



جامعة المستقبل
AL MUSTAQL UNIVERSITY

كلية العلوم قسم الأدلة الجنائية

Lecture (9)

عنوان المحاضرة

Structure and Function of DNA

المادة : باليوجي

المرحلة : الاولى

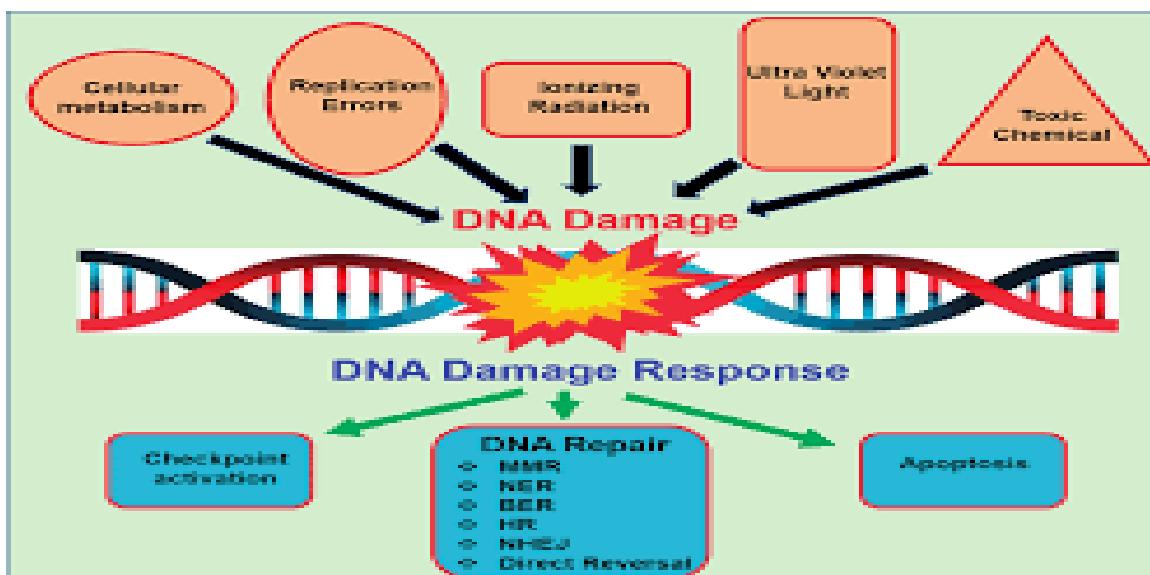
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Structure and Function of DNA (Part 2)

17. DNA Damage and Repair Mechanisms

DNA molecules are continuously exposed to various internal and external factors that can cause structural damage, including radiation, chemical agents, and reactive oxygen species. If left unrepaired, such damage may lead to mutations, genomic instability, or cell death. Therefore, cells are equipped with highly efficient DNA repair mechanisms to preserve genetic integrity.



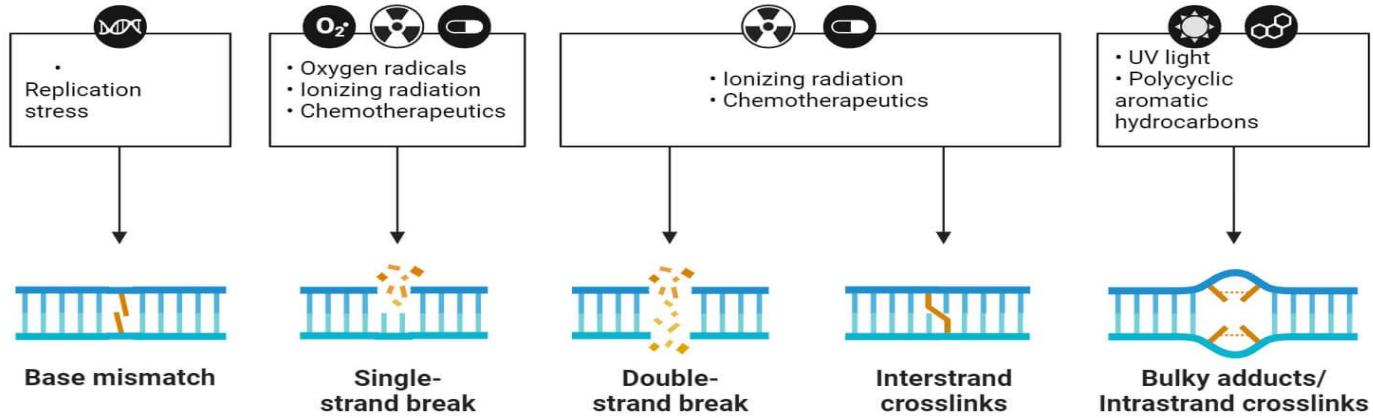
17.1 Types of DNA Damage

DNA damage can occur in several forms, including:

- Base modifications caused by chemical alterations
- Single-strand breaks affecting one DNA strand
- Double-strand breaks involving both DNA strands
- Formation of thymine dimers induced by ultraviolet (UV) radiation



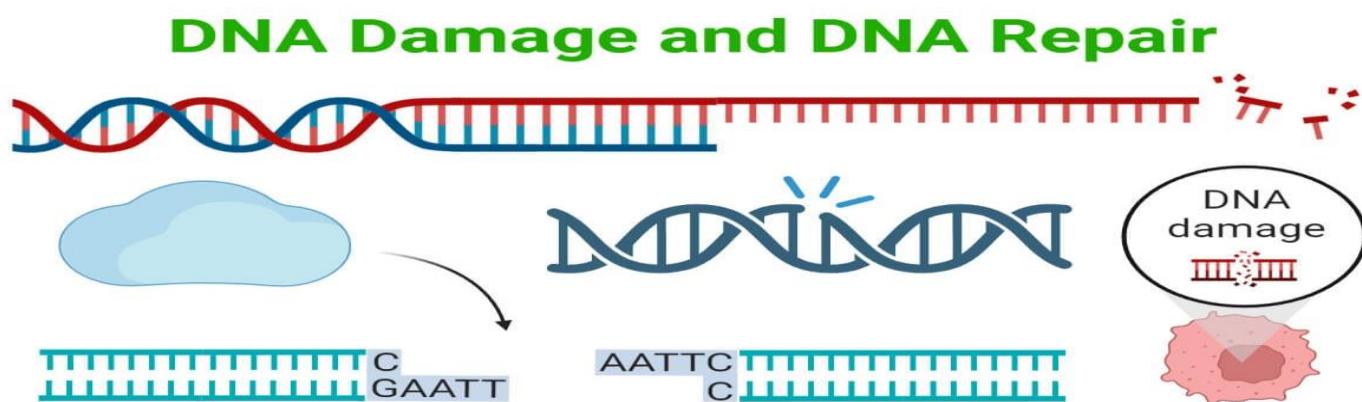
Common Causes of DNA Damage



17.2 DNA Repair Mechanisms

Cells utilize multiple repair pathways, each specialized for particular types of damage:

- Base Excision Repair (BER):** Repairs small, non-bulky base lesions
- Nucleotide Excision Repair (NER):** Removes bulky DNA distortions such as thymine dimers
- Mismatch Repair (MMR):** Corrects replication errors missed by DNA polymerase
- Double-Strand Break Repair:** Includes homologous recombination and non-homologous end joining





18. DNA Recombination

DNA recombination is the process by which genetic material is exchanged between DNA molecules, resulting in new combinations of genetic information.

Importance of Recombination

- Enhances genetic diversity within populations
- Plays a critical role during meiosis
- Contributes to the repair of damaged DNA

19. Epigenetics and DNA Modification

Epigenetics refers to heritable changes in gene expression that occur without altering the underlying DNA sequence. These modifications regulate gene activity and play a vital role in development and disease.

19.1 DNA Methylation

- Involves the addition of a methyl group to cytosine bases
- Commonly associated with gene silencing

19.2 Histone Modification

- Includes acetylation, methylation, and phosphorylation
- Alters chromatin structure and influences gene accessibility

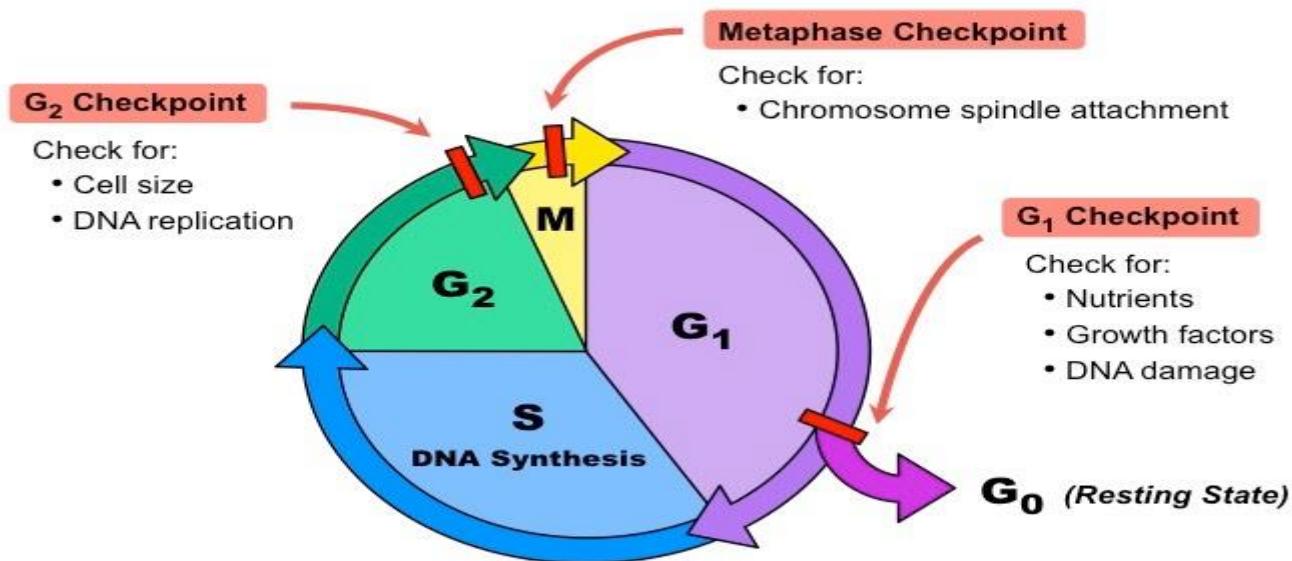
20. DNA and the Cell Cycle

DNA activity is tightly coordinated with the stages of the cell cycle to ensure accurate replication and division.

- **G1 Phase:** Cell growth and preparation for DNA synthesis
- **S Phase:** DNA replication
- **G2 Phase:** Preparation for mitosis
- **M Phase:** Mitosis and cell division

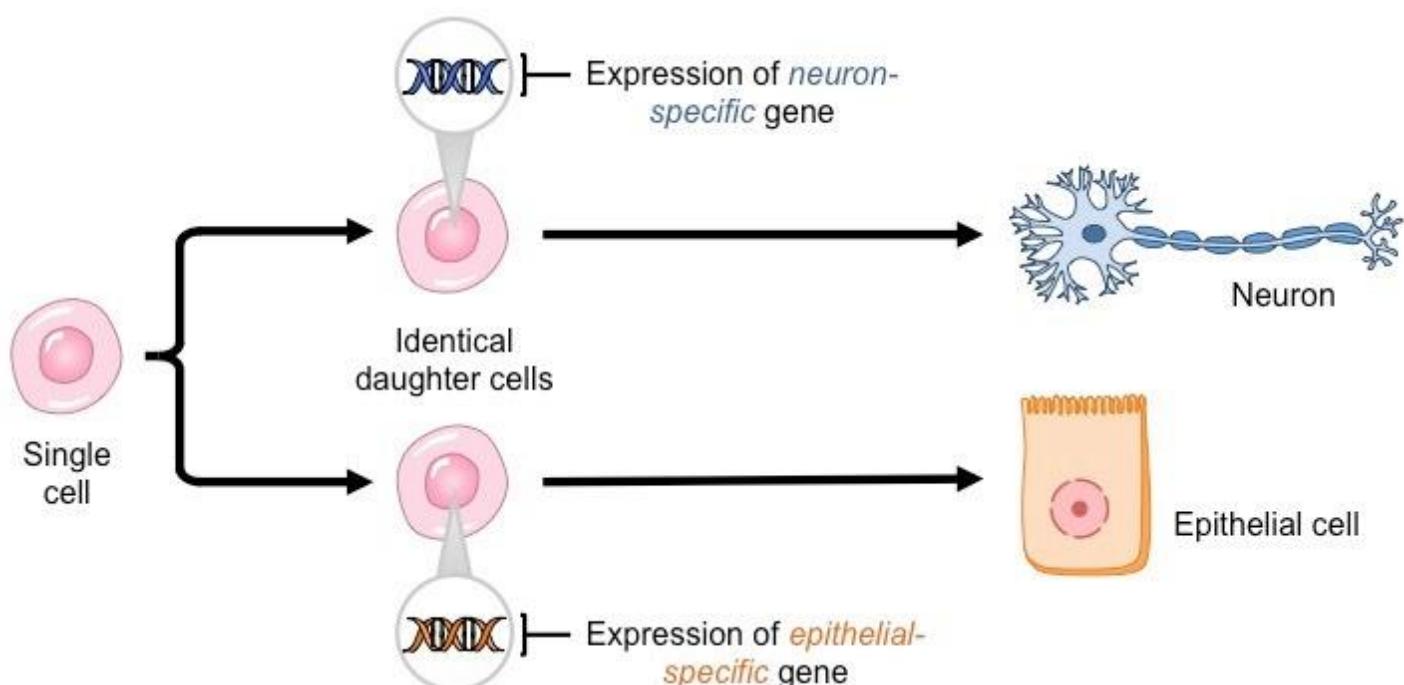


Cell cycle checkpoints monitor DNA integrity and prevent the progression of damaged DNA.



21. DNA in Development and Differentiation

Although all somatic cells contain identical DNA, different cell types express distinct sets of genes. Controlled gene expression enables cells to differentiate into specialized types such as muscle, nerve, and epithelial cells.





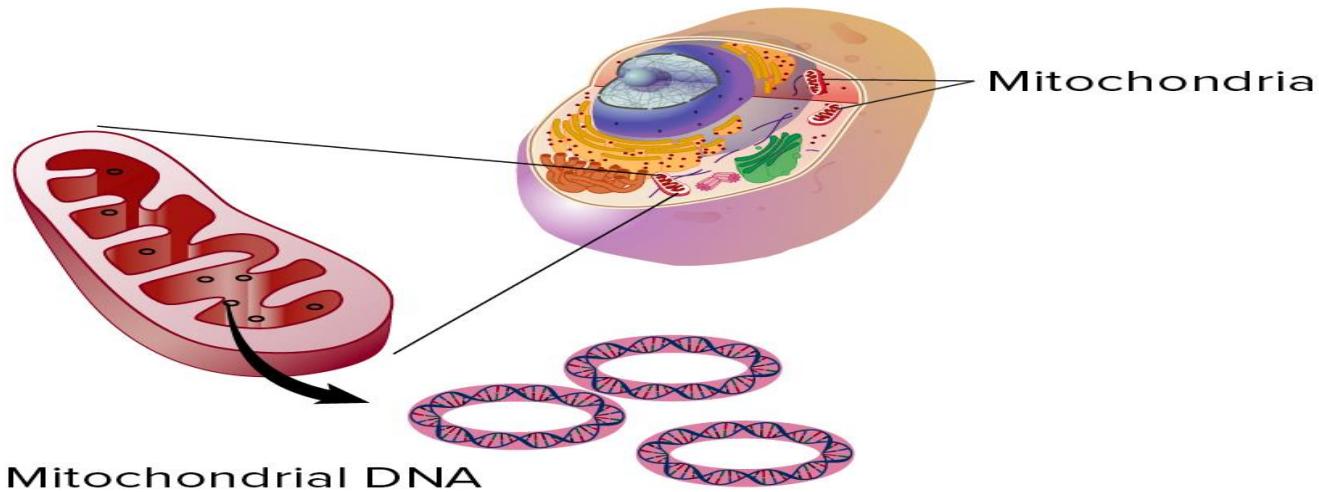
22. Mitochondrial DNA (mtDNA)

Mitochondria possess their own circular DNA, which is distinct from nuclear DNA and essential for cellular energy production.

Characteristics of mtDNA

- Inherited exclusively from the mother
- Encodes proteins involved in oxidative phosphorylation
- Exhibits a relatively high mutation rate

Mitochondrial DNA is widely used in evolutionary biology and forensic investigations.



23. DNA in Forensic Science

DNA analysis has become a cornerstone of modern forensic science.

Applications

- Identification of criminal suspects
- Paternity and kinship testing
- Identification of victims in mass disasters

Common techniques include Polymerase Chain Reaction (PCR) and Short Tandem Repeat (STR) analysis.



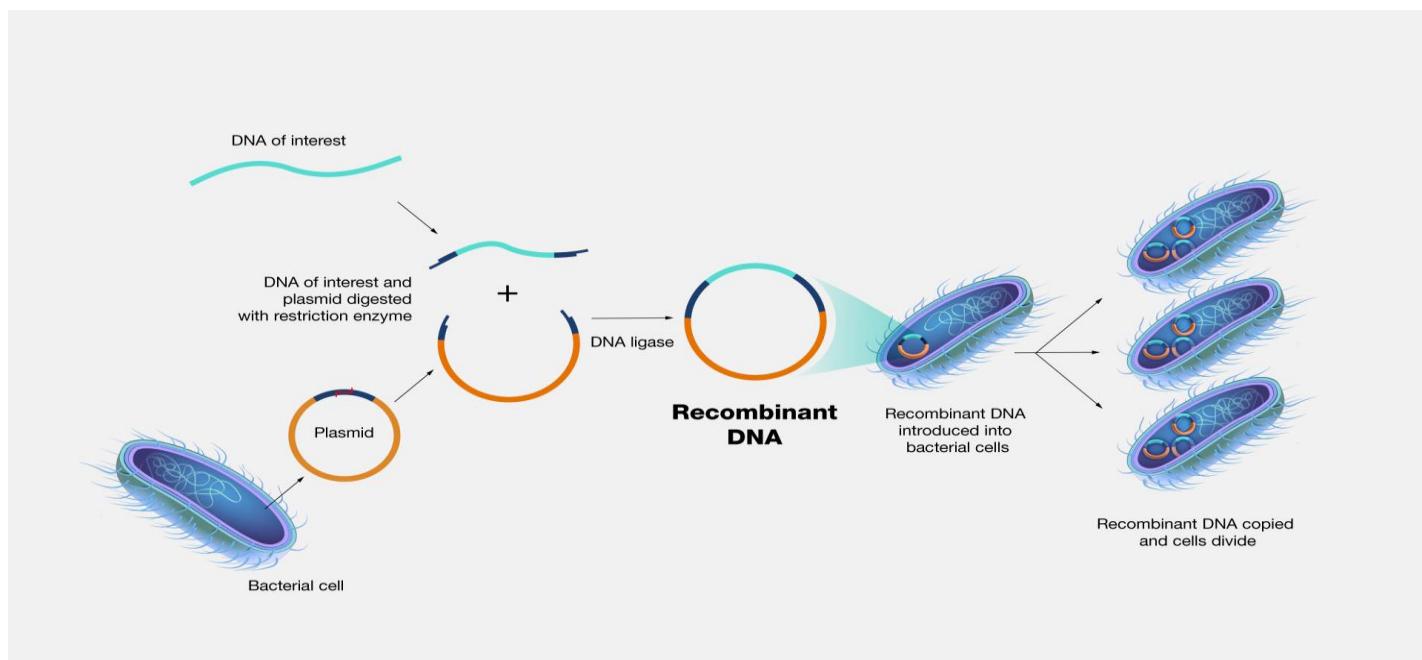
24. DNA Technology and Biotechnology

Advances in biotechnology rely heavily on the manipulation of DNA.

Key Technologies

- Recombinant DNA technology
- Gene cloning
- CRISPR-Cas9 gene editing

These techniques have transformative applications in medicine, agriculture, and biological research.



25. DNA and Genetic Disorders

Genetic disorders often arise from mutations or structural abnormalities in DNA.

Examples

- Sickle cell anemia
- Cystic fibrosis
- Hemophilia



Understanding DNA structure and function is essential for accurate diagnosis and the development of targeted therapies.

26. Ethical Issues Related to DNA Technology

The rapid advancement of DNA-based technologies has raised important ethical concerns, including:

- Protection of genetic privacy
- Ethical limits of human gene editing
- Cloning and its societal implications

Establishing ethical frameworks is crucial to guide responsible scientific progress.

27. Future Perspectives of DNA Research

DNA research continues to evolve rapidly, opening new possibilities such as:

- Personalized and precision medicine
- Gene therapy for inherited diseases
- Advanced applications in forensic science

28. Summary

DNA is not merely a static carrier of genetic information but a dynamic molecule involved in regulation, repair, and adaptation. An advanced understanding of DNA structure and function provides new opportunities in science, medicine, and biotechnology.