DNA Structure and DNA Replication
Why Do Cells Divide?

- Reproduction
- Growth and Development
- Tissue Renewal

(a) Reproduction. An amoeba, a single-celled eukaryote, is dividing into two cells. Each new cell will be an individual organism (LM).

(b) Growth and development. This micrograph shows a sand dollar embryo shortly after the fertilized egg divided, forming two cells (LM).

(c) Tissue renewal. These dividing bone marrow cells (arrow) will give rise to new blood cells (LM).
What Structures Do Divide When The Cell Divides?
What is a Chromosome?
How many chromosomes do humans have?

1. 46
2. 46 pairs
3. 23
4. 23 pairs
5. 1 and 4
DNA Replication: When Does It Happen?

- **G₁**: This phase is also known as the gap 1 phase, where the cell prepares for DNA replication.
- **S**: During this phase, DNA synthesis occurs, resulting in two copies of the DNA molecule.
- **G₂**: This phase follows S and is another gap phase before the cell enters mitosis.
- **INTERPHASE**: This is the period outside of cell division, during which the cell grows and performs its normal functions.
- **MITOTIC (M) PHASE**: This phase includes mitosis and cytokinesis, where the cell divides into two daughter cells.
How Are Features Passed Along?
Mendel and The Idea of Gene
Where Are Genes Located?
Genes Are Stretches of DNA (deoxyribonucleic acid)

- **Genes** are instructions for producing a trait
- **Locus** is the spot each genes has on a chromosome
- A gene is a stretch of DNA
DNA Structure: The Double Helix
DNA as Hereditary Material
DNA is a Nucleic Acid: Nucleic Acids Are Made of Nucleotides

RNA is a single-stranded molecule
DNA is a double-stranded molecule
DNA Structure

- DNA is a stretch of nucleotides made each of a deoxyribose, a nitrogen containing base (A, T, G, C), and a phosphate group.
- The molecule is structured as a double helix constituted by two strands.
A nucleotide is made of:

1. phosphate group + nitrogenous base
2. phosphate group + nitrogenous base + sugar
3. nitrogenous base + sugar
How Is the Helix Held?

- Hydrogen bonds establish between complementary nitrogen containing bases (A-T, C-G)
- Purines (A, G) bond to pyrimidines (T, C)
- A establishes two hydrogen bonds with T
- G establishes three hydrogen bonds with C
The Structure of DNA Is Revealed

(a) Rosalind Franklin
(b) Franklin’s X-ray diffraction photograph of DNA

Rosalind Franklin

James Watson and Francis Crick
DNA Structure: The Double Helix
Let’s Do the Complementary Strand To:

5’ AATCGTAGTGCCATTAGTGTACACT 3’
Adenine establishes two hydrogen bonds with thymine. Do you agree?

1. Yes
2. No
Guanine establishes three hydrogen bonds with thymine. Do you agree?

1. Yes
2. No
How many cytosines will be found in a molecule of DNA that has 422 guanines?

1. 422
2. 211
3. 844
4. 1,688
DNA Replication
DNA Replication: When Does It Happen?

- G₁
- S (DNA synthesis)
- G₂
- Mitotic (M) Phase
- Cytokinesis

INTERPHASE
During S Phase Chromosomes Duplicate (DNA Replication)
DNA Replication

(a) The parent molecule has two complementary strands of DNA. Each base is paired by hydrogen bonding with its specific partner, A with T and G with C.

(b) The first step in replication is separation of the two DNA strands.

(c) Each parental strand now serves as a template that determines the order of nucleotides along a new, complementary strand.
DNA Replication

- Sugar-phosphate backbone
- Base pair (joined by hydrogen bonding)
- Old strands
- Nucleotide about to be added to a new strand
- New strands
Let’s Replicate DNA

5’ AATCGTAGTGCCATTAGTGTACACT 3’
DNA Replication: Replication Forks

(a) In eukaryotes, DNA replication begins at many sites along the giant DNA molecule of each chromosome.

(b) In this micrograph, three replication bubbles are visible along the DNA of a cultured Chinese hamster cell (TEM).
DNA Replication: How Does It Happen?
Enzymes and Proteins Involved in DNA Replication

- Helicase: unwind double helix
- Single-strand binding proteins
- Primase: adds RNA primer
- DNA Polymerase: adds nucleotides 5’ to 3’
- DNA Ligase: joints Okazaki fragments
Replication of The Leading Strand

- DNA polymerase copy the leading strand in a 5’ to 3’ direction
- The elongation of the leading strand is continuous, and towards the direction of opening of the replication fork
Replication of The Lagging Strand

- Primase initiates multiple RNA primers in order to duplicate the entire lagging strand
- The replication of the lagging strand is discontinuous, through multiple segments (Okazaki fragments). It proceeds away from the direction of opening of the replication fork
- DNA ligase joins Okazaki fragments
continuous replication: 5’ to 3’:
DNA

1. DNA lagging strand
2. DNA leading strand
3. RNA
discontinuous replication: 3’ to 5’
DNA: Okazaki fragments

1. DNA lagging strand
2. DNA leading strand
3. Replication does not occur 3’ to 5’