

OBJECTIVE BOTANY

Recombinant DNA Technology

for

M.Sc. (Semester IV) Paper 2

Author

Dr. Subhash Kumar

Assistant Professor & HOD

Dept. of Botany, CCR (PG) College, Muzaffarnagar (UP)

Dr. Pragati

Associate Professor

Dept. of Botany, MS College, Saharanpur (UP)



First Edition : 2025

ISBN : 978-93-49911-20-8

Printing : Shiv Offset Printers, Meerut

DTP : Learning Media DTP Unit, Meerut

Design: Learning Media Designing Unit, Meerut

© *Publisher*

Publisher: Learning Media Publication, Meerut

Regd. Office :

Learning Media Publication

A-16, Aman Vihar, Mawana Road,

Opp. J.P. Academy, Meerut- 250001

Contact No. +91-8449001390, 8791976106

E-mail : learningmediapublicationmeerut@gmail.com

Website : www.learningmedia.in

Price : ₹ 200

- The views expressed by the authors are their own. The editors and publishers do not own any legal responsibility or liability for the views of the authors, any omission or inadvertent errors.
- No part of this book may be reproduced or transmitted by any means/forms, electronic, mechanical, or any other way, without prior written permission from the publishers.
- Any dispute arising due to any issue/issues related to the publication of this book shall be subject to the jurisdiction of Meerut Courts only.

CONTENT

Solved Paper	1-10
UNIT 1. Introduction: r-DNA Technology	1-18
Important contribution of pioneer workers in this field, Research developments, Opportunities, Institutions and journals.	
UNIT 2. Genetic Engineering	19-44
Definition and explanation, restriction enzymes and restriction modification system, Cloning and expression vectors – Definition and explanation: plasmids, cosmids, and phagemids, fd, fl, and M13 vectors, transposons vectors, Artificial chromosomes as vector, Expression vectors; Use of promoters and expression cassettes, Virus expression vectors, binary and shuttle vectors.	
UNIT 3. Reconstruction of chimeric DNA	45-67
Reconstruction of chimeric DNA – staggered cleavage, addition of Oligopolymer tailing, blunt end ligation, Cloning in bacteria vs. cloning in Eukaryotic cells, Preparation of molecular probes and their uses; labeling of probes, radioactive vs non-radioactive. Techniques used in probing DNA, RNA & Protein electrophoresis, Southern, Northern and Western blotting, Techniques of restriction mapping.	
UNIT 4. Polymerase Chain Reaction	68-86
Principles, techniques and modification, gene cloning vs. PCR, application and uses of PCR, Chromosome walking, Chromosome jumping, Chromosome landing, map-based cloning, Compliment DNA, its cloning and cDNA library.	

UNIT 5.	RFLPs, RAPD and Gene Sequencing	87-100
	RFLPs & RAPD and their applications, Gene sequencing	

UNIT 6.	Protein Engineering & Drug Designing	101-124
	Protein Engineering- definition and explanation, Steps involved, methods used, Achievements and future prospectus, Drug designing – methods used, blocking enzyme activity, blocking hormones receptors, inhibition of DNA/RNA synthesis, Chemical synthesis vs recombinant DNA technology in protein engineering and drug designing.	

UNIT 01

Introduction: r-DNA Technology

Syllabus: Important contribution of pioneer workers in this field, Research developments, Opportunities, Institutions and journals.

Important Contributions of Pioneer Workers

Recombinant DNA (r-DNA) technology, developed in the 1970s, revolutionized genetic engineering. Key pioneers include:

- **Paul Berg** (1972) - Created the first recombinant DNA molecule by combining SV40 virus DNA with bacterial DNA (Nobel Prize, 1980).
- **Herbert Boyer & Stanley Cohen** - Developed methods to insert recombinant DNA into bacterial cells (Cohen-Boyer experiment, 1973).
- **Frederick Sanger** - Developed DNA sequencing techniques (Nobel Prize, 1980).
- **Kary Mullis** - Invented PCR (Polymerase Chain Reaction, 1983), crucial for amplifying DNA (Nobel Prize, 1993).
- **Werner Arber, Daniel Nathans, and Hamilton Smith** - Discovered restriction enzymes (Nobel Prize, 1978).

Research Developments

- **Gene Cloning & Expression** - Production of insulin (Humulin, 1982), growth hormones, and vaccines.

- **CRISPR-Cas9** - Precision gene editing (Emmanuelle Charpentier & Jennifer Doudna, Nobel Prize, 2020).
- **Synthetic Biology** - Designing artificial genes and metabolic pathways.
- **Gene Therapy** - Treating genetic disorders (e.g., CAR-T cell therapy for cancer).
- **Agricultural Biotechnology** - GM crops (Bt cotton, Golden Rice).

Opportunities

- **Pharmaceutical Industry** - Biopharmaceuticals, vaccines, and personalized medicine.
- **Agriculture** - Drought-resistant and high-yield crops.
- **Environmental Biotechnology** - Bioremediation, biofuels.
- **Forensic Science** - DNA fingerprinting.
- **Academia & Research** - Genetic engineering, synthetic biology.

Key Institutions

- **MIT & Harvard (Broad Institute)** - Leading in CRISPR and genomics.
- **Stanford University** - Pioneering work in r-DNA technology.

- **CSIR-IGIB (India)** - Genome editing and biotechnology research.
- **European Molecular Biology Laboratory (EMBL)** - Advanced genetic research.
- **Biotech Companies** - Genentech, Amgen, Moderna, CRISPR Therapeutics.

Major Journals

- **Nature Biotechnology** - Cutting-edge biotech research.
- **Science (Biotechnology Section)** - High-impact studies.

- **Journal of Molecular Biology** - Fundamental genetic research.
- **Biotechnology Advances** - Reviews on biotech progress.
- **CRISPR Journal** - Focus on gene-editing technologies.

Conclusion

r-DNA technology has transformed medicine, agriculture, and industry. With advancements like CRISPR and synthetic biology, the field continues to grow, offering vast opportunities in research and industry. Institutions and journals play a key role in disseminating knowledge and innovations.

EXERCISE

1. Who is known as the Father of Genetic Engineering?

- (a) Gregor Mendel (b) Paul Berg
(c) Watson (d) Nirenberg

Ans. (b) Paul Berg was the first to create recombinant DNA molecules using SV40 virus and bacterial plasmid DNA.

2. Which enzyme is essential for joining DNA fragments?

- (a) DNA polymerase
(b) DNA ligase
(c) Restriction endonuclease
(d) Helicase

Ans. (b) DNA ligase seals nicks and joins DNA fragments during cloning.

3. The first successful recombinant DNA experiment was conducted in:

- (a) 1953 (b) 1968
(c) 1972 (d) 1980

Ans. (c) Paul Berg's group performed the first rDNA experiment in 1972.

4. Which of the following is used to cut DNA at specific sequences?

- (a) Ligase
(b) Restriction enzyme
(c) Exonuclease
(d) DNA polymerase

Ans. (b) These enzymes recognize specific palindromic sequences and cleave DNA.

5. pBR322 is a commonly used:

- (a) Gene (b) Vector
(c) Enzyme (d) Antibiotic

Ans. (b) pBR322 is a circular plasmid vector used in recombinant DNA cloning.

6. The process of introducing foreign DNA into host cells is called:

- (a) Amplification (b) Ligation
(c) Transformation (d) Transcription

Ans. (c) Transformation is the uptake of foreign DNA by a host cell.

7. Which journal is most renowned in the field of molecular biology and rDNA research?

- (a) Indian Journal of Botany
- (b) Nature Biotechnology
- (c) Plant Cell Reports
- (d) Indian Journal of Genetics

Ans. (b) It covers the latest advancements in rDNA and molecular biology.

8. Shuttle vectors can replicate in:

- (a) Only prokaryotes
- (b) Only eukaryotes
- (c) Both prokaryotes and eukaryotes
- (d) Only viruses

Ans. (c) Shuttle vectors contain origins of replication for two different species.

9. The first genetically engineered product approved for use in humans was:

- (a) Insulin
- (b) Growth hormone
- (c) Interferon
- (d) Vaccine

Ans. (a) Humulin (rDNA insulin) was approved by the FDA in 1982.

10. Transposons are:

- (a) RNA molecules
- (b) DNA fragments that jump
- (c) Ribosomes
- (d) Protein channels

Ans. (b) Transposons are “jumping genes” that can move within the genome.

11. The function of alkaline phosphatase in cloning is:

- (a) Cutting DNA
- (b) Sealing DNA
- (c) Preventing self-ligation of vectors
- (d) Synthesizing DNA

Ans. (c) It removes phosphate groups, avoiding vector re-circularization.

12. Yeast plasmids are mainly used in:

- (a) Animal gene transfer
- (b) Plant cloning
- (c) Eukaryotic genetic studies
- (d) Bacterial mutation

Ans. (c) Yeast plasmids replicate in yeast cells and are tools for eukaryotic cloning.

13. Which vector is derived from bacteriophage?

- (a) Ti plasmid
- (b) pUC19
- (c) Cosmid
- (d) Lambda phage vector

Ans. (d) Lambda vectors allow large DNA inserts and efficient infection in bacteria.

14. Reverse transcriptase is an enzyme that:

- (a) Synthesizes RNA from DNA
- (b) Synthesizes DNA from RNA
- (c) Cuts DNA
- (d) Degrades RNA

Ans. (b) Used to make cDNA from mRNA for cloning in eukaryotic genes.

15. The first rDNA product used in agriculture was:

- (a) Bt cotton
- (b) Golden rice
- (c) Herbicide-resistant soybean
- (d) Flavor-Saver tomato

Ans. (d) It was engineered to delay ripening and was approved in 1994.

16. The role of polymerase in rDNA technology is:

- (a) Restrict DNA
- (b) Ligate DNA
- (c) Amplify DNA
- (d) Label DNA

Ans. (c) DNA polymerase is used in PCR to amplify specific gene sequences.

17. Which Indian institution is leading in rDNA research?

- (a) CSIR-CFTRI (b) NBRI
(c) CCMB (d) FSSAI

Ans. (c) The Centre for Cellular and Molecular Biology (CCMB), Hyderabad is a leader in genetic research.

18. Which of the following is a phagemid vector?

- (a) pBR322 (b) M13mp18
(c) Lambda phage (d) Cosmids

Ans. (b) Phagemids are hybrids of plasmids and bacteriophages like M13.

19. What was the key feature of the Human Genome Project?

- (a) Discovery of DNA
(b) Sequencing of all human chromosomes
(c) Finding only protein-coding genes
(d) Gene therapy trials

Ans. (b) The Human Genome Project aimed to map and understand all the genes in human DNA.

20. The first Nobel Prize in recombinant DNA-related research was awarded to:

- (a) Watson and Crick
(b) Paul Berg
(c) Kary Mullis
(d) Har Gobind Khorana

Ans. (b) Berg was awarded the Nobel Prize in Chemistry in 1980 for his fundamental studies in nucleic acids.

21. Which of the following is a palindromic sequence?

- (a) ATCGTA (b) GAATTC
(c) ACGGTC (d) TTAACC

Ans. (b) A palindromic sequence reads the same forward and backward; GAATTC is the recognition site for EcoRI.

22. Which of the following enzymes creates sticky ends in DNA?

- (a) Taq polymerase (b) EcoRI
(c) Ligase
(d) Reverse transcriptase

Ans. (b) EcoRI cuts DNA to leave overhanging "sticky" ends that are helpful in ligating with complementary sequences.

23. Which of the following is NOT a feature of plasmid vectors?

- (a) Origin of replication
(b) Antibiotic resistance gene
(c) Large size
(d) Multiple cloning site

Ans. (c) Vectors should be small for easy manipulation; large size is disadvantageous.

24. A gene library contains:

- (a) Only tRNA genes
(b) Only protein-coding genes
(c) A collection of DNA fragments from an organism
(d) Only mitochondrial DNA

Ans. (c) Gene libraries can be genomic or cDNA, depending on their source.

25. cDNA libraries are prepared using:

- (a) DNA ligase
(b) Restriction enzymes
(c) Reverse transcriptase
(d) Taq polymerase

Ans. (c) Reverse transcriptase converts mRNA into complementary DNA (cDNA).

26. DNA sequencing using chain termination method was developed by:

- (a) Paul Berg (b) Kary Mullis
(c) Frederick Sanger (d) Herbert Boyer

Ans. (c) Sanger's method uses dideoxynucleotides to terminate DNA synthesis for sequencing.

27. The term "molecular scissors" refers to:

- (a) DNA ligase
- (b) Restriction endonuclease
- (c) DNA polymerase
- (d) RNA polymerase

Ans. (b) They cut DNA at specific sequences like scissors.

28. A common reporter gene used in screening is:

- (a) TATA box
- (b) GFP (Green Fluorescent Protein)
- (c) OriC
- (d) Poly-A tail

Ans. (b) Reporter genes help identify successful transformation events.

29. Which of these cloning vectors allows large DNA inserts (>40kb)?

- (a) Plasmid
- (b) Cosmid
- (c) pUC19
- (d) pBR322

Ans. (b) Cosmids combine plasmid features with cos sites from lambda phage.

30. DEAE-dextran is used for:

- (a) Enzyme purification
- (b) Inducing mutation
- (c) DNA transfer into cells
- (d) Protein translation

Ans. (c) It helps in transfection by promoting DNA uptake by the cell.

31. Which enzyme removes nucleotides from the end of a DNA strand?

- (a) Restriction endonuclease
- (b) Exonuclease
- (c) Polymerase
- (d) Ligase

Ans. (b) Exonucleases digest DNA from the ends, unlike endonucleases which cut internally.

32. A selectable marker helps in:

- (a) Identifying protein structure
- (b) Cutting DNA
- (c) Identifying transformed cells
- (d) Regulating gene expression

Ans. (c) Selectable markers like antibiotic resistance genes help in identifying successfully modified cells.

33. A vector must have:

- (a) Start and stop codon
- (b) Telomeres
- (c) Selectable marker
- (d) Poly-A tail

Ans. (c) To distinguish between transformed and non-transformed cells.

34. Charon phage is an example of:

- (a) Plant virus
- (b) Shuttle vector
- (c) Bacteriophage-based cloning vector
- (d) Eukaryotic transposon

Ans. (c) Charon vectors are lambda phage derivatives used in gene cloning.

35. What is the purpose of using alkaline phosphatase in vector preparation?

- (a) Add phosphate group
- (b) Increase DNA yield
- (c) Remove phosphate group to prevent recircularization
- (d) Digest proteins

Ans. (c) Alkaline phosphatase prevents the vector from self-ligating.

36. The first cloning vector developed was:

- (a) pBR322
- (b) pUC18
- (c) SV40
- (d) pSC101

Ans. (d) pSC101 was the first plasmid used as a cloning vector.

37. What is an expression vector?

- (a) A vector without origin
- (b) A vector that produces proteins
- (c) A vector used for PCR
- (d) A vector with no selection marker

Ans. (b) Expression vectors have promoters and ribosome binding sites for expressing the inserted gene.

38. A plasmid that can replicate in both yeast and bacteria is called:

- (a) Shuttle vector
- (b) Cosmid
- (c) Integrating vector
- (d) Episome

Ans. (a) These are engineered to function in multiple host systems.

39. In PCR, the enzyme used for DNA amplification is:

- (a) DNA polymerase I
- (b) Taq polymerase
- (c) RNA polymerase
- (d) DNA ligase

Ans. (b) Taq polymerase is heat-stable and used in PCR cycles.

40. The Indian journal primarily focused on biotechnology is:

- (a) Journal of Genetics
- (b) Indian Journal of Experimental Biology
- (c) Indian Journal of Biotechnology
- (d) Indian Journal of Ecology

Ans. (c) Published by CSIR, it covers biotechnology and rDNA research in India.

41. Who is credited with proposing the "Wobble Hypothesis" in genetic code interpretation?

- (a) James Watson
- (b) Francis Crick
- (c) Marshall Nirenberg
- (d) Har Gobind Khorana

Ans. (b) Crick proposed the Wobble Hypothesis (1966), explaining flexibility in codon-anticodon pairing at the third nucleotide. Nirenberg and Khorana deciphered the genetic code experimentally.

42. Which institution is renowned for the discovery of the CRISPR-Cas9 gene-editing system?

- (a) MIT
- (b) Broad Institute
- (c) Max Planck Institute
- (d) Pasteur Institute

Ans. (b) Emmanuelle Charpentier (Max Planck) and Jennifer Doudna (UC Berkeley) pioneered CRISPR, but Broad Institute (Feng Zhang) patented its use in eukaryotic cells.

43. The journal Nature Methods primarily focuses on:

- (a) Clinical trials
- (b) New laboratory techniques
- (c) Ecological studies
- (d) Theoretical physics

Ans. (b) Nature Methods highlights innovative tools/methods in molecular biology (e.g., single-cell sequencing).

44. Who isolated the first restriction enzyme, earning a Nobel Prize?

- (a) Kary Mullis
- (b) Hamilton Smith
- (c) Werner Arber
- (d) Paul Berg

Ans. (b) Smith isolated HindII (1970). Arber predicted restriction enzymes; Berg pioneered recombinant DNA.

45. The Human Genome Project was coordinated by:

- (a) NIH and DOE (USA)
- (b) WHO and UNESCO
- (c) CSIR and ICAR (India)
- (d) European Molecular Biology Laboratory

Ans. (a) Led by Francis Collins (NIH) and international collaborators (1990-2003).

46. Which pioneer developed the polymerase chain reaction (PCR)?

- (a) Frederick Sanger (b) Kary Mullis
- (c) Sydney Brenner (d) Craig Venter

Ans. (b) Mullis invented PCR in 1983, revolutionizing DNA amplification.

47. Cell, Science, and Nature are examples of:

- (a) Open-access journals
- (b) Peer-reviewed research journals
- (c) Government reports
- (d) Popular science magazines

Ans. (b) These are high-impact journals publishing cutting-edge molecular biology research.

48. The first synthetic genome was created by:

- (a) Craig Venter's team
- (b) Jennifer Doudna's lab
- (c) James Watson's institute
- (d) Gregor Mendel's foundation

Ans. (a) Venter's team synthesized *Mycoplasma genitalium*'s genome (2010).

49. Which Indian institution is a leader in structural biology research?

- (a) IISc Bangalore (b) TIFR Mumbai
- (c) CCMB Hyderabad
- (d) All of the above

Ans. (d) IISc (G.N. Ramachandran), TIFR (protein crystallography), and CCMB (genomics) contribute significantly.

50. The term "molecular biology" was coined by:

- (a) Linus Pauling (b) Warren Weaver
- (c) Rosalind Franklin
- (d) Barbara McClintock

Ans. (b) Weaver (Rockefeller Foundation) used the term in 1938 to describe biological processes at the molecular level.

51. Which Nobel laureate discovered transposons ("jumping genes")?

- (a) Barbara McClintock
- (b) Thomas Hunt Morgan
- (c) Hermann Muller (d) Joshua Lederberg

Ans. (a) McClintock discovered transposons in maize (1940s), earning the 1983 Nobel Prize.

52. The Sanger sequencing method was developed by:

- (a) Frederick Sanger (b) Walter Gilbert
- (c) Allan Maxam (d) Kary Mullis

Ans. (a) Sanger's dideoxy method (1977) was foundational for DNA sequencing.

53. Which journal published the first paper on the double-helix structure of DNA?

- (a) Nature (b) Science
- (c) Cell (d) PNAS

Ans. (a) Watson and Crick's 1953 paper appeared in Nature.

54. The European Molecular Biology Organization (EMBO) is headquartered in:

- (a) Heidelberg, Germany
- (b) Cambridge, UK
- (c) Paris, France
- (d) Zurich, Switzerland

Ans. (a) EMBO promotes life sciences research and training in Europe.

55. Who pioneered the use of GFP (Green Fluorescent Protein) as a molecular tag?

- (a) Martin Chalfie (b) Roger Tsien
- (c) Osamu Shimomura
- (d) All of the above

Ans. (d) Shimomura isolated GFP; Chalfie and Tsien developed its applications (2008 Nobel Prize).

56. The CRISPR Journal focuses on:

- (a) Gene-editing technologies
- (b) Cancer immunotherapy
- (c) Stem cell therapies
- (d) Nanotechnology

Ans. (a) Dedicated to CRISPR-based research and ethical discussions.

57. The first genetically modified organism (GMO) was created by:

- (a) Stanley Cohen and Herbert Boyer
- (b) Ian Wilmut
- (c) Robert Hooke
- (d) Gregor Mendel

Ans. (a) Engineered recombinant DNA in *E. coli* (1973).

58. Which Indian scientist contributed significantly to RNA biology and institutions like IISER?

- (a) C.N.R. Rao
- (b) Venkatraman Ramakrishnan
- (c) Manju Bansal
- (d) Obaid Siddiqi

Ans. (b) Nobel laureate Ramakrishnan studied ribosome structure and supported IISER Pune.

59. The National Centre for Biological Sciences (NCBS) is located in:

- (a) Bangalore
- (b) New Delhi
- (c) Pune
- (d) Kolkata

Ans. (a) NCBS is a premier TIFR institute for molecular and cellular biology.

60. The first complete genome sequenced was of:

- (a) *Homo sapiens*
- (b) *Escherichia coli*
- (c) *Haemophilus influenzae*
- (d) *Mycoplasma genitalium*

Ans. (c) Sequenced by Craig Venter's team in 1995.

61. Who proposed the cell theory?

- (a) Charles Darwin
- (b) Robert Hooke
- (c) Theodor Schwann and Matthias Schleiden
- (d) Gregor Mendel

Ans. (c) The cell theory was formulated by Theodor Schwann and Matthias Schleiden, which states that all living organisms are composed of cells, and that the cell is the basic structural and functional unit of life.

62. Which scientist proposed the wobble hypothesis?

- (a) Francis Crick
- (b) James Watson
- (c) Marshall Nirenberg
- (d) Rosalind Franklin

Ans. (a) The wobble hypothesis, proposed by Francis Crick in 1966, explains how a single tRNA molecule can recognize multiple codons, thus accounting for the redundancy in the genetic code.

63. Which bacterium is commonly used in biotechnology for pest resistance in crops?

- (a) *Escherichia coli*
- (b) *Bacillus thuringiensis*
- (c) *Streptomyces griseus*
- (d) *Clostridium botulinum*

Ans. (b) *Bacillus thuringiensis* is widely used in agricultural biotechnology as it produces a toxin that is toxic to specific insects, making it useful for pest-resistant crops.

64. Which journal is considered one of the leading publications for molecular biology research?

- (a) Nature
- (b) Science
- (c) Cell
- (d) The Lancet

Ans. (c) Cell is one of the most prestigious journals in molecular biology and cell science, publishing high-impact research on cellular and molecular processes.

65. Who is regarded as the father of modern genetics?

- (a) Charles Darwin
- (b) Gregor Mendel
- (c) Louis Pasteur
- (d) Thomas Hunt Morgan

Ans. (b) Gregor Mendel is considered the father of modern genetics due to his foundational work in the inheritance of traits in pea plants, leading to the laws of inheritance.

66. Which of the following is NOT a key contribution of Charles Darwin?

- (a) Theory of natural selection
- (b) Theory of evolution
- (c) Formulation of the cell theory
- (d) Study of adaptation in species

Ans. (c) Charles Darwin is known for his work on natural selection and the theory of evolution, but the formulation of the cell theory is attributed to Theodor Schwann and Matthias Schleiden.

67. Which research development is closely associated with the discovery of the structure of DNA?

- (a) X-ray crystallography
- (b) PCR (Polymerase Chain Reaction)
- (c) Electrophoresis
- (d) Cloning

Ans. (a) X-ray crystallography played a crucial role in determining the double-helix structure of DNA, primarily through the work of Rosalind Franklin, whose X-ray diffraction images were vital.

68. What is the main role of the *Bacillus thuringiensis* toxin in pest resistance?

- (a) Inhibits photosynthesis in pests
- (b) Disrupts the insect's digestive system
- (c) Acts as a repellent
- (d) Increases pest reproduction

Ans. (b) The toxin produced by *Bacillus thuringiensis* disrupts the digestive system of insects, leading to their death. This makes it an effective biological pesticide.

69. Which of the following is a major research development in plant biotechnology?

- (a) Genetic modification of crops for drought resistance
- (b) Development of high fructose corn syrup
- (c) Discovery of CRISPR technology
- (d) Improvement of yeast fermentation

Ans. (a) A significant development in plant biotechnology includes the genetic modification of crops to resist environmental stressors like drought, improving crop yields in challenging conditions.

70. Which institution is a leading global center for genetic research?

- (a) Max Planck Institute
- (b) Harvard University
- (c) The Salk Institute
- (d) All of the above

Ans. (d) Institutions like the Max Planck Institute, Harvard University, and the Salk Institute are recognized worldwide for their contributions to genetic and molecular biology research.

71. Which scientific journal publishes research related to genetics and evolution?

- (a) Nature Genetics
- (b) Molecular Biology of the Cell
- (c) PLOS One
- (d) Annual Review of Genetics

Ans. (a) Nature Genetics is a leading journal for research in genetics and evolutionary biology, publishing groundbreaking studies in these fields.

72. Which cell structure was discovered by Robert Hooke?

- (a) Nucleus
- (b) Cell membrane
- (c) Mitochondria
- (d) Cell wall

Ans. (d) Robert Hooke is credited with discovering the cell while observing cork under a microscope and describing the "cells" that he saw, which were actually the cell walls of plant tissue.

73. Which of the following journals primarily focuses on research in cell biology?

- (a) Cell
- (b) Nature Neuroscience
- (c) The Journal of Cell Biology
- (d) Developmental Cell

Ans. (c) The Journal of Cell Biology is a key journal that publishes research focused on cell biology, including studies on cellular processes and mechanisms.

74. What major contribution did Louis Pasteur make to microbiology?

- (a) Germ theory of disease
- (b) Discovery of antibiotics
- (c) Formulation of the cell theory
- (d) Discovery of the double-helix structure of DNA

Ans. (a) Louis Pasteur's germ theory of disease revolutionized our understanding of infection and led to developments in sterilization and vaccines.

75. Which of the following is a characteristic of the wobble hypothesis?

- (a) It explains the redundancy in the genetic code
- (b) It describes the structure of DNA
- (c) It helps explain the mutation process
- (d) It outlines the structure of proteins

Ans. (a) The wobble hypothesis helps explain why multiple codons can code for the same amino acid due to the flexibility in base pairing between the third codon position and tRNA anticodons.

76. Which scientific technique was pivotal in the development of genetic engineering?

- (a) Cloning
- (b) Gel electrophoresis
- (c) Recombinant DNA technology
- (d) Electroporation

Ans. (c) Recombinant DNA technology allows scientists to combine DNA from different organisms, enabling the creation of genetically modified organisms (GMOs).

77. Which of the following is NOT a characteristic of the *Bacillus thuringiensis* bacterium?

- (a) Produces insecticidal toxins
- (b) Used in the production of genetically modified crops
- (c) Found naturally in soil
- (d) Causes human diseases

Ans. (d) *Bacillus thuringiensis* is not harmful to humans and is widely used in agriculture for pest control, producing proteins toxic to certain insects.

78. Which institution played a significant role in the development of the Human Genome Project?

- (a) Cold Spring Harbor Laboratory
- (b) National Institutes of Health (NIH)
- (c) Max Planck Institute
- (d) Oxford University

Ans. (b) The NIH was a key player in the Human Genome Project, which mapped the entire human genome and provided crucial insights into genetics.

79. What is a major benefit of using *Bacillus thuringiensis* in agriculture?

- (a) Increased crop yield
- (b) Reduced pesticide use
- (c) Faster crop growth
- (d) Increased resistance to viruses

Ans. (b) *Bacillus thuringiensis* is used in genetically modified crops to reduce the need for chemical pesticides, providing a more environmentally friendly option for pest control.

80. Which of the following best describes the primary focus of *Nature Biotechnology* journal?

- (a) Genetic disease research
- (b) Molecular biology
- (c) Biotechnology innovations and applications
- (d) Evolutionary genetics

Ans. (c) Biotechnology innovations and applications

81. Who is known for creating the first recombinant DNA molecule?

- (a) James Watson (b) Francis Crick
- (c) Paul Berg (d) Herbert Boyer

Ans. (c) Paul Berg is credited with the creation of the first recombinant DNA

molecule in 1972, using restriction enzymes and ligases.

82. Which scientist is credited with the discovery of restriction enzymes used in r-DNA technology?

- (a) James Watson (b) Werner Arber
- (c) Edward Jenner (d) Alexander Fleming

Ans. (b) Werner Arber discovered restriction enzymes, which are crucial for cutting DNA at specific sequences, a key step in recombinant DNA technology.

83. Who developed the first recombinant plasmid to introduce foreign genes into bacteria?

- (a) Stanley Cohen and Herbert Boyer
- (b) Francis Crick and James Watson
- (c) Albert Einstein (d) Robert Hooke

Ans. (a) In 1973, Stanley Cohen and Herbert Boyer created the first recombinant plasmid to transfer foreign DNA into bacteria.

84. Which scientist was awarded the Nobel Prize for the discovery of the double helix structure of DNA, laying the foundation for genetic research?

- (a) James Watson
- (b) Rosalind Franklin
- (c) Albert Einstein
- (d) Charles Darwin

Ans. (a) James Watson, along with Francis Crick, is credited for the discovery of the double helix structure of DNA, which led to major advancements in molecular biology, including r-DNA technology.

85. Who is credited with developing the technique of gel electrophoresis, a key tool in molecular biology?

- (a) Kary Mullis (b) Ed Southern
- (c) Arthur Kornberg (d) Stanley Cohen

Ans. (b) Ed Southern developed the Southern blot technique, a method for detecting specific DNA sequences, which is widely used in r-DNA research.

86. Which scientist was responsible for the development of polymerase chain reaction (PCR)?

- (a) Kary Mullis (b) J. Craig Venter
- (c) Albert Einstein (d) George Beadle

Ans. (a) Kary Mullis developed the PCR technique in 1983, which allows for the amplification of specific DNA sequences and plays a key role in r-DNA technology.

87. Who first synthesized insulin using r-DNA technology for therapeutic use?

- (a) Stanley Cohen (b) Herbert Boyer
- (c) Genentech (d) Eli Lilly

Ans. (c) Genentech, in 1978, became the first company to produce synthetic insulin using recombinant DNA technology.

88. Which discovery is considered the cornerstone of r-DNA technology?

- (a) Polymerase chain reaction (PCR)
- (b) Cloning of the first animal
- (c) Discovery of the structure of DNA
- (d) Isolation of the first restriction enzyme

Ans. (d) The discovery of restriction enzymes allowed scientists to cut DNA at specific sites, a critical development for the creation of recombinant DNA molecules.

89. Who were the first to patent a genetically modified organism (GMO)?

- (a) Stanley Cohen and Herbert Boyer
- (b) James Watson and Francis Crick
- (c) Monsanto
- (d) Genentech

Ans. (a) Cohen and Boyer were the first to patent their genetically engineered bacteria in the 1970s, marking a pivotal moment in biotechnology.

90. Which is the first genetically engineered vaccine produced using r-DNA technology?

- (a) Hepatitis B vaccine
- (b) MMR vaccine
- (c) Polio vaccine
- (d) Smallpox vaccine

Ans. (a) The first recombinant DNA-based vaccine, the Hepatitis B vaccine, was developed using yeast cells to produce the viral protein.

91. Which breakthrough technology allows for the precise editing of DNA sequences?

- (a) CRISPR-Cas9
- (b) PCR
- (c) RNA interference
- (d) Gel electrophoresis

Ans. (a) CRISPR-Cas9 is a revolutionary gene-editing tool that allows scientists to precisely alter DNA, advancing research in genetic engineering and therapy.

92. What role do restriction enzymes play in recombinant DNA technology?

- (a) They replicate DNA sequences
- (b) They cut DNA at specific locations
- (c) They synthesize RNA
- (d) They form covalent bonds between DNA strands

Ans. (b) Restriction enzymes act as molecular scissors, cutting DNA at specific sequences, which is crucial for the creation of recombinant DNA.

93. Which of the following is a primary use of r-DNA technology in agriculture?

- (a) Producing genetically modified crops with improved resistance
- (b) Manufacturing medicines
- (c) Developing synthetic plastics
- (d) Creating biodegradable oils

Ans. (a) r-DNA technology is widely used to engineer crops with desirable traits like pest resistance, drought tolerance, and increased nutritional value.

94. What is the primary aim of gene therapy, a research development in r-DNA technology?

- (a) To develop new vaccines
- (b) To correct genetic disorders by altering DNA
- (c) To create genetically modified food
- (d) To clone organisms

Ans. (b) Gene therapy aims to treat or prevent diseases by inserting, altering, or removing genes within a patient's cells.

95. Which organism is commonly used as a host in r-DNA technology for the production of insulin?

- (a) *E. coli* (bacteria)
- (b) Yeast
- (c) Tobacco plants
- (d) Sheep

Ans. (a) *E. coli* is commonly used in r-DNA technology for producing insulin, as it can be genetically engineered to express human insulin.

96. Which of the following is a direct application of r-DNA technology in medicine?

- (a) Production of human insulin
- (b) Creation of genetically modified plants
- (c) Development of artificial intelligence
- (d) Production of biofuels

Ans. (a) Recombinant DNA technology has enabled the production of human insulin, replacing animal-derived insulin for diabetes treatment.

97. Which of the following was a significant achievement in r-DNA technology?

- (a) Cloning of Dolly the sheep
- (b) Mapping of the human genome
- (c) The first synthetic organism
- (d) All of the above

Ans. (d) These are all significant milestones achieved through the application of r-DNA technology: cloning, sequencing, and synthetic biology.

98. Which technology is often used alongside r-DNA technology for identifying and analyzing genetic material?

- (a) Electrophoresis
- (b) Mass spectrometry
- (c) Nuclear magnetic resonance
- (d) 3D printing

Ans. (a) Electrophoresis is used to separate DNA fragments by size, helping in the analysis and manipulation of genetic material.

99. Which method is used to introduce recombinant DNA into a host cell?

- (a) Gel electrophoresis
- (b) Transformation
- (c) PCR
- (d) Immunization

Ans. (b) Transformation is the process of introducing foreign DNA into a host cell, typically bacteria, which is fundamental to recombinant DNA technology.

100. What was a major development in r-DNA technology in the 1990s?

- (a) The discovery of gene cloning
- (b) The development of the first synthetic organism
- (c) The first cloning of human cells
- (d) The completion of the Human Genome Project

Ans. (d) The completion of the Human Genome Project in 2003 was a milestone in genetics, enabling deeper understanding and applications of r-DNA technology.

101. Which industry offers career opportunities in genetic engineering and r-DNA technology?

- (a) Pharmaceuticals
- (b) Agriculture
- (c) Environmental science
- (d) All of the above

Ans. (d) Genetic engineering offers opportunities in various industries, including medicine, agriculture, and environmental science.

102. In which area can r-DNA technology be used to improve public health?

- (a) Water purification
- (b) Cancer treatment
- (c) Waste management
- (d) Climate change mitigation

Ans. (b) r-DNA technology is used in the development of targeted therapies and vaccines for various types of cancer.

103. What career would involve working with genetically modified organisms (GMOs)?

- (a) Geneticist
- (b) Environmental consultant
- (c) Biotech researcher
- (d) All of the above

Ans. (d) Many careers in biotechnology, environmental science, and genetic research involve working with GMOs.

104. Which professional organization would most likely publish research in the field of molecular genetics?

- (a) American Chemical Society
- (b) American Society for Microbiology
- (c) International Society for Molecular Biology
- (d) Society for Human Resource Management

Ans. (c) The International Society for Molecular Biology focuses on advancing research in genetics, including r-DNA technologies.

105. Which career opportunity exists for researchers working with recombinant DNA technology in agriculture?

- (a) Plant biotechnologist
- (b) Molecular geneticist
- (c) Agricultural geneticist
- (d) All of the above

Ans. (d) Researchers in agriculture can work in various roles related to genetic engineering and improving crops using r-DNA technology.

106. Which institution is known for its cutting-edge research in biotechnology and r-DNA technology?

- (a) Massachusetts Institute of Technology (MIT)
- (b) Harvard University
- (c) Stanford University
- (d) All of the above

Ans. (d) MIT, Harvard, and Stanford are leading institutions in biotechnology research, including r-DNA technology.

107. Which scientific journal is dedicated to publishing articles related to genetic engineering?

- (a) Nature Biotechnology
- (b) The Lancet
- (c) Cell
- (d) New England Journal of Medicine

Ans. (a) Nature Biotechnology is a leading journal for research on genetic engineering, molecular biology, and r-DNA technology.

108. Which organization was instrumental in funding research for the Human Genome Project?

- (a) NIH (National Institutes of Health)
- (b) FDA (Food and Drug Administration)
- (c) WHO (World Health Organization)
- (d) NASA

Ans. (a) The NIH played a significant role in funding and overseeing the Human Genome Project.

109. Which institution pioneered the use of r-DNA technology for producing synthetic human insulin?

- (a) Genentech
- (b) University of California, San Francisco
- (c) Eli Lilly
- (d) Monsanto

Ans. (a) Genentech was the first company to use r-DNA technology to produce synthetic human insulin.

110. Which publication is considered one of the most authoritative sources for molecular biology research?

- (a) Journal of Molecular Biology
- (b) Science
- (c) Nature
- (d) All of the above

Ans. (d) The Journal of Molecular Biology, Nature, and Science are all considered authoritative journals for molecular biology research, including r-DNA technology.

111. Who developed the first genetically modified bacteria in the 1970s?

- (a) James Watson
- (b) Herbert Boyer and Stanley Cohen
- (c) Kary Mullis
- (d) Paul Berg

Ans. (b) Boyer and Cohen are credited with developing the first genetically modified bacteria in the 1970s using recombinant DNA technology.

112. Which scientist is known for developing the concept of cloning through the process of somatic cell nuclear transfer?

- (a) Dolly the Sheep
- (b) Ian Wilmut
- (c) George Beadle
- (d) Max Delbrück

Ans. (b) Ian Wilmut is known for leading the team that cloned Dolly the sheep, the first mammal cloned from an adult somatic cell.

113. Which biotechnology company produced the first recombinant DNA-based vaccine?

- (a) Genentech
- (b) Amgen
- (c) Merck
- (d) Genzyme

Ans. (c) Merck developed the first recombinant DNA-based vaccine for Hepatitis B in 1986, marking a major milestone in biotechnology.

114. Which researcher was the first to clone a human gene using recombinant DNA technology?

- (a) Stanley Cohen
- (b) Rosalind Franklin
- (c) Herbert Boyer
- (d) Kary Mullis

Ans. (c) Herbert Boyer is credited with the first cloning of a human gene, paving the way for recombinant gene therapies.

115. Who was the first to demonstrate that recombinant DNA molecules can be integrated into the genome of living organisms?

- (a) Peter D. Mitchell
- (b) Paul Berg
- (c) Barbara McClintock
- (d) Carl Woese

Ans. (b) Paul Berg demonstrated that recombinant DNA molecules could be integrated into the genomes of living organisms, which was a major step forward in genetic engineering.

116. Which pioneer is known for developing the technique of in vitro mutagenesis, which is essential for r-DNA technology?

- (a) Hermann Müller (b) Michael Smith
- (c) Frederick Sanger (d) Alfred Hershey

Ans. (b) Michael Smith developed the technique of in vitro mutagenesis, which allows for the precise alteration of genes, a technique integral to r-DNA technology.

117. Who developed the first commercially available r-DNA-based medicine (Insulin)?

- (a) Eli Lilly (b) Genentech
- (c) Amgen (d) Merck

Ans. (a) Eli Lilly was the first company to produce recombinant insulin for commercial use, a significant achievement in pharmaceutical biotechnology.

118. Which researcher is associated with the discovery and application of transposons (jumping genes) in recombinant DNA technology?

- (a) Barbara McClintock
- (b) Max Delbrück
- (c) James Watson
- (d) Albert Einstein

Ans. (a) Barbara McClintock discovered transposons, or "jumping genes," which can move within the genome and are a powerful tool in genetic engineering.

119. Which of these pioneers was instrumental in the development of monoclonal antibody technology?

- (a) Georges Köhler and César Milstein
- (b) Rosalind Franklin
- (c) Paul Berg
- (d) Kary Mullis

Ans. (a) Georges Köhler and César Milstein developed monoclonal antibody technology in the 1970s, which is essential for both research and therapeutic applications.

120. Who is known for the discovery of the role of plasmids in bacterial gene transfer?

- (a) Rosalind Franklin
- (b) Jacob and Monod
- (c) Alexander Fleming
- (d) Joshua Lederberg

Ans. (d) Joshua Lederberg was pivotal in the discovery of plasmids, which are key elements in bacterial gene transfer and recombinant DNA technology.

121. Which technology has enabled high-throughput DNA sequencing, making it easier to conduct genetic studies?

- (a) Sanger sequencing
- (b) Next-generation sequencing (NGS)
- (c) PCR amplification
- (d) CRISPR-Cas9

Ans. (b) Next-generation sequencing (NGS) allows for high-throughput and cost-effective sequencing of DNA, revolutionizing genetic research.

122. Which is a primary application of CRISPR-Cas9 technology in r-DNA research?

- (a) Editing animal genomes for increased size
- (b) Replacing defective genes to treat genetic disorders
- (c) Cloning animals
- (d) Producing recombinant proteins

Ans. (b) CRISPR-Cas9 is primarily used to edit genes, including replacing defective genes to treat genetic disorders like cystic fibrosis and muscular dystrophy.

123. Which of the following is a breakthrough in r-DNA technology for agriculture?

- (a) Genetically modified Bt cotton
- (b) Gene editing to increase fruit size
- (c) Development of drought-resistant wheat
- (d) All of the above

Ans. (d) r-DNA technology has led to the development of genetically modified crops, such as Bt cotton, and gene-edited crops with enhanced resilience and yield.

124. Which of the following is NOT a tool used in r-DNA technology?

- (a) Restriction enzymes
- (b) DNA ligase
- (c) Taq polymerase
- (d) Insulin receptor blockers

Ans. (d) Insulin receptor blockers are not part of the tools used in r-DNA technology, which

primarily involves restriction enzymes, ligases, and other DNA-modifying tools.

125. What is a major challenge in r-DNA research related to gene editing?

- (a) Ethical concerns and potential misuse
- (b) High cost of reagents
- (c) Difficulty in maintaining gene edits across generations
- (d) Both A and C

Ans. (d) The major challenges in r-DNA technology include ethical concerns (e.g., gene editing in humans) and ensuring stable genetic modifications across generations.

126. What is the purpose of electroporation in r-DNA research?

- (a) To purify DNA
- (b) To amplify DNA
- (c) To introduce recombinant DNA into cells
- (d) To sequence DNA

Ans. (c) Electroporation is used to introduce recombinant DNA into cells by applying an electric field that temporarily makes cell membranes permeable.

127. Which of the following is a major focus of current r-DNA technology research in medicine?

- (a) Gene therapy for genetic diseases
- (b) Creating antibiotics for resistant bacteria
- (c) Developing vaccines for emerging diseases
- (d) All of the above

Ans. (d) r-DNA technology is being researched for applications in gene therapy, antibiotic development, and vaccine creation.

128. Which biotechnology company produced the first r-DNA-based human growth hormone (HGH)?

- (a) Genentech
- (b) Amgen
- (c) Roche
- (d) Eli Lilly

Ans. (a) Genentech was the first to produce r-DNA-based human growth hormone, providing an important therapeutic protein for patients with growth deficiencies.

129. What was the first genetically engineered organism to be patented?

- (a) The "oncomouse" (cancer-resistant mouse)
- (b) E. coli producing human insulin

- (c) The "super-salmon" fish
- (d) Bt cotton

Ans. (b) The first genetically engineered organism to be patented was E. coli bacteria engineered to produce human insulin, which revolutionized diabetes treatment.

130. Which process is used to purify proteins produced by recombinant DNA technology?

- (a) Gel electrophoresis
- (b) Chromatography
- (c) Electroporation
- (d) PCR amplification

Ans. (b) Chromatography is a technique used to purify proteins and other biomolecules produced by recombinant DNA technology.