells not immortal)
- Requires repeated treatments
- Partial cure only

Permanent solution: Gene therapy at embryonic stem cell level

---

9. Diagrammatically represent the... ...like E. coli?

Answer: Steps for cloning human growth hormone gene in E. coli:

Step 1: Gene Isolation
Human DNA → PCR amplification → Growth hormone gene

Step 2: Vector Preparation
Plasmid → Restriction enzyme cutting → Linear plasmid with sticky ends

Step 3: Gene Insertion
Growth hormone gene + Linear plasmid → DNA ligase → Recombinant plasmid

Step 4: Transformation
Recombinant plasmid + E. coli → Heat shock/electroporation → Transformed E. coli

Step 5: Selection
Transformed bacteria → Antibiotic selection → Positive clones

Step 6: Expression
Selected clones → Fermentation → Growth hormone production

Step 7: Purification
Cell harvest → Cell lysis → Protein purification → Pure growth hormone

Key components needed:

- Restriction enzymes (EcoRI, BamHI)
- DNA ligase
- Competent E. coli cells
- Selection markers (antibiotic resistance)
- Expression vectors with promoters

---

10. Can you suggest... ...chemistry of oil?

Answer: Method to remove oil from seeds using rDNA technology:

Approach: Modify lipase enzyme production in seeds

Strategy:

1. **Gene identification:** Isolate genes encoding lipase enzymes
2. **Gene modification:** Engineer lipase genes for enhanced activity
3. **Transformation:** Introduce modified genes into oil-containing plants
4. **Expression control:** Use seed-specific promoters
5. **Enzyme production:** Seeds produce enhanced lipase enzymes
6. **Oil breakdown:** Lipases break down triglycerides into fatty acids and glycerol

Chemical basis:

- Lipases catalyze hydrolysis: Triglycerides → Fatty acids + Glycerol
- Modified enzymes have higher activity and stability
- Water-soluble products easily removed from seeds

Alternative approach:

- Knock down genes for oil synthesis enzymes
- Reduce oil accumulation during seed development
- Redirect metabolism toward other storage compounds

---

11. Find out from... ...is golden rice.

Answer: Golden Rice: Genetically modified rice enriched with beta-carotene (Vitamin A precursor).

Development:

- Created by Ingo Potrykus and Peter Beyer (2000)
- Contains genes from daffodil and bacteria
- Produces beta-carotene in rice endosperm

Genetic modification:

1. **Genes introduced:**
   - *psy* gene (daffodil) - encodes phytoene synthase
   - *crtI* gene (bacteria) - encodes carotene desaturase
2. **Pathway completion:** Enables beta-carotene synthesis in rice grains
3. **Visual marker:** Golden color due to carotenoids

Purpose:

- Address Vitamin A deficiency (VAD)
- Prevent blindness in developing countries
- Nutritional enhancement of staple food

Significance:

- 250 million children suffer from VAD globally
- Could prevent 1-2 million deaths annually
- Sustainable solution for malnutrition

---

12. Does our blood... ...proteases and nucleases?

Answer: Yes, human blood contains both proteases and nucleases.

Proteases in blood:

1. **Coagulation proteases:**
   - Thrombin, plasmin, factor Xa
   - Function: Blood clotting and clot dissolution
2. **Complement proteases:**
   - C3 convertase, C5 convertase
   - Function: Immune defense
3. **Other proteases:**
   - Elastase, cathepsins
   - Function: Protein turnover and immune responses

Nucleases in blood:

1. **DNases:**
   - DNase I, DNase II
   - Function: DNA degradation and apoptotic cell clearance
2. **RNases:**
   - RNase A, RNase L
   - Function: RNA degradation and antiviral defense

Clinical significance:

- Used as biomarkers for diseases
- Important in blood coagulation
- Role in immune system function
- Can degrade therapeutic proteins (challenge for drug delivery)

---

13. Consult internet and... ...to be encountered?

Answer: Making orally active protein pharmaceuticals:

Methods:

1. **Encapsulation techniques:**
   - Liposomes, microspheres, nanoparticles
   - Protect proteins from digestive enzymes
2. **Chemical modification:**
   - PEGylation (polyethylene glycol attachment)
   - Increases stability and half-life
3. **Enteric coating:**
   - pH-sensitive coatings
   - Release in intestine, not stomach
4. **Permeation enhancers:**
   - Increase intestinal absorption
   - Open tight junctions temporarily

Major problems encountered:

1. **Protein degradation:**
   - Stomach acid (pH 1.5-2.0) denatures proteins
   - Pepsin and other proteases break down proteins
   - Solution: Acid-resistant formulations
2. **Poor absorption:**
   - Large molecular size prevents crossing intestinal barrier

- Hydrophilic nature limits membrane permeability
- Solution: Absorption enhancers, smaller fragments

3. **First-pass metabolism:**
   - Liver enzymes degrade absorbed proteins
   - Reduces bioavailability significantly
   - Solution: Modified drug delivery routes
4. **Stability issues:**
   - Proteins unstable at body temperature
   - Aggregation and precipitation problems
   - Solution: Stabilizing excipients, controlled release

Current research: Focus on peptide drugs, insulin analogues, and novel delivery systems.