

Mendelian Genetics and Genetic Recombination



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المزيد من مادة
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التواصل الاجتماعي بحسب الصف الحادي عشر العام



صفحة المناهج
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ارتباط الجينات وتعدد المجموعات الكروموسومية

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علم الوراثة المنديلية

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الانقسام المنصف

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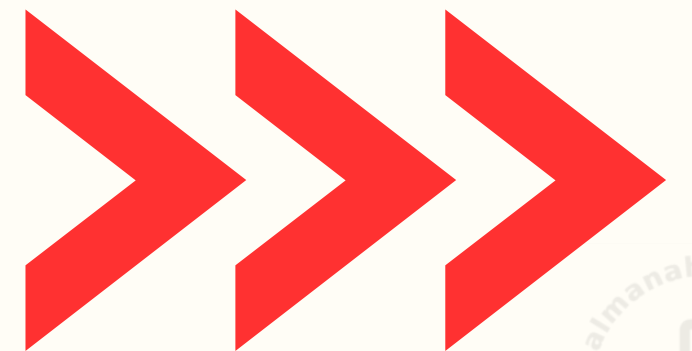
انسباير منهج Cellular Energy - Solution Paper

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Mendelian genetics



MENDELIAN GENETICS

INTRODUCTION:

GREGOR MENDEL, KNOWN AS THE "FATHER OF GENETICS," PIONEERED THE STUDY OF HEREDITY THROUGH EXPERIMENTS WITH GARDEN PEA PLANTS. HIS SYSTEMATIC APPROACH PROVIDED A SCIENTIFIC EXPLANATION FOR INHERITANCE PATTERNS.

KEY CONCEPTS OF MENDEL'S WORK

TRAITS AND INHERITANCE

INHERITANCE/HEREDITY: PASSING TRAITS FROM PARENTS TO OFFSPRING.

MENDEL FOCUSED ON OBSERVABLE TRAITS LIKE SEED COLOR (YELLOW OR GREEN) AND TEXTURE (SMOOTH OR WRINKLED).

EXPERIMENTAL METHODOLOGY

MENDEL CHOSE PEA PLANTS FOR THEIR:

- OBSERVABLE TRAITS: EASILY DISTINGUISHABLE CHARACTERISTICS.
- SHORT GENERATION TIME: RAPID RESULTS.
- CONTROLLED MATING: SELF- OR CROSS-POLLINATION ENABLED SPECIFIC TRAIT COMBINATIONS.
- TRUE BREEDING: ENSURED CONSISTENT TRAITS IN SUCCESSIVE GENERATIONS.

FINDINGS ON INHERITANCE

1. PARENT (P) GENERATION:

- ORIGINAL PURE-BREEDING PLANTS (E.G., GREEN SEEDS VS. YELLOW SEEDS).

2. F1 GENERATION:

- OFFSPRING FROM CROSSING P PLANTS.
- ONLY DOMINANT TRAITS (E.G., YELLOW SEEDS) WERE VISIBLE, WHILE RECESSIVE TRAITS (E.G., GREEN SEEDS) WERE MASKED.

3. F2 GENERATION:

- SELF-POLLINATION OF F1 PLANTS RESULTED IN A 3:1 PHENOTYPIC RATIO OF DOMINANT TO RECESSIVE TRAITS.

4. CONCLUSION:

- EACH ORGANISM INHERITS TWO ALLELES FOR EACH GENE, ONE FROM EACH PARENT.

MENDELIAN GENETICS

MENDEL'S LAWS

1. LAW OF SEGREGATION

- TWO ALLELES FOR A SINGLE TRAIT SEPARATE DURING GAMETE FORMATION (MEIOSIS).
- DURING FERTILIZATION, ONE ALLELE FROM EACH PARENT RECOMBINES, ENSURING GENETIC DIVERSITY.

2. LAW OF INDEPENDENT ASSORTMENT

- ALLELES FOR DIFFERENT TRAITS ARE DISTRIBUTED INDEPENDENTLY DURING GAMETE FORMATION.
- APPLICABLE TO GENES LOCATED ON DIFFERENT CHROMOSOMES.

ALLELES, GENOTYPE, AND PHENOTYPE

ALLELES

- DIFFERENT FORMS OF A GENE, E.G., YELLOW (Y) OR GREEN (y) SEED COLOR ALLELES.

GENOTYPE

- THE GENETIC MAKEUP OF AN ORGANISM:
- **Homozygous:** Two identical alleles (YY or yy).
- **HETEROZYGOUS (HYBRID):** TWO DIFFERENT ALLELES (Yy).

PHENOTYPE

- OBSERVABLE TRAITS RESULTING FROM A GENOTYPE, E.G., YELLOW OR GREEN SEEDS.

DOMINANT AND RECESSIVE ALLELES

- **Dominant** (e.g., Y): Masks the expression of the recessive allele (e.g., y).
- **Recessive:** Only expressed when both alleles are recessive (yy).

PUNNETT SQUARES

1. Monohybrid Cross

- Examines one trait.
- Results in:
- Genotypic ratio: 1:2:1 (e.g., FF: Ff: ff).
- Phenotypic ratio: 3:1 (dominant to recessive).

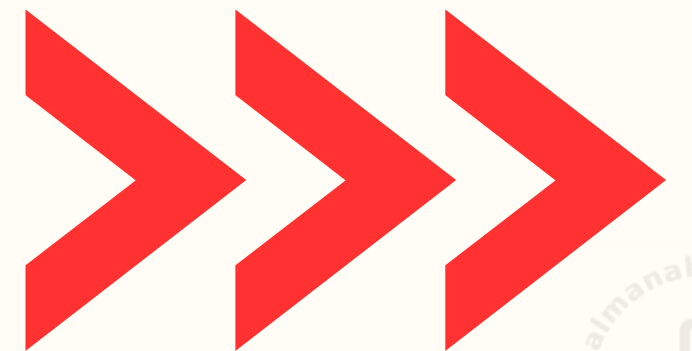
2. Dihybrid Cross

- Examines two traits simultaneously.
- Produces a 9:3:3:1 phenotypic ratio.

PROBABILITY AND GENETICS

- MENDEL USED PROBABILITY TO PREDICT GENETIC OUTCOMES.
- LARGER SAMPLE SIZES LEAD TO CLOSER MATCHES WITH PREDICTED RATIOS (E.G., 9:3:3:1 IN DIHYBRID CROSSES).

Genetic recombination and gene linkage



Genetic Recombination and Gene Linkage

Introduction

This lesson focuses on understanding how genetic recombination and gene linkage contribute to genetic variation and their relationship to Mendel's principles.

Key Concepts

Genetic Recombination

1. **Definition:** The new combination of genes created through:

- Crossing Over: Exchange of genetic material between homologous chromosomes during meiosis.
- Independent Assortment: Random distribution of chromosome pairs into gametes.

2. **Variation Formula:**

- Genetic combinations due to independent assortment are calculated as $2n \times 2^n$, where n is the number of chromosome pairs.
- **Total combinations after fertilization:** $2n \times 2n \times n \times 2^n \times 2n$.

3. **Impact:**

- Increases genetic diversity within a species.

Gene Linkage

1. **Definition:** Genes located close to each other on the same chromosome are linked and tend to be inherited together.

2. **Exception to Mendel's Law of Independent Assortment:**

- Linked genes do not assort independently unless separated by crossing over.

3. **Chromosome Maps:**

- Crossing over occurs more frequently between genes farther apart.
- This frequency is used to map gene positions on chromosomes.

Genetic Recombination and Gene Linkage

Polyploidy

1. Definition:

- Polyploidy refers to the occurrence of extra sets of chromosomes in an organism (e.g., $3n$, $4n$).
- Example: A triploid ($3n$) organism has three full sets of chromosomes.

2. Significance in Agriculture:

- Many crops, such as wheat ($6n$), oats ($6n$), and sugarcane ($8n$), are polyploid.
- Benefits: Increased size, vigor, and resilience in plants.

Summary of Key Takeaways

1. Genetic Recombination:

- Promotes variation through crossing over and independent assortment, enabling adaptability in species.

2. Gene Linkage:

- Challenges Mendel's laws but provides insights into inheritance patterns and chromosomal organization.

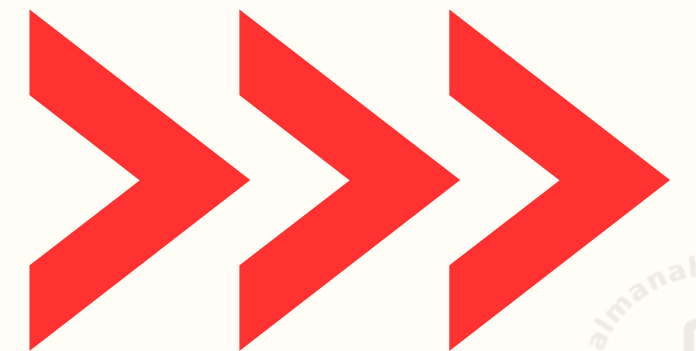
3. Polyploidy:

- A crucial feature in agriculture, offering practical benefits for food production.

4. Chromosome Maps:

- A valuable tool for visualizing gene positions and understanding recombination frequencies.

Applied genetics



Applied Genetics

Introduction

This lesson focuses on selective breeding, its methods, and the use of test crosses to determine genotypes. It highlights how humans have manipulated genetics for thousands of years to enhance desired traits in plants and animals.

Key Concepts

Selective Breeding

- Definition:** The process of selecting and breeding plants or animals to enhance specific traits for future generations.
- Examples:**
 - Sweeter, faster-growing fruits.
 - Dogs bred for tasks like herding or guarding.
- Methods:**
 - Hybridization:
 - Crossing organisms with different forms of a trait to produce hybrids with specific traits.
 - Advantages: Increased adaptability, larger offspring numbers.
 - Disadvantages: Expensive, time-consuming.
 - Example: Crossing a disease-resistant tomato with a fast-growing tomato to get both traits.
- Inbreeding:**
 - Breeding closely related organisms to ensure desired traits are passed on.
 - Advantages: Produces pure breeds (e.g., Clydesdale horses, German shepherds).
 - Disadvantages: Increased risk of harmful recessive traits being expressed.

Applied Genetics

Test Cross

- Definition:** A technique used to determine the genotype of an organism with a dominant phenotype.
- Process:**
 - Cross the organism with an unknown genotype (e.g., white fruit tree) with a homozygous recessive organism (e.g., red fruit tree).
- Outcomes:**
 - If the unknown genotype is homozygous dominant (WW), all offspring will show the dominant phenotype (Ww).
 - If the unknown genotype is heterozygous (Ww), offspring will show a 1:1 phenotypic ratio (50% white fruit, 50% red fruit).
- Applications:**
 - Used in agriculture and breeding to determine genetic traits.

Applied Genetics

Summary of Key Takeaways

1. Selective Breeding:

- Enhances specific traits through methods like hybridization (for adaptability) and inbreeding (for pure breeds).
- Critical in agriculture and domestication of animals.

2. Test Cross:

- A vital tool to uncover the genetic makeup of organisms, especially for traits with dominant-recessive inheritance.

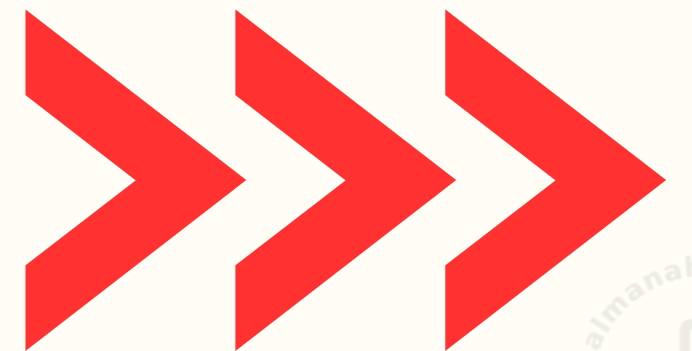
3. Applications in Agriculture:

- Selective breeding has led to stronger animals, higher crop yields, and desirable traits in plants and animals.

4. Challenges:

- Hybridization requires significant resources, while inbreeding risks perpetuating genetic disorders.

Basic patterns for human inheritance



Basic Patterns of Human Inheritance

Introduction

This lesson explores how traits and genetic disorders are passed through generations. Pedigrees are used to trace inheritance patterns and predict the likelihood of disorders in offspring.

Key Concepts

Pedigrees

- Definition:** A diagram that traces the inheritance of specific traits through multiple generations.
- Usage:**
 - Helps identify carriers (heterozygous individuals) of recessive traits.
 - Predicts the probability of disorders appearing in future generations.
 - Infers genotypes based on observed phenotypes.
- Symbols:**
 - Squares represent males, circles represent females.
 - Half-filled shapes indicate carriers; filled shapes indicate affected individuals.

Recessive Genetic Disorders

- Expressed only when an individual is homozygous recessive (e.g., aa).
- Example Disorder: Tay-Sachs
- Pedigree Insight: Unaffected parents with an affected child are heterozygous carriers.

Dominant Genetic Disorders

- Expressed when an individual has at least one dominant allele (e.g., AA or Aa).
- Example Disorder: Polydactyly
- Pedigree Insight: Affected parents can pass the disorder to their children; unaffected parents cannot have affected children.

Basic Patterns of Human Inheritance

Recessive Genetic Disorders

Albinism

- Cause:** Lack of melanin production.
- Effects:** No pigmentation, susceptibility to UV damage, vision issues.
- Treatment:** No cure; protect skin and eyes.

Cystic Fibrosis

- Cause:** Defective gene for a membrane protein.
- Effects:** Mucus buildup, respiratory and digestive failure.
- Treatment:** Mucus-thinning drugs, daily cleaning, enzyme supplements.

Galactosemia

- Cause:** Missing enzyme to break down galactose.
- Effects:** Mental disabilities, liver enlargement, kidney failure.
- Treatment:** Dietary restrictions on lactose/galactose.

Tay-Sachs Disease

- Cause:** Absence of enzyme breaking down fatty substances.
- Effects:** Fat buildup in the brain, mental disabilities, death by age 5.
- Treatment:** None.

Dominant Genetic Disorders

Huntington's Disease

- Cause:** Defective gene affecting neurological function.
- Effects:** Decline in mental abilities, loss of motor function.
- Treatment:** None.

Achondroplasia

- Cause:** Abnormal gene affecting bone growth.
- Effects:** Short arms and legs, large head.
- Treatment:** None.

◇ Summary of Key Takeaways

1. Pedigrees:

- A vital tool for tracking genetic traits and predicting inheritance risks.

2. Recessive Disorders:

- Only expressed in homozygous recessive individuals.
- Examples include Tay-Sachs and cystic fibrosis.

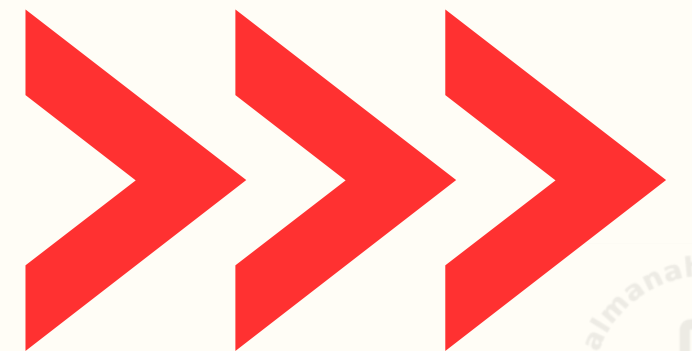
3. Dominant Disorders:

- Require just one dominant allele for expression.
- Examples include Huntington's disease and achondroplasia.

4. Applications:

- Pedigree analysis aids in medical and genetic research, helping families understand risks and inheritance patterns.

Complex patterns of inheritance



Complex Patterns of Inheritance

Introduction

This lesson examines inheritance patterns that go beyond Mendelian genetics, including incomplete dominance, codominance, multiple alleles, and environmental influences. It also explores epistasis, dosage compensation, sex-linked traits, and polygenic traits.

Key Concepts#1

Incomplete Dominance

- **Definition:** A heterozygous phenotype appears as an intermediate between two homozygous phenotypes.
- **Example:** In radishes, red (dominant) crossed with white (recessive) produces purple (intermediate).
- **Phenotypic Ratio:** 1:2:1 when heterozygous individuals are crossed.

Codominance

- **Definition:** Both alleles are fully expressed in heterozygous individuals.
- **Example:** In sickle-cell disease, heterozygous individuals have both normal and sickle-shaped red blood cells.
- **Advantage:** Resistance to malaria in heterozygous individuals (e.g., in central Africa).

Multiple Alleles

- **Definition:** Traits governed by more than two alleles.
- **Example:** Human ABO blood groups involve three alleles (IA, IB, i).
- Blood type inheritance includes Rh factor, where Rh+ is dominant, and Rh- is recessive.
- **Example in Animals:** Coat color in rabbits demonstrates a hierarchy of dominance among four alleles.

Epistasis

- **Definition:** One gene masks or modifies the expression of another gene.
- **Example:** In Labrador retrievers, the E allele determines pigment presence, and the B allele affects pigment intensity. If ee is present, the coat will be yellow regardless of the B allele.

Key Concepts#2

Dosage Compensation

- **Definition:** In females, one X chromosome is randomly inactivated in each cell to balance gene expression with males.
- **Example:** The inactivated X chromosome forms a Barr body.
- **Applications:** Coat color in calico cats is determined by random X chromosome inactivation.

Sex-Linked Traits

1. **Definition:** Traits controlled by genes on the X chromosome.
2. **Examples:**
 - Red-Green Colorblindness: More common in males since they have only one X chromosome.
 - Hemophilia: A recessive trait historically seen in Queen Victoria's family.

Polygenic Traits

- **Definition:** Traits influenced by multiple gene pairs.
- **Examples:** Skin color, height, and eye color.
- **Environmental Influences:** Factors like sunlight, water, and temperature affect the expression of polygenic traits.

Complex Patterns of Inheritance

Environmental Influences

Examples:

Lack of sunlight prevents flowering in plants.

Extreme temperatures can cause phenotypic changes in organisms.

Twin Studies:

Identical twins help distinguish genetic versus environmental contributions to traits.

Traits shared between twins indicate heredity, while differences point to environmental effects.

Summary of Key Takeaways

1. Complex Inheritance Patterns:

- Traits like blood types and coat colors exhibit multiple alleles, incomplete dominance, or codominance.
- Epistasis and polygenic inheritance add further complexity.

2. Environmental Impacts:

- Traits are influenced by genetic and environmental factors, highlighting the role of external conditions in phenotypic expression.

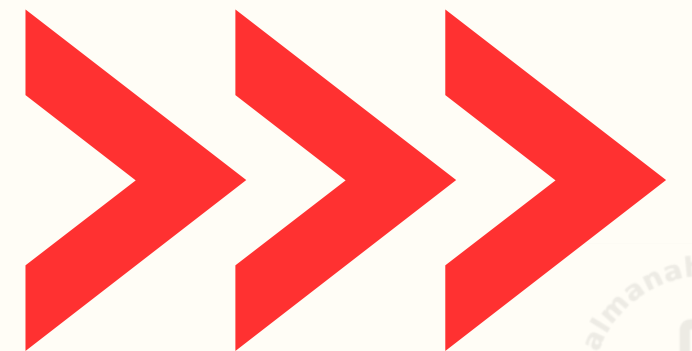
3. Applications:

- Pedigree analysis, Punnett squares, and understanding dosage compensation are crucial for genetic studies.

4. Importance of Sex-Linked Traits:

- X-linked disorders disproportionately affect males and are valuable in studying inheritance patterns.

DNA the genetic material



DNA—The Genetic Material

Introduction

This lesson focuses on the experiments that led to the discovery of DNA as the genetic material, the identification of its structure, and its role in heredity. It also highlights the differences between DNA and RNA.

Discovery of DNA

Key Concepts

Frederick Griffith:

- Conducted experiments demonstrating that a substance can transform bacteria.
- Transformation experiment: Non-disease-causing rough (R) bacteria changed into disease-causing smooth (S) bacteria.

Oswald Avery:

- Identified DNA as the "transforming factor" responsible for this change.
- Showed that R bacteria incorporated DNA from S bacteria, transforming into S bacteria.

Hershey and Chase:

- Used radioactive labeling to study bacteriophages (viruses that infect bacteria).
- Concluded that DNA, not protein, is the genetic material injected by bacteriophages into host cells to produce new viruses.

Discovery of DNA Structure

Erwin Chargaff:

- Analyzed base composition in DNA.
- Established Chargaff's Rule: Adenine (A) pairs with Thymine (T), and Cytosine (C) pairs with Guanine (G) in equal amounts.

Rosalind Franklin and Maurice Wilkins:

- Used X-ray diffraction to suggest DNA's double helix structure.

James Watson and Francis Crick:

1. Built a DNA model using Franklin's and Chargaff's data.
2. Key features of the model:
 - DNA's backbone consists of alternating deoxyribose (sugar) and phosphate groups.
 - Base pairs:
 - Cytosine (C) pairs with Guanine (G) via three hydrogen bonds.
 - Adenine (A) pairs with Thymine (T) via two hydrogen bonds.
3. DNA strands are oriented antiparallel: one runs 5' to 3', and the other runs 3' to 5'.

Nucleotide Structure

Nucleotides: The building blocks of DNA.

1. Components:

- 5-carbon sugar (deoxyribose in DNA).
- Phosphate group.
- Nitrogenous base (A, T, C, G in DNA).

2. DNA resembles a twisted ladder:

- Rails: Alternating deoxyribose and phosphate.
- Steps: Base pairs (A-T, C-G).

Key Differences Between DNA and RNA

1. DNA:

- Double-stranded, contains deoxyribose.
- Bases: A, T, C, G.

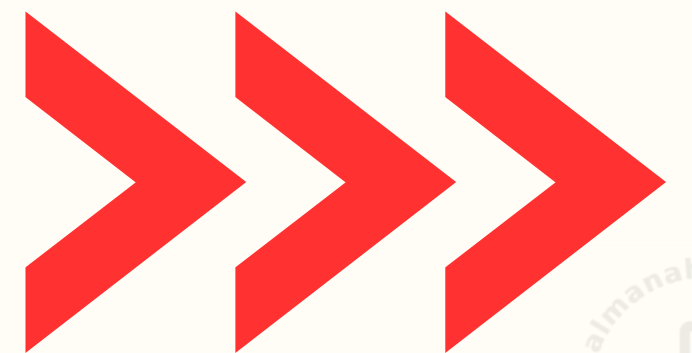
2. RNA:

- Single-stranded, contains ribose.
- Bases: A, U (uracil), C, G.



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Replication of DNA



Replication of DNA

Introduction

This lesson explores the process of DNA replication, emphasizing its mechanism, enzymes involved, and differences between replication in eukaryotes and prokaryotes.

Key Concepts

Semiconservative Replication

- **Definition:** During replication, the parental DNA strands separate, each serving as a template for a new strand. The resulting DNA molecules consist of one parental strand and one new strand.
- **Occurs in:** Interphase of mitosis and meiosis.
- **Stages of Replication:**
 1. **Unwinding:**
 - DNA helicase unwinds the double helix by breaking hydrogen bonds between base pairs.
 - Single-stranded binding proteins prevent the strands from rejoining.
 - RNA primase adds short RNA primers to initiate replication.
 2. **Base Pairing:**
 - DNA polymerase adds complementary nucleotides to the 3' end of the new strand.
 - Leading strand: Synthesized continuously toward the replication fork.
 - Lagging strand: Synthesized discontinuously away from the fork in short fragments called Okazaki fragments.
 3. **Joining:**
 - DNA polymerase removes RNA primers and replaces them with DNA nucleotides.
 - DNA ligase links the Okazaki fragments to form a continuous strand.

DNA Replication in Eukaryotes vs. Prokaryotes

1. Eukaryotes:

- DNA unwinds in multiple areas simultaneously.
- Replication occurs bidirectionally at several origins of replication.

2. Prokaryotes:

- DNA is circular, with replication starting at one origin.
- Replication proceeds in two directions until the circle is complete.

Key Enzymes and Components

1. **DNA Helicase:** Unwinds the DNA double helix.
2. **RNA Primase:** Lays down RNA primers to initiate replication.
3. **DNA Polymerase:** Adds nucleotides to the growing strand and replaces RNA primers.
4. **DNA Ligase:** Joins Okazaki fragments on the lagging strand.

Summary of Key Takeaways

1. **Mechanism of Replication:**
 - DNA replication is semiconservative, ensuring genetic consistency during cell division.
2. **Role of Enzymes:**
 - Specific enzymes like DNA polymerase and DNA ligase are essential for accurate replication.
3. **Differences in Replication:**
 - Eukaryotic DNA replicates at multiple origins, while prokaryotic DNA has a single origin with bidirectional replication.
4. **Applications:**
 - Understanding DNA replication is crucial for genetics, molecular biology, and biotechnology.