CHAPTER 3
STRUCTURE AND FUNCTION OF THE CELL

CHAPTER OVERVIEW: This chapter introduces the parts of the eukaryotic cell which will be developed in future chapters to explain the functions performed by particular tissues and organs. The phenomena associated with diffusion and osmosis across a semi-permeable membrane are explained. The processes of protein synthesis and cell division, both mitotic and meiotic (including cytokinesis), are described in some detail.

OUTLINE (one or two fifty-minute lectures):
Seeley, A&P, 5/e

Chapt. Object.	Topic Outline, Chapter 3	Figures & Tables	Transparency Acetates
1	I. How We Learn About Cells, p. 58		
	II. Plasma Membrane, p.58	Fig. 3.1, p.58	TA-42
	A. Physical Barrier Marking Limit of Cell		
	B. Chemical Composition of Plasma Membrane		
	1. Lipid Bilayer	Fig. 3.2, p.60	TA-43
	a. Phospholipids		
	b. Cholesterol		
	2. Proteins	Fig. 3.3, p. 61	TA-44
	a. Integral or Intrinsic v. Peripheral or Extrinsic Proteins	Fig. 3.4, p. 62	TA-45
	b. Channel Proteins	Fig. 3.5a, p. 63	TA-46
	1). Ligand-gated		
	2). Voltage-gated		
	c. Receptor Molecules	Fig. 3.5b, p. 63	
	d. G-Proteins; Intracellular Messages		
	3. Marker Molecules	Fig. 3.5c, p. 63	
	a. Glycoproteins		
	b. Glycolipids		
	C. Fluid Mosaic Model of the Membrane	Fig. 3.2, p.60	TA-43
2	III. The Nucleus, p. 61		
	A. Nuclear Envelope	Fig. 3.6, p. 64	TA-47
	1. Double Layer of Membrane		

Chapt. Object.	Topic Outline, Chapter 3	Figures & Tables	Transparency Acetates
	2. Nuclear Pores		
	B. Encloses Cellular DNA		
	1. DNA + Associated Histone Proteins = Chromatin		
	2. Chromatin Forms Chromosomes During Cell Division		
	3. Directs Cellular Processes in Uncondensed Form	Clinical Note, p.61	
	C. Encloses Nucleoli	Fig.3.6, p.64	TA-47
	1. Areas High in RNA		
	2. Sites of Ribosome Subunit Construction		
3	IV. Cytoplasm, p. 63		
	A. Cytosol, p. 63		
	1. Fluid Portion		
	a. Complex Solution - Colloid		
	b. Rich in Protein		
4	2. Cytoskeleton	Fig. 3.7, p.65	TA-48
	a. Tubulin and Microtubules		
	b. Actin and Microfilaments		
	c. Intermediate Filaments		
	3. Cytoplasmic Inclusions, p. 63		
	a. Chemical Aggregates		
	b. Not Surrounded by Membrane		
3	B. Organelles, p. 64		
	1. Highly Organized Intracellular Structures		
	2. Ribosomes		
	a. Made of Protein and rRNA	Fig. 3.8, p. 66	
	b. Catalyze Peptide Bond Formation		
5	3. Endoplasmic Reticulum (E.R.), p. 66	Fig. 3.9, p. 67	
	a. Connections to Nuclear Envelope		
	b. Rough E.R.		

Chapt. Object.	Topic Outline, Chapter 3	Figures & Tables	Transparency Acetates
	1. Ribosomes Attached		
	2. Protein Synthesis		
	c. Smooth E. R.		
	1. Site of Lipid Synthesis		
	2. Detoxification Rxns.		
	3. Intracellular Compartment Formation		
6	4. The Golgi Apparatus, p. 66	Fig. 3.10, p. 67	
	a. Flattened Sacs of Membrane Surrounding Cisternae		
	b. Involved in Modifying, Packaging and Distributing Proteins and Lipids, Esp. for Secretion	Fig. 3.11, p. 68	TA-49
	5. Vesicles & Secretory Vesicles, p. 68		
	a. Membrane Sacs for Intracellular Transport		
	b. Between Rough E.R. and Golgi Apparatus		
	c. Secretory Vesicles Between Golgi Apparatus and Plasma Membrane	Fig. 3.11, p. 68	
7	6. Lysosomes, p. 68	Fig. 3.12, p.69; Clinical Note, p.68-69	TA-50
	a. Specialized Vesicle		
	b. Contain Hydrolytic Enzymes		
	c. Controlled Intracellular Digestion		
	1). Intracellular Part of Phagocytosis		
	2). Autophagia of Cell Parts		
7	7. Peroxisomes, p. 69		
	a. Similar to, but smaller than Lysosomes		
	b. Contains Catalase		
	c. Associated with Detoxification		
8	8. Mitochondria, p. 69	Fig. 3.13, p.70	

Chapt. Object.	Topic Outline, Chapter 3	Figures & Tables	Transparency Acetates
	a. Double Membrane	Clinical Note p. 70	
	b. Matrix Between Membranes Contains Enzymes of Citric Acid Cycle	Predict Question, 1, p. 70	
	c. Inner Membrane		
	1). Folds Called Cristae		
	2). Components of Electron Transport Chain		
	d. Contains Its Own DNA		
	e. Major site of Aerobic Respiration		
9	9. Centrioles and Spindle Fibers, p. 70	Fig. 3.14, p. 71	
	a. Formed of Microtubules		
	b. Centrosome Site of Microtubule Formation for Cytoskeleton		
	c. Spindle Fibers		
	1). Form After Centrioles Have Duplicated		
	2). Attach to Kinetochore of Chromosomes		
	3). Produce Movement of Chromosomes During Cell Division		
9	10. Cilia and Flagella, p. 71	Fig. 3.15, p. 72	TA-51
	a. Anchored by Basal Body		
	b. Produce Active Movement		
	1). Short Cilia Move Things Over Cell Surface	Fig. 3.15, p. 72	
	2). Longer Flagella Move Whole Cells		
9	11. Microvilli, p. 71	Fig. 3.16, p. 72	
	a. Extensions of Plasma Membrane, Shorter than Cilia		
	b. Increase Surface Area of Cell		
	V. Summary of Cell Structures and Functions, p. 71	Table 3.1, p. 73	

Chapt. Object.	Topic Outline, Chapter 3	Figures & Tables	Transparency Acetates
	VI. Movement Through the Plasma Membrane, p. 74	Table 3-2, p. 85	
	A. Selective Permeability Helps Maintain Cells		
10	B. Ways a Substance Can Cross Plasma Membrane		
	1. Directly Across Lipid Bilayer - non-selective If Small and Lipid-Soluble		
	2. Through Open Membrane Channels - Selective by Size		
	3. In Association with a Carrier Molecule in the Membrane - Highly Selective		
	4. Contained Inside a Vesicle - Only Path for Very Large Molecules		
10	C. Diffusion, p. 74		
	1. Definition	Fig. 3.17, p. 75	TA-52
	2. Rate Determined by a. Size of Conc. Difference	Predict Quest. 2, p. 75	
	b. Temperature of the Solution		
	c. Size of Solute Molecules		
	d. Viscosity of Solvent		
	3. In Cells - Diffusion of Solutes is Through Lipid Bilayer or Open Channels		
11	D. Osmosis, p. 75	Fig. 3.18, p. 76	TA-53
	1. Definition		
	2. Net Movement of Water is in Opposite Direction of Solute Concentration Gradient		
	3. Osmotic Pressure - Definition	Predict Quest. 3, p. 76	
	a. Two Solutions are Isosmotic, Hyperosmotic or Hypoosmotic in Comparison to Each Other		
	b. A Solution is Isotonic, Hypertonic or Hypotonic in Comparison to a Cell	Fig. 3.19a,b,c, p. 77	
	c. Isosmotic Solutions are Not Necessarily Isotonic		
	d. Mismatches Can Produce Crenation or Lysis	Fig.3.19a,b, p. 77	

Chapt. Object.	Topic Outline, Chapter 3	Figures & Tables	Transparency Acetates
	E. Filtration, p. 77		
	1. Definition		
	2. Net Rate of Filtration Determined by		
	a. Size of Holes in Barrier		
	b. Net Pressure Difference Across Barrier		
12	F. Mediated Transport Mechanisms, p. 78		
	1. General Characteristics of All Types	Fig. 3.20a,b,, p. 78	
	a. Greater Specificity - Membrane Protein Acts as Carrier Molecule	Fig. 3.21a, p. 78	
	b. Competition for Carriers	Fig. 3.21b, p. 78	
	c. Saturation of Carriers Produces Maximum Transport Rates	Fig. 3.22, p. 80	TA-54
13	2. Facilitated Diffusion, p. 79		
	a. Movement in Direction of Solute's Concentration Gradient		
	b. Rate of Transport Proportional to Conc. Difference up to Saturation Point	Predict Quest. 4, p. 79	
13	3. Active Transport, p. 79		
	a. Movement Against Solute's Concentration Gradient		
	b. Requires the Input of ATP Energy	Clinical Note, p.79	
	c. Movement of Two Substances in Opposite Directions Possible (Na^+/ K^+ Pump as Example)	Fig. 3.23, p. 81	TA-55
13	4. Secondary Active Transport, p. 79	Fig. 3.24, p. 82	TA-56
	a. Active Transport Enhances an Ion's Concentration Gradient		
	b. Ion Moving Along It's Conc. Gradient Drives Movement of Second Molecule		
	b. Cotransport - Both Ion and Second Molecule are Moved in Same Direction		
	c. Countertransport - Ion and Second Molecule are Moved in Opposite Directions	Predict Quest. 5, p. 79	

Chapt. Object.	Topic Outline, Chapter 3	Figures & Tables	Transparency Acetates
13	G. Endocytosis and Exocytosis, p. 81		
	1. Transport of Materials in Vesicles		
	2. Endocytosis - Movement Into Cell		
	a. Phagocytosis - Engulfment of Large Particle or Cell	Fig. 3.25a,b, p. 83	TA-57
	b. Pinocytosis - Engulfment of Materials in Solution	Fig. 3.25c,d, p. 83	TA-5
	c. Receptor-Mediated Endocytosis More Specific	Fig. 3.25e, p. 83 Clinical Note p. 82	TA-57
	d. Endocytotic Vesicles Often Fuse with Lysosomes Intracellularly		
	3. Exocytosis - Movement Out of Cell	Fig. 3.26, p. 84	
	a. Final Stages of Secretory Vesicles from Golgi Apparatus		
	b. Opposite of Endocytosis		
14	VII. Cell Metabolism, p. 82	Fig. 3.27, p. 86	TA-58
	A. Sum of Anabolism and Catabolism		
	B. ATP Production in Cytosol and Mitochondria		
	1. Glycolysis in Cytosol		
	2. Aerobic Respiration in Mitochondria		
	a. Captures 36 to 38 ATP per Molecule of Glucose Catabolized		
	b. Oxygen Final Electron Acceptor		
	3. Anaerobic Respiration in Cytosol		
	a. Net Capture of Only 2 ATP per Molecule of Glucose		
	b. Short-Term Strategy in Humans		
15	VIII. Protein Synthesis, p. 84	Fig. 3.28, p. 86	TA-359
	A. Instructions for Which Proteins to Make in Segments of DNA = Genes		
	B. Transcription, p. 87		

Chapt. Object.	Topic Outline, Chapter 3	Figures & Tables	Transparency Acetates
	1. Synthesis of RNA from Pattern in DNA	Fig. 3.29, p. 87	TA-60
	a. Using RNA Nucleotides		
	b. Adenine Pairs with Thymine or Uracil		
	c. Guanine Pairs with Cytosine		
	2. Types of RNA		
	a. Messenger (mRNA)		
	b. Transfer (tRNA)		
	c. Ribosomal (rRNA)		
	3. Transcription Units and Genes		
	a. More DNA in Genes than Codes for mRNA		
	b. Post-Transcriptional Processing	Fig. 3-30, p.88: Clinical Note, p.88	TA-61
	1). Bringing Exons Together		
	2). Removing Introns		
	C. Translation, p. 88	Fig. 3.31, p. 89	TA-62
	1. mRNA Codons Matched to tRNA Anticodons	Predict Quest. 6, p. 88	
	2. Ribosome Catalyzes Peptide Bonds Between Amino Acids Attached to tRNAs		
	3. Growing Protein Stays With Ribosome Until End of mRNA Reached - Polyribosomes Possible		
	a. tRNA's Released When Ribosome Position on mRNA Shifts		
	b. Protein and Ribosome Subunits Freed When "Stop" Codon Encountered		
	4. Post-Translational Processing in Golgi Apparatus		
	a. Portions Removed		
	b. Carbohydrates or Lipids Added		
	D. Regulation of Protein Synthesis, p. 88		
	1. Accounts for Differences in Cellular Specialization		

Chapt. Object.	Topic Outline, Chapter 3	Figures & Tables	Transparency Acetates
	2. Involves Function of Nuclear Proteins		
16	IX. Cell Life Cycle, p. 90	Fig. 3.32, p. 90	TA-63
	A. Interphase, p. 90		
	1. Most of a Cell's Life, Specialized Functions		
	2. All of Metabolism Including DNA replication, p. 91	Fig. 3.33, p.91; Predict Quest. 7, p. 92	TA-64
	B. Cell Division, p. 92		
	1. Mitosis in Somatic Cells, p. 92		
	a. Two Diploid (N=46) Products Result		
	b. Prophase, Metaphase, Anaphase, Telophase	Fig. 3.34, p. 94-95	TA-65
	c. Cytokinesis Optional in Some Cells, p. 92	Fig. 3.34d-f, p. 95	
17	X. Meiosis, p. 92	Fig. 3.35, p. 96 Table 3.3, p, 97	TA-66
	2. Meiosis in Sex Cells		
	a. Four Haploid (N=23) Products Result		
	b. Prophase I, Metaphase I, Anaphase I, Telophase I, Interkinesis (NO DNA Replication Here), Prophase II, Telophase II	Fig. 3.35, p. 96	TA-66
	c. Cytokinesis Unequal in Females		
	d. Crossing-Over During Synapsis of Prophase I	Fig. 3.36, p. 97 Clinical Focus, p. 93	

IMPORTANT CONSIDERATIONS: If this material is to be covered in one lecture or only part of one lecture as an introduction to histology, then obviously a detailed presentations of cellular organelles will not be possible. As long as more detailed knowledge is not required, students can be asked to learn the basic information through their reading. Detailed discussions of Cellular Metabolism are probably better left to later chapters, although an understanding of ATP will certainly help during discussions of muscle physiology. The details of the cell life cycle and cell division may also be expendable at this point in the course for some groups of students.

If this material is to be covered in two lecture sessions, then the natural logical break is to discuss the cell parts and transport functions in one session followed by the whole cell activities in the second session.

SEE INSTRUCTOR'S MANUAL AND COURSE SOLUTIONS MANUAL FOR ADDITIONAL RESOURCES.