Biotechnology: Principles and Processes

Class 12 Biology · 24 NEET MCQs with answers & explanations

Biotechnology: Principles and Processes covers genetic engineering tools (restriction enzymes, vectors, host cells), recombinant DNA technology steps, PCR, gel electrophoresis and bioreactors. NEET tests the specific tools (EcoRI, pBR322, Ti plasmid), the steps of rDNA technology, and diagram-based questions on vectors and cloning.

Key Tools & Steps

Tool / Step	Key Fact
Restriction enzymes	EcoRI: cuts at GAATTC (palindromic); produces sticky ends
Vectors	pBR322 (ampR, tetR), Ti plasmid (Agrobacterium), λ phage
PCR	Denaturation (94°C) → Annealing (55°C) → Extension (72°C); Taq polymerase (thermostable)
Gel electrophoresis	DNA fragments separate by size (smaller = faster); stained with EtBr, seen under UV
Competent host	$CaCl_2$ treatment or heat shock for bacterial cells to take up DNA
Bioreactors	Stirred-tank bioreactor for large-scale rDNA protein production; downstream processing for purification

Questions

Q1. Which is the first step in recombinant DNA technology as described by NCERT?

(A) Isolation of genetic material
(B) Digestion with restriction enzymes
(C) Ligation into vector
(D) Introduction into host cell

Q2. Which chemical is used during DNA isolation to remove proteins associated with DNA?

(A) Chloroform
(B) Ethanol
(C) Phenol
(D) Isopropanol

Q3. Which substance precipitates DNA from aqueous solution during DNA isolation?

(A) Detergent
(B) Sodium chloride
(C) Chilled ethanol
(D) Protease

Q4. Manipulation of DNA in genetic engineering became practically possible mainly because of the discovery of which enzyme?

(A) Restriction endonuclease
(B) DNA ligase
(C) DNA polymerase
(D) Primase

Q5. In recombinant DNA technology, the enzyme that covalently joins a foreign DNA fragment with a cut plasmid vector is:

(A) DNA polymerase
(B) DNA ligase
(C) Restriction endonuclease
(D) Helicase

Q6. Which feature of a cloning vector is most desirable for efficient insertion of foreign DNA without unnecessarily fragmenting the vector?

(A) Many recognition sites for the same restriction enzyme
(B) A very large vector with no selectable marker
(C) A single or very few suitable restriction sites
(D) Absence of an origin of replication

Q7. Which organism and genetic element are exploited for natural gene transfer into plant cells in biotechnology?

(A) Agrobacterium tumefaciens with Ti plasmid
(B) Bacillus subtilis with pBR322
(C) Escherichia coli with F plasmid
(D) Saccharomyces cerevisiae with YAC

Q8. Which physical method uses brief electrical pulses to create transient pores in bacterial membranes for DNA uptake?

(A) Chemical transformation with $CaCl_2$
(B) Electroporation
(C) Biolistic gene gun method
(D) Microinjection into nucleus

Q9. Which plasmid vector contains both ampicillin and tetracycline resistance genes used as selectable markers?

(A) pUC19
(B) pBR322
(C) Ti plasmid
(D) Bacteriophage lambda

Q10. Which class of enzymes cuts DNA at specific nucleotide sequences during recombinant DNA technology?

(A) Restriction endonucleases
(B) DNA ligase
(C) DNA polymerase
(D) RNA polymerase

Q11. Which enzyme joins two DNA fragments by forming phosphodiester bonds between adjacent nucleotides?

(A) DNA helicase
(B) DNA ligase
(C) Restriction endonuclease
(D) DNA polymerase

Q12. Which feature of plasmids makes them suitable as cloning vectors in genetic engineering?

(A) They contain only ribosomal RNA genes
(B) They degrade incoming foreign DNA
(C) They replicate independently inside host cells
(D) They integrate into the host chromosome permanently

Q13. A plasmid used as a cloning vector must be able to replicate independently inside the host cell. Which vector feature directly provides this capability?

(A) Selectable marker
(B) Restriction site
(C) Origin of replication
(D) Promoter

Q14. Which sequence correctly represents the major stages used to amplify a target DNA segment by PCR?

(A) Denaturation → annealing → extension
(B) Annealing → denaturation → extension
(C) Extension → denaturation → annealing
(D) Ligation → denaturation → translation

Q15. A foreign DNA fragment and a plasmid are cut with the same restriction endonuclease. Which enzyme is required to covalently join the two compatible DNA molecules?

(A) Primase
(B) DNA ligase
(C) Helicase
(D) RNA polymerase

Q16. Which combination correctly represents the three essential components required for efficient PCR amplification of a selected DNA segment?

(A) Restriction enzyme, DNA ligase and ribosome
(B) Template DNA, specific primers and thermostable DNA polymerase
(C) Selectable marker, ori and antibiotic
(D) Probe, antibody and plasmid

Q17. Why does DNA migrate towards the positive electrode during agarose-gel electrophoresis?

(A) Phosphate groups give DNA a net negative charge
(B) DNA contains positively charged amino-acid residues
(C) DNA is neutral but is pushed by the gel matrix
(D) DNA has specific affinity for the positive electrode

Q18. A recombinant bacterial culture produces a desired protein in a bioreactor. The product is mixed with cells and other components. Which process should be selected to obtain a purified final product?

(A) PCR amplification of the product gene
(B) Downstream processing of the culture
(C) Transformation of fresh host cells
(D) Restriction digestion of the harvest

Q19. A stirred tank bioreactor is distinguished from a simple flask by which structural feature described in NCERT?

(A) Transparent walls for optical monitoring
(B) Built-in PCR thermocycling unit
(C) Agitator system with impeller and baffles
(D) Gel electrophoresis chamber attached

Q20. The impeller in a stirred tank bioreactor serves which primary function during fermentation?

(A) Homogeneous mixing of culture medium
(B) Monitoring dissolved oxygen levels
(C) Sterilizing incoming nutrients
(D) Separating cells from broth

Q21. A bioreactor maintains optimal microbial growth by simultaneously controlling multiple parameters. Which combination of parameters is monitored and regulated in a production bioreactor?

(A) Only temperature and pH
(B) Only dissolved oxygen and cell density
(C) Temperature, pH, dissolved oxygen, and agitation speed
(D) Carbon dioxide concentration only

Q22. Which fundamental principle of modern biotechnology allows scientists to deliberately modify an organism's genome to introduce desirable traits?

(A) Genetic engineering
(B) Downstream processing
(C) Microbial fermentation
(D) Gel electrophoresis

Q23. Which statement best explains the universality of the genetic code in the context of biotechnology?

(A) Different organisms use different codons for the same amino acid
(B) Only viruses follow the universal genetic code
(C) The same codons specify the same amino acids in most organisms
(D) Genetic code universality is limited to eukaryotes

Q24. Which example correctly represents traditional biotechnology rather than modern biotechnology?

(A) Production of recombinant insulin in E. coli
(B) Gene cloning using plasmid vectors
(C) Fermentation of sugar to produce alcohol
(D) DNA amplification using PCR

Answer key

1-A	2-C	3-C	4-A	5-B	6-C	7-A	8-B
9-B	10-A	11-B	12-C	13-C	14-A	15-B	16-B
17-A	18-B	19-C	20-A	21-C	22-A	23-C	24-C

Answers with explanations

Q1 — Answer: (A) Isolation of genetic material
NCERT lists isolation of DNA as the first step before any enzymatic manipulation can occur in recombinant DNA technology.

Q2 — Answer: (C) Phenol
Phenol denatures and separates proteins from nucleic acids during DNA extraction. Chloroform is used subsequently to remove phenol itself, not proteins directly.

Q3 — Answer: (C) Chilled ethanol
DNA is insoluble in alcohol; chilled ethanol causes DNA to precipitate out of solution. Sodium chloride adjusts ionic strength but does not precipitate DNA directly.

Q4 — Answer: (A) Restriction endonuclease
Restriction endonucleases made site-specific cutting of DNA possible, allowing DNA fragments to be isolated and recombined. DNA ligase joins DNA fragments after cutting but did not provide the original site-specific cutting capability. DNA polymerase synthesises new strands and primase synthesises RNA primers.

Q5 — Answer: (B) DNA ligase
DNA ligase seals the phosphodiester backbone between compatible DNA fragments. Restriction endonucleases cut DNA at specific recognition sites. DNA polymerase synthesises DNA and helicase separates the two strands of double-stranded DNA.

Q6 — Answer: (C) A single or very few suitable restriction sites
A cloning vector should preferably possess a single recognition site for a commonly used restriction enzyme so that insertion does not occur at multiple unwanted positions. Multiple recognition sites can fragment the vector. Absence of an origin of replication would prevent autonomous replication entirely.

Q7 — Answer: (A) Agrobacterium tumefaciens with Ti plasmid
Agrobacterium tumefaciens naturally transfers T-DNA from its Ti plasmid into plant cell chromosomes. This system is exploited to deliver desired genes into plant genomes.

Q8 — Answer: (B) Electroporation
Electroporation applies a brief high-voltage pulse that transiently disrupts the membrane, allowing DNA to enter. $CaCl_2$ treatment is chemical, not electrical; biolistics uses particle bombardment.

Q9 — Answer: (B) pBR322
pBR322 carries ampR and tetR genes serving as selectable markers. pUC19 carries ampR and lacZ but not tetR. Ti plasmid is a plant transformation vector, not a standard E. coli cloning vector.

Q10 — Answer: (A) Restriction endonucleases
Restriction endonucleases recognize specific palindromic sequences and cleave both strands of DNA, generating fragments for cloning. DNA ligase joins fragments; polymerase synthesizes; RNA polymerase transcribes — none cut at specific sites.

Q11 — Answer: (B) DNA ligase
DNA ligase seals nicks in the sugar-phosphate backbone by catalysing phosphodiester bond formation between the 3'-OH and 5'-phosphate of adjacent nucleotides. Helicase unwinds DNA; restriction enzymes cut; polymerase extends existing strands.

Q12 — Answer: (C) They replicate independently inside host cells
Plasmids are extrachromosomal circular DNA that replicate autonomously using the host's replication machinery — this independence from the chromosome allows the inserted gene to be maintained and multiplied. Permanent chromosomal integration would prevent controlled vector maintenance.

Q13 — Answer: (C) Origin of replication
The origin of replication (ori) is the sequence from which replication of the vector begins. A selectable marker identifies transformants, a restriction site permits insertion, and a promoter controls transcription — none of these directly confer replication ability.

Q14 — Answer: (A) Denaturation → annealing → extension
High temperature first separates the DNA strands (denaturation). Primers then anneal to complementary sequences at a lower temperature, followed by extension by Taq DNA polymerase at ~72°C. Repetition of these three steps amplifies the target DNA exponentially.

Q15 — Answer: (B) DNA ligase
DNA ligase forms phosphodiester bonds between adjacent DNA fragments after compatible sticky ends have associated, creating the recombinant molecule. Restriction endonuclease performs the cutting step; primase and helicase are involved in DNA replication, not ligation.

Q16 — Answer: (B) Template DNA, specific primers and thermostable DNA polymerase
PCR requires template DNA as a starting material, specific primers that define the boundaries of the target region and a thermostable DNA polymerase such as Taq that survives repeated denaturation cycles. Restriction enzymes, ligases and ribosomes are not components of PCR.

Q17 — Answer: (A) Phosphate groups give DNA a net negative charge
DNA carries negatively charged phosphate groups in its sugar-phosphate backbone, giving it an overall negative charge. Under an electric field, negatively charged molecules migrate towards the positive electrode, the anode. Smaller fragments move faster through the gel matrix.

Q18 — Answer: (B) Downstream processing of the culture
Downstream processing encompasses recovery, separation and purification of the desired biological product after large-scale production in the bioreactor. PCR amplification, transformation and restriction digestion are upstream molecular steps used in constructing or introducing the recombinant gene.

Q19 — Answer: (C) Agitator system with impeller and baffles
NCERT describes the stirred tank bioreactor as a cylindrical vessel fitted with an agitator (impeller) and baffles that prevent vortex formation, ensuring homogeneous mixing of cells, nutrients, and dissolved gases throughout the culture volume.

Q20 — Answer: (A) Homogeneous mixing of culture medium
The impeller generates turbulent flow that distributes oxygen, nutrients, and pH-adjusting agents uniformly throughout the vessel, preventing concentration gradients that would create microenvironments of suboptimal growth conditions.

Q21 — Answer: (C) Temperature, pH, dissolved oxygen, and agitation speed
Productive fermentation requires simultaneous control of temperature (enzyme activity), pH (metabolic balance), dissolved oxygen (aerobic respiration), and agitation speed (mixing). Failure of any single parameter disrupts cellular metabolism and reduces product yield.

Q22 — Answer: (A) Genetic engineering
Modern biotechnology rests on genetic engineering — deliberate modification of genetic material to obtain desired characteristics. Downstream processing, fermentation, and electrophoresis are tools/steps, not the founding principle.

Q23 — Answer: (C) The same codons specify the same amino acids in most organisms
NCERT explains that codon-amino acid correspondence is universal across most organisms, allowing genes from one organism to function in another. Prokaryotes and eukaryotes alike use the same code — it is not restricted to any group.

Q24 — Answer: (C) Fermentation of sugar to produce alcohol
Traditional biotechnology uses natural organisms without genetic manipulation — fermentation (alcohol, curd) is the classic example. Recombinant insulin, gene cloning, and PCR all involve deliberate gene-level intervention, placing them in modern biotechnology.

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