

Chapter One  
Lecture (2)

# Human Biology

## OBJECTIVES

◆ **At the completion of this lecture, you should be able to do the following:**

1. Discuss the cell theory of human biology.
2. List and describe the molecular composition of the human body.
3. Explain the parts and function of the human cell.
4. Describe the processes of mitosis and meiosis.
5. Evaluate the radiosensitivity of tissues and organs.

# The Human Cell

- ◊ The principal molecular components of the human body are made of intricate (complex) cellular structures.
- ◊ The two major structures of the cell are the nucleus and the cytoplasm.
- ◊ The principal molecular component of the nucleus is DNA, the genetic material of the cell.
- ◊ The nucleus also contains some RNA, protein, and water.

## The human cell (cont.)

◇ The **cytoplasm** contains great quantities of all molecular components except DNA.

◇ **Endoplasmic reticulum**

◇ channels that allows the nucleus to communicate with the cytoplasm.

◇ **mitochondria.**

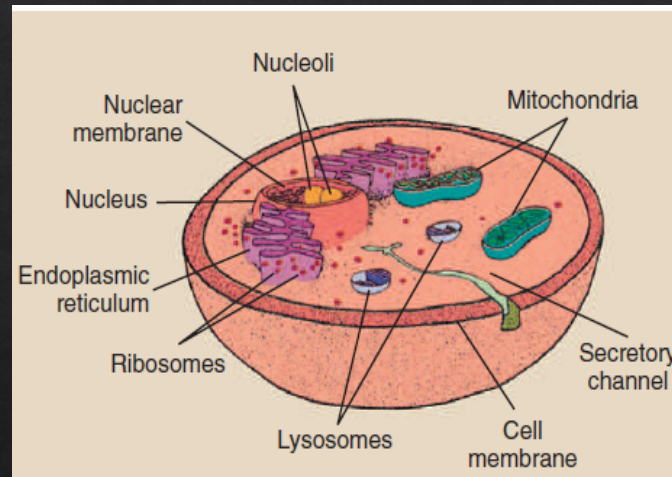
◇ Produce energy for the cell.

◇ **Ribosomes**

◇ Site of protein synthesis

◇ **Lysosomes**

◇ Control intracellular contaminants.



## The human cell (cont.)

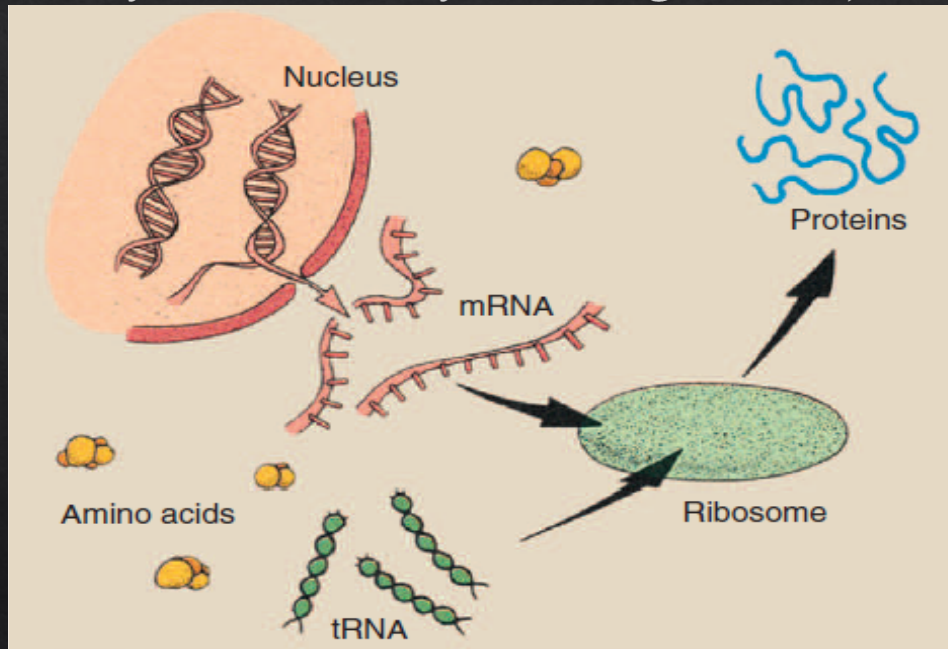
- ◇ When the critical macromolecular cellular components are irradiated by themselves, a dose of approximately 10 kGy (1 Mrad) is required to produce a measurable change in any physical characteristic of the molecule.
- ◇ When a macromolecule is incorporated (combined ) into the apparatus of a living cell, only a few mGy are necessary to produce a measurable biologic response.
- ◇ A number of experiments have shown that the nucleus is much more sensitive than the cytoplasm to the effects of radiation.

# Cell Function

- ◆ Every human cell has a specific function in supporting the total body (nerve cells, blood cells, and muscle cells).
- ◆ Protein synthesis is a good example of a critical cellular function necessary for survival.
- ◆ If this molecular synthesis is damaged by radiation exposure, the cell may malfunction and die.

## Cell Function

- ◇ DNA contains a molecular (code) that identifies which proteins the cell will make.
- ◇ This code is determined by the sequence of base pairs (adenine–thymine and cytosine–guanine).



## Cell Function

(cont.)

- ◆ A series of three base pairs, called a codon, identifies one of the 22 human amino acids available for protein synthesis.
- ◆ Interference with any phase of this procedure for protein synthesis could result in damage to the cell.
- ◆ Radiation interaction in which the molecule has primary control over protein synthesis (DNA) is more effective in producing a response than is radiation interaction with other molecules involved in protein synthesis.

# Cell Proliferation

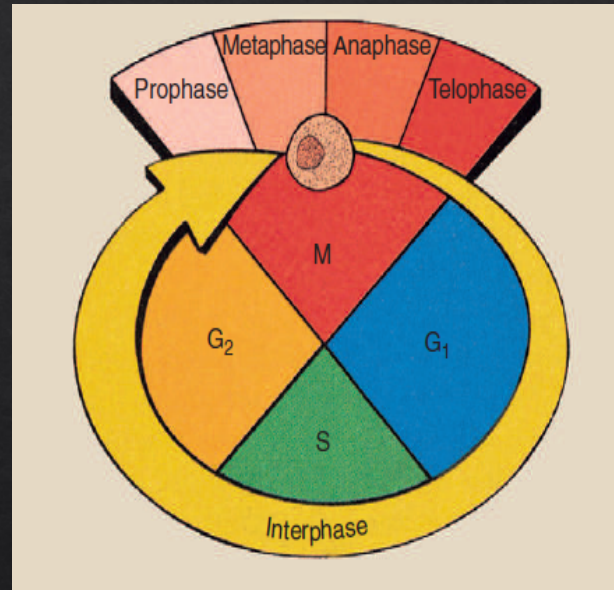
- ◇ It is the act of a single cell or group of cells to reproduce and multiply in number.
- ◇ The human body consists of two general types of cells
  - ◇ **Genetic cells:**
    - ◇ Oogonium (female)
    - ◇ Spermatogonium (male)
    - ◇ Proliferate or divide by **meiosis**.
  - ◇ **Somatic cells:**
    - ◇ All other cells of the body.
    - ◇ Proliferate or divide by **mitosis**.

# Cell Proliferation

## (cont.)

### Mitosis:

- ◇ The cell cycle consists of two phases:
  - ◇ **mitosis (M)**
  - ◇ **interphase.**
- ◇ **Mitosis**, the division phase, is characterized by four subphases:
  - ◇ **prophase**
  - ◇ **Metaphase**
  - ◇ **Anaphase**
  - ◇ **Telophase.**
- ◇ **Interphase** is the period of growth of the cell between divisions.

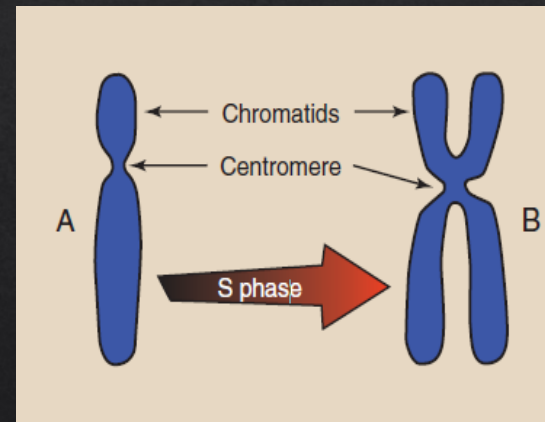


# Cell Proliferation

## (cont.)

### Mitosis:

- ◊ The four phases of the cell cycle (M, G1, S, and G2) are characterized by the structure of the chromosomes, which contain the genetic material DNA.
- ◊ **G1** is the gap in cell growth between M and (pre-DNA synthesis phase).
- ◊ **S** is DNA synthesis phase and during this period, each DNA molecule is replicated into two identical daughter DNA molecules.
- ◊ **G2** phase is the post-DNA synthesis gap of cell growth.



# Cell Proliferation

## (cont.)

### Mitosis:

- ◇ During **interphase** the chromosomes are not visible; however, during **mitosis**, the DNA slowly takes the form of the chromosomes as seen microscopically.
- ◇ During **prophase**:
  - ◇ the nucleus swells, and the DNA becomes more prominent and begins to take structural form.
- ◇ During **metaphase**:
  - ◇ the chromosomes appear and are lined up along the equator of the nucleus.
  - ◇ It is during metaphase that mitosis can be stopped and chromosomes can be studied carefully under the microscope.

*Radiation-induced chromosome damage is analyzed during metaphase.*

# Cell Proliferation

## (cont.)

### Mitosis:

#### ◇ Anaphase:

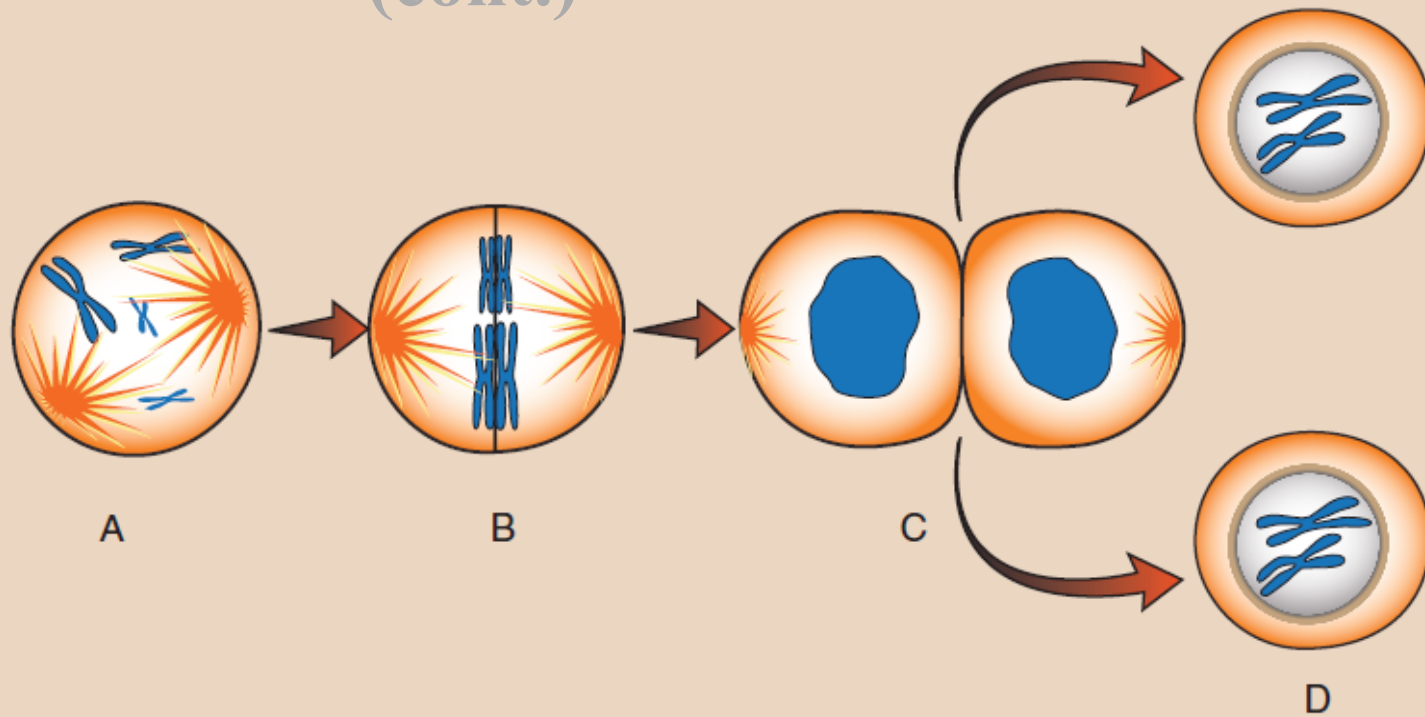
- ◇ is characterized by the splitting of each chromosome at the centromere.
- ◇ The number of chromatids per centromere has been reduced by half.

#### ◇ Telophase:

- ◇ the cytoplasm is divided into two equal parts, each of which accompanies one of the new nuclei.
- ◇ The two daughter cells look precisely the same as the parent cell and contain exactly the same genetic material.

# Cell Proliferation

(cont.)



chromosomes become visible, divide, and migrate to daughter cells.

# Cell Proliferation

## (cont.)

### ◆ Meiosis

- ◆ *Meiosis is the process whereby genetic cells undergo reduction division.*
- ◆ The genetic cell to be capable of marriage to another genetic cell, its complement of chromosomes must be reduced by half to 23, so that after conception and the union of two genetic cells, the daughter cells again will contain 46 chromosomes .
- ◆ The genetic cell begins meiosis with 46 chromosomes that appear the same as in a somatic cell that has completed the G2 phase.

# Cell Proliferation

## (cont.)

### ♦ Meiosis

- ♦ The first division gives two daughter cells, each containing 46 chromosomes.
- ♦ Each of the daughter cells undergo second division is not accompanied by an S phase, (no chromosomes are duplicated).
- ♦ Each of the resulting granddaughter cells contains only 23 chromosomes.
- ♦ Each parent has undergone two division processes, which have resulted in four daughter cells.

# Tissues and organs

- ◇ Tissues are the collections of cells of similar structure and function, which is precisely bound together to form organs.
- ◇ The tissues and the organs of the body serve as discrete units with specific functional responsibilities.
- ◇ Some tissues and organs combine into an overall integrated organization known as an organ system.

## Tissues and organs (cont.)

- ◇ The principal organ systems of the body are the:
  - ◇ Nervous system
  - ◇ Digestive system
  - ◇ Endocrine system
  - ◇ Respiratory system
  - ◇ Reproductive system.
  
- ◇ Effects of radiation that appear at the whole-body level result from damage to these organ systems that occurs as the result of radiation injury to the cells of that system.

## Tissues and organs (cont.)

- ◇ The cells of a tissue system are identified by their rate of proliferation and their stage of development.
- ◇ Immature cells are :
  - ◇ undifferentiated cells
  - ◇ Precursor cells
  - ◇ stem cells.
- ◇ Mature cells pass through various stages of differentiation into a fully functional and mature cell.
- ◇ *Stem cells are more sensitive to radiation than mature cells.*

## Tissues and organs (cont.)

- ◇ The sensitivity of the cell to radiation is determined somewhat by its state of maturity and its functional role.

| TABLE 29-2 Response to Radiation Is Related to Cell Type |                                                                         |
|----------------------------------------------------------|-------------------------------------------------------------------------|
| Radiosensitivity                                         | Cell Type                                                               |
| High                                                     | Lymphocytes<br>Spermatogonia<br>Erythroblasts<br>Intestinal crypt cells |
| Intermediate                                             | Endothelial cells<br>Osteoblasts<br>Spermatids<br>Fibroblasts           |
| Low                                                      | Muscle cells<br>Nerve cells                                             |

## Tissues and organs (cont.)

- ◇ Several types of tissue can be classified according to structural or functional features which influence the degree of radiosensitivity of the tissue.
- ◇ Epithelium is the covering tissue, and it lines all exposed surfaces of the body, both exterior and interior.
- ◇ Epithelium covers the:
  - ◇ Skin
  - ◇ Blood vessels
  - ◇ Abdominal and chest cavities
  - ◇ Gastrointestinal tract.

## Tissues and organs (cont.)

- ◊ Connective and supporting tissues are composed principally of fibers that are usually highly elastic.
- ◊ Connective tissue binds tissues and organs together.
  - ◊ Bone ligaments and cartilage.
- ◊ Muscle is a special type of tissue that can contract.
- ◊ Nervous tissue consists of specialized cells called neurons that have long, thin extensions from the cell to distant parts of the body.

## Tissues and organs (cont.)

- ◊ The deterministic effects of high-dose radiation may include observable organ damage.
- ◊ The various organs of the body exhibit a wide range of sensitivity to radiation.
- ◊ This radiosensitivity is determined by the:
  - ◊ function of the organ in the body
  - ◊ rate at which cells mature within the organ,
  - ◊ inherent radiosensitivity of the cell type.
- ◊ The general levels of radiosensitivity of various organ is helpful toward understanding the effects of whole-body radiation exposure, particularly in the acute radiation syndrome

# Tissues and organs (cont.)

**TABLE 29-3**

**Relative Radiosensitivity of Tissues and Organs Based on Clinical Radiation Oncology**

| Level of Radiosensitivity*                                | Tissue or Organ        | Effects         |
|-----------------------------------------------------------|------------------------|-----------------|
| High: 2–10 Gy <sub>t</sub><br>(200–1000 rad)              | Lymphoid tissue        | Atrophy         |
|                                                           | Bone marrow            | Hypoplasia      |
|                                                           | Gonads                 | Atrophy         |
| Intermediate:<br>10–50 Gy <sub>t</sub><br>(1000–5000 rad) | Skin                   | Erythema        |
|                                                           | Gastrointestinal tract | Ulcer           |
|                                                           | Cornea                 | Cataract        |
|                                                           | Growing bone           | Growth arrest   |
|                                                           | Kidney                 | Nephrosclerosis |
|                                                           | Liver                  | Ascites         |
|                                                           | Thyroid                | Atrophy         |
| Low: >50 Gy <sub>t</sub><br>(>5000 rad)                   | Muscle                 | Fibrosis        |
|                                                           | Brain                  | Necrosis        |
|                                                           | Spinal                 | Transection     |

\*The minimum dose delivered at the rate of approximately 2 Gy/day (200 rad/day), which will produce a response.

THANKS FOR  
YOUR ATTENTION  
**Any Question**

