**Chapter 3**

1. **INTRODUCTION**
2. A cell is the basic, living, structural, and functional unit of the body.
3. Cytology is the **study of cell structure**, and cell physiology is the **study of cell function.**.
4. **PARTS of a CELL**
5. A generalized view of the cell is a composite of many different cells in the body. **No single cell includes all of the features seen in the generalized cell.**
6. The cell can be divided into three principal parts for ease of study.
7. **Plasma (cell) membrane**
8. **cytoplasm**
9. Cytosol
10. **Organelles** (except for the nucleus)
11. **nucleus**
12. **THE PLASMA MEMBRANE**
13. The plasma membrane is a **flexible, sturdy barrier** that surrounds and contains the cytoplasm of the cell.
14. The **fluid mosaic** model describes its structure.
15. The membrane consists of **proteins in a sea of lipids**.
16. The Lipid Bilayer
17. The lipid bilayer is the basic framework of the plasma membrane and is made up of three types of lipid molecules: **phospholipids, cholesterol, and glocolipids**.
18. The bilayer arrangement occurs because the lipids are **amphipathic** molecules. They have both polar (**charged**) and nonpolar (**uncharged**) parts with the polar “head” of the phospholipid pointing out and the nonpolar “tail” pointing toward the center of the membrane.
19. Cholesterol molecules are weakly **amphiphotic** and are interspersed among other lipids.
20. Glycolipids appear only in the membrane layer which faces the **extracellular** fluid.

C. Arrangement of Membrane Proteins

1. The membrane proteins are divided into integral and peripheral proteins.
2. **Integral proteins extend into or across the entire lipid bilayer among the fatty acid tails of the phospholipid molecules.**
3. **Peripheral proteins are found at the inner or outer surface of the membrane and can be stripped away from the membrane without disturbing membrane integrity.**
4. Integral membrane proteins are amphipathic.
5. **Those that stretch across the entire bilayer and project on both sides of the membrane are termed transmembrane proteins**.
6. Many integral proteins are glycoproteins.
7. The combined glycoproteins and glycolipids form the glycocalyx which helps cells recognize one another, adhere to one another, and be protected from digestion by enzymes in the extracellular fluid.
8. Functions of Membrane Proteins
9. Membrane proteins vary in different cells and functions as...**channels (pores), transporters, receptors, enzymes, cell-identity markers, and linkers.**
10. The different proteins help to determine many of the functions of the plasma membrane.
11. Membrane Fluidity
12. Membranes are fluid structures, rather like cooking oil, because most of the membrane lipids and many of the membrane proteins **easily move in the bilayer**.
13. Membrane lipids and proteins are mobile in their own half of the bilayer.
14. **Cholesterol** serves to stabilize the membrane and reduce membrane fluidity.
15. Membrane Permeability
16. Plasma membranes are **selectively permeable**, meaning that some things can pass through and others cannot.
17. The lipid bilayer portion of the membrane is permeable to **small, nonpolar, uncharged** molecules but impermeable **to ions and charged or polar molecules**. It is also permeable to water.
18. **Transmembrane** proteins that act as channels or transporters increase the permeability of the membrane to molecules that cannot cross the lipid bilayer.
19. Macromolecules are unable to pass through the plasma membrane except by **vesicular transport**.
20. Gradients Across the Plasma Membrane
21. A concentration gradient is the difference in the concentration...**of a chemical between one side of the plasma membrane and the other.**
22. Oxygen and sodium ions are more concentrated outside the cell membrane with carbon dioxide and potassium ions more concentrated inside the cell membrane.
23. The inner surface of the membrane is more negatively charged and the outer surface is more positively charged. This sets up an **electrical gradient**, also called the membrane potential.
24. Maintaining the concentration and electrical gradients are **important to the life of the cell.**
25. The combined concentration and electrical gradients are called the **electrochemical** gradient.
26. **TRANSPORT ACROSS THE PLASMA MEMBRANE**
27. Processes to move substances across the cell membrane are **essential to the life of the cell.**
28. Some substances cross the lipid bilayer while others cross through ion channels.
29. Transport processes that mover substances across the cell membrane are either **active or passive**.
30. Three types of passive processes **are diffusion through the lipid bilayer, diffusion through ion channels, and facilitated diffusion**
31. Active transport requires cellular **energy**.
32. Materials can also enter or leave the cell through **vesicle transport**.
33. Principles of Diffusion
34. Diffusion is the random mixing of particles that occurs in a solution as a result of the **kinetic** energy of the particles.
35. Diffusion rate across plasma membranes is influenced by several factors:
36. **Steepness of the concentration gradient**
37. **temperature**
38. **size or mass of the diffusing substance**
39. **surface area**
40. **diffusion distance**
41. Diffusion Through the Lipid Bilayer
42. Nonpolar, hydrophobic molecules such as respiratory gases, some lipids, small alcohols, and ammonia can diffuse across the lipid bilayer.
43. It is important... **for gas exchange, absorption of some nutrients, and excretion of some wastes.**
44. Diffusion Through Membrane Channels
45. Most membrane channels are ion channels, allowing passage of small, inorganic ions which are **hydrophilic**.
46. Ion channels are **selective and specific** and may be gated or open all the time.
47. Osmosis is the net movement of a solvent through a selectively permeable membrane, or in living systems**, the movement of water (the solute) from an area of higher concentration to an area of lower concentration across the membrane.**
48. Water molecules penetrate the membrane by diffusion through the lipid bilayer or through aquaporins, **transmembrane proteins that function as water channels.**
49. Water moves from an area of **lower** solute concentration to an area of **higher** solute concentration.
50. Osmosis occurs only when the membrane is permeable to water but not to certain solutes.
51. Osmotic pressure of a solution is proportional to the concentration of the solute particles that cannot cross the membrane.
52. **Tonicity** is a measure of a solution’s ability to change the volume of cells by altering their water concentration.
53. In an isotonic solution, red blood cells **maintain** their normal shape.
54. In a hypotonic solution, red blood cells undergo **hemolysis**.
55. In a hypertonic solution, red blood cells undergo **cremation**.
56. There are important medical uses of **isotonic, hypotonic, and hypertonic solutions.**
57. Facilitated Diffusion
58. In facilitated diffusion, a **solute binds to a specific transporter** on one side of the membrane and is released on the other side after the transporter undergoes a conformational change.
59. Solutes that move across membranes by facilitated diffusion include **glucose, urea, fructose, galactose, and some vitamins.**
60. Transport maximum is the **upper limit** on the rate at which facilitated diffusion can occur. If all the transporters are occupied, then the rate of facilitated diffusion **does not increase**.
61. Glucose enters the cell by **facilitated diffusion**.
62. Active Transport
63. Active transport is an **energy requiring process** that moves solutes such as ions, amino acids, and monosaccharides against a concentration gradient.
64. Primary Active Transport
65. In primary active transport, energy derived from **ATP** changes the shape of a transporter protein, which pumps a substance across a plasma membrane against its concentration gradient.
66. The most prevalent primary active transport mechanism is **the sodium ion/potassium ion pump.**
67. Clinical Application: Cystic fibrosis is caused by a defective gene that produces an abnormal chloride ion transported. The disease affects the **respiratory, digestive, urinary, and reproductive systems**
68. Secondary Active Transport
69. In secondary active transport, the energy stored in the form of a sodium or hydrogen ion concentration gradient is used to drive other **substances against their own concentration gradients.**
70. Plasma membranes contain several antiporters and symporters powered by the sodium ion gradient.
71. **Digitalis** slows the sodium ion-calcium ion antiporters, allowing more calcium to stay inside heart muscle cells, which increases the force of their contraction and thus strengthens the heartbeat.
72. Transport in Vesicles
73. A vesicle is a **small membranous sac formed by budding off from an existing membrane.**
74. Two types of vesicular transport are endocytosis and exocytosis.
75. Endocytosis
76. In endocytosis, materials move **into** a cell in a vesicle formed from the plasma membrane.
77. Receptor-mediated endocytosis is the selective uptake of large molecules and particles by cells.
78. **The steps of receptor-mediated endocytosis includes binding, vesicle formation, uncoating, fusion with endosome, recycling of receptors, and degradation in lysosomes.**
79. **Viruses** can take advantage of this mechanism to enter cells.
80. Phagocytosis is the ingestion of **solid particles**.
81. Pinocytosis is the ingestion of **extracellular fluid**.
82. In exocytosis, membrane-enclosed structures called secretory vesicles that form inside the cell fuse with the plasma membrane and **release their contents** into the extracellular fluid.
83. Transcytosis may be used to move a substance into, across and out of a cell.
84. **CYTOPLASM**
85. Cytosol, the intracellular fluid, is the **semifluid portion of cytoplasm** that contains inclusions and dissolved solutes.
86. Cytosol is composed mostly of **water, plus proteins, carbohydrates, lipids, and inorganic substances.**
87. The chemicals in cytosol are either in solution or in a colloidal (suspended) form.
88. Functionally, cytosol is the medium in which many metabolic reactions occur.
89. Organelles
90. Organelles are specialized structures that **have characteristic shapes and perform specific functions in cellular growth, maintenance, and reproduction.**
91. Cytoskeleton
92. The cytoskeleton is a...**network of several kinds of protein filaments that extend throughout the cytoplasm and provides a structural framework for the cell.**
93. It consists of microfilaments, intermediate filaments, and microtubules.
94. Most microfilaments are composed of actin and function in movement and mechanical support.
95. Intermediate filaments are composed of several different proteins and function in support and to help anchor organelles such as the nucleus.
96. Microtubules are composed of a protein called **tubulin and help determine cell shape and function in the intracellular transport of organelles and the migration of chromosome during cell division.**
97. Centrosomes are dense areas of cytoplasm containing the centrioles, which are paired cylinders arranged at right angles to one another, and serve as centers **for organizing microtubules in interphase cells and the mitotic spindle during cell division**.
98. Cilia and Flagella
99. Cilia are numerous, **short hairlike projections** extending from the surface of a cell and functioning to move materials across the surface of the cell.
100. Flagella are similar to cilia but are **much longer**; usually moving an entire cell. The only example of a flagellum in the human body is the sperm cell tail.
101. Ribosomes
102. Ribosomes are tiny spheres consisting of ribosomal RNA and several ribosomal proteins; they occur free (singly or in clusters) or together with endoplasmic reticulum.
103. Functionally, ribosomes are the sites of **protein synthesis.**.
104. Endoplasmic Reticulum
105. The endoplasmic reticulum (ER) is a network of membranes that form flattened sacs or tubules called cisterns.
106. Rough ER is continuous with the nuclear membrane and has its outer surface studded with **ribosomes**.
107. Smooth ER extends from the rough ER to form a network of membrane tubules but does not **contain ribosomes** on its membrane surface.
108. The ER...**transports substance, stores newly synthesized molecules, synthesizes and packages molecules, detoxifies chemicals, and releases calcium ions involved in muscle contraction.**
109. Clinical Application: One of the functions of smooth ER is to detoxify drugs. Repeated exposure to certain drugs produces changes to the smooth ER in the liver which results in tolerance to the drug.
110. Golgi Complex
111. The Golgi complex consists of three to twenty stacked, flattened membranous sacs (cisterns) referred to as cis, medial, and trans.
112. The principal function of the Golgi complex is to **process, sort, and deliver** proteins and lipids to the plasma membrane, lysosomes, and secretory vesicles.
113. Lysosomes
114. Lysosomes are membrane-enclosed vesicles that form in the Golgi complex and contain powerful digestive enzymes.
115. Lysosomes function in...**intrascellular digestion, digestion of worn out organelles (autophagy), digestion of cellular contents (autolysis), during embryological development and extracellular digestion.**
116. Tay-Sachs disease is an example of a disorder caused by faulty lysosomes.
117. Perioxosomes
118. Peroxisomes are similar in structure to lysosomes, but are smaller.
119. They contain enzymes (e.g., catalase) that use molecular oxygen to **oxidize various organic substances**.
120. Proteosomes
121. **Proteosomes are similar in structureto lysosomes, but are smaller.**
122. They contain proteases which cut proteins into small peptides.
123. Proteosomes are thought to be a factor in several diseases.
124. Mitochondria
125. The mitochondrion is bound by a double membrane. The outer membrane is smooth with the inner membrane arranged in folds called cristae.
126. Mitochondria are the site of **ATP production in the cell** by the catabolism of nutrient molecules.
127. Mitochondria self-replicate using their own DNA.
128. Mitochondrial DNA (genes) are usually inherited only from the **mother**.
129. Clinical Application: Mitochondrial myopathies are inherited muscle disorders resulting from faulty mitochondrial genes. As a result muscles become **weak and fatigue easily.**

#### NUCLEUS

1. The nucleus is usually the most prominent feature of a cell.
2. Most body cells have a single nucleus; some (**red blood cells**) have none, whereas others (**skeletal muscle fibers**) have several.
3. The parts of the nucleus include the **nuclear envelope**, which is perforated by channels called nuclear pores, **nuceloli**, and **gene material (DNA)**,
4. Within the nucleus are the cell’s hereditary units, called **genes**, which are arranged in single file along **chromosomes**.
5. Each chromosome is a long molecule of DNA that is coiled together with several proteins.
6. Human somatic cells have **46** chromosomes arranged in **23** pairs.
7. The various levels of DNA packing are represented by **nucleosomes, chromatin fibers, loops, chromatids, and chromosomes**.
8. Genomics
9. Genomics is the study of the relationships between the genome **and the biological functions of an organism**.
10. At least half of the genome consists of repeated sequences that do **not code for proteins**.
11. Genomic medicine hopes to **genetic diseases**.
12. **PROTEIN SYNTHESIS**
13. Much of the cellular machinery is devoted to synthesizing large numbers of diverse proteins.
14. The proteins determine the **physical and chemical characteristics of cells**.
15. The instructions for protein synthesis is found in the DNA in the nucleus.
16. Protein synthesis involves **transcription**  & **translation**.
17. Transcription

1. Transcription is the process by which genetic information encoded in DNA is

copied onto a strand of RNA called **messenger RNA** (**mRNA**), which

directs protein synthesis.

1. Besides serving as the template for the synthesis of mRNA, DNA also synthesizes two other kinds of RNA, **ribosomal RNA (rRNA) and transfer RNA (tRNA)**.
2. Transcription of DNA is catalyzed by RNA polymerase.
3. Antisense therapy shuts down gene expression by blocking the action of mRNA.
4. Translation
5. Translation is the process of reading the mRNA nucleotide sequence to determine the  **amino acid sequence of the protein.**
6. The sequence of translation is as follows.
7. Messenger RNA associated with **ribosomes**, which consist of tRNA and proteins.
8. Specific amino acids attach to molecules of tRNA. Another portion of the tRNA has a triplet of nitrogenous bases called an anticodon, a codon is a segment of three bases of mRNA.
9. Transfer RNA delivers a specific amino acid to the codon; the ribosome moves along an mRNA strand as amino acids are joined to form a growing **polypeptide**.
10. As a result of recombinant DNA techniques, **genetic engineering** has arisen; strains of recombinant bacteria produce important therapeutic substances such as **human growth hormone,** **insulin,** and **vaccines** against several viruses.
11. **CELL DIVISION**
12. Cell division is the process by which cells reproduce themselves. It consists of nuclear division (**mitosis and meiosis**) and cytoplasmic division (**cytokenesis**).
13. Cell division that results in an increase in body cells is called **somatic cell division** and involves a nuclear division called mitosis, plus cytokinesis.
14. Cell division that results in the production of sperm and eggs is called **reproductive cell division** and consists of a nuclear division called meiosis plus cytokinesis.
15. The Cell Cycle in Somatic Cells
16. The cell cycle is an orderly sequence of events by which a cell duplicates its contents and divides in two.
17. It consists of interphase and the mitotic phase.
18. Chromosome number
19. Human somatic cells contain **46** chromosomes or **23** pairs of chromosomes
20. The two chromosomes that make up a chromosome pair are called **homologous** chromosomes or homologs.
21. A cell with a full set of chromosomes is called a **diploid** (2N). One with only one chromosome from each pair is termed **haploid** (N).
22. Interphase
23. During interphase the cell carries on every life process except division. Interphase consists of three phases: **G1, S and G2.**.
24. In the G1 phase, the cell is metabolically active, duplicating its organelles and cytosolic components except for DNA.
25. In the S phase, **chromosomes** are replicated.
26. In the G2 phase, cell growth continues and the cell completes its preparation for cell division.
27. A cell in interphase shows a distinct nucleus and the absence of chromosomes.
28. Mitotic Phase
29. The mitotic phase consists of mitosis (or nuclear division) and cytokinesis (**or cytoplasmic division**).
30. Nuclear division: mitosis
31. Mitosis is the…**distribution of two sets of chromosomes, one set into each of two separate nuclei.**
32. Stages of mitosis are prophase, metaphase, anaphase, and telophase.
33. During prophase, the chromatin condenses and shortens into **chromosomes**.
34. During metaphase, the centromeres line up at the exact center of the mitotic spindle, a region called the metaphase plate or equatorial plane region.
35. Anaphase is characterized by the splitting and separation of centromeres and the movement of the two sister chromatids of each pair toward opposite poles of the cell.
36. Telophase begins as soon as chromatid movement stops; the identical sets of chromosomes at opposite poles of the cell uncoil and revert to their threadlike chromatin form, microtubules disappear or change form, a new nuclear envelope forms, new nucleoli appear, and the new mitotic spindle eventually breaks up.
37. Cytoplasmic Division: Cytokinesis
38. Cytokinesis is the division of a parent cell’s cytoplasm and organelles. The process begins in late anaphase or early telophase with the formation of a cleavage furrow.
39. When cytokinesis is complete, **interphase** begins
40. Cancer is an uncontrolled cell division. Some anticancer drugs stop this cell division by inhibiting **spindle formation**.
41. Control of Cell Destiny
42. The three possible destinies of a cell are to remain **alive and functioning without dividing**, to  **grow and divide**, or **to die**.
43. Maturation promoting factor (MPF) induces cell division.
44. Cell death, a process called **apoptosis**, is triggered either from outside the cell or from inside the cell due to a: cell-suicide” gene.
45. Necrosis is a pathological cell death due to **injury**.
46. Tumor-suppressor genes can produce proteins that normally inhibit cell division resulting in the uncontrollable cell growth known as **cancer**.
47. Reproductive Cell Division
48. Meiosis results in the production of haploid cells that contain only **23 chromosomes**.
49. Meiosis occurs in two successive stages: meiosis I and meiosis II.
50. Meiosis I
51. Meiosis I consists of four phases: prophase I, metaphase I, anaphase I, and telophase I.
52. During prophase I, the chromosomes become arranged in homologous pairs through a process called synapsis. The resulting four chromatids form a structure called a **tetrad**. The tetrads may exchange genetic material between nonsister chromatids through a process known as **crossing over**
53. During metaphase I, the homologous pairs of chromosomes line up along the metaphase plate of the cell, with the homologous chromosomes side by side.
54. During anaphase I, the members of each homologous pair separate, with one member of each pair moving to an opposite pole of the cell.
55. Telophase I and cytokinesis are similar to telophase and cytokinesis of mitosis.
56. The net effect of meiosis I is that each resulting cell contains only one member of each pair of homologous chromosomes. It is now **haploid in number**.
57. Meiosis II
58. Meiosis II consists of prophase II, metaphase II, anaphase II, and telophase II.
59. These phases are similar to those in mitosis, but result in four **haploid** cells.
60. **CELLULAR DIVERSITY**
61. **Not all cells look alike, nor do they perform identical functional roles in the body.**
62. **The shapes of cells vary considerably.**
63. **CELLS AND AGING**
64. Aging is a **normal process accompanied by a progressive alteration of the body’s homeostatic adaptive responses**; the specialized branch of medicine that deals with the medical problems and care of elderly persons is called **geriatrics**.
65. The physiological signs of aging are **gradual deterioration in function and capacity to respond to environmental stresses**.
66. These signs are related to a net **decrease** in the number of cells in the body and to the **dysfunctioning** of the cells that remain.
67. The extracellular components of tissues (e.g., collagen fibers and elastin) **also change with age**.
68. Many theories of aging have been proposed, **including genetically programmed cessation of cell division, glucose addition to proteins, free radical reactions, and excessive immune responses**
69. Progeria and Werner’s Syndrome
70. Progeria is caused by a genetic deficit in which **telomeres are very short.**
71. Werner’s Syndrome is an inherited disease **which causes premature aging**. The gene has recently been identified.

XI**. DISORDERS: HOMEOSTATIC IMBALANCES**

1. Cancer is a group of diseases characterized by **uncontrolled cell proliferation**.
2. Cells that divide without control develop into a **tumor** or neoplasm.
3. A cancerous neoplasm is called a **malignant** tumor or malignancy. It has the ability to undergo **metastasis**, the spread of cancerous cells to other parts of the body. A **benign** tumor is a noncancerous growth.
4. Types of Cancer
5. **Carcinomas arise from epithelial cells.**
6. **Melanomas are cancerous growths of melanocytes.**
7. **Sarcomas arise from muscle cells or connective tissues.**
8. **Leukemia is a cancer of blood-forming organs.**
9. **Lymphoma is a cancer of lymphatic tissue.**
10. Growth and Spread of Cancer
11. Cancer cells **divide rapidly and continuously**.
12. They trigger angiogenesis, **the growth of new networks of blood vessels.**
13. Cancer cells can leave their site of origin and travel to other tissues or organs, a process called **metastasis**.
14. Causes of Cancer
15. **Environmental agents** can cause cancer growth. A chemical agent. or radiation that produces cancer is termed a **carcinogen** and induces mutations in DNA.
16. **Viruses** can cause cancer.
17. **Cancer causing genes, or oncogenes**, can cause cancer.
18. The normal counterparts of oncogenes are called proto-oncogenes; **these are found in every cell and carry out normal cellular functions until a malignant change occurs via a mutation.**
19. Some cancers may also be caused by genes called anti-oncogenes or tumor-suppressing genes. **These genes may produce proteins that normally oppose the action of an oncogene or inhibit cell division.**
20. Carcinogenesis is a multistep process involving mutation of oncogenes and anti-oncogenes**; as many as 10 distinct mutations may have to accumulate in a cell before it becomes cancerous**.
21. Treatment of Cancer
22. Treatment of cancer is difficult because it is **not a single disease and all the cells in a tumor do not behave in the same way**.
23. Various treatments include **surgery, chemotherapy, and radiation therapy.**