

# CONTENTS

## PART ONE INTRODUCTION TO CELL BIOLOGY

<b>CHAPTER 1 – Introduction. History and General Concepts of Cell Biology.....</b>	<b>3</b>
LEVELS OF ORGANIZATION IN BIOLOGY.....	3
LIMITS AND DIMENSIONS IN BIOLOGY.....	4
PROKARYOTIC AND EUKARYOTIC CELLS.....	7
<i>The Bacterial Cell.....</i>	8
<i>The Smallest Mass of Living Matter.....</i>	9
HISTORY OF CYTOLOGY.....	10
<i>Cell Theory.....</i>	10
<i>Cytology and Genetics: Cytogenetics.....</i>	11
<i>Cytology and Physiology: Cell Physiology.....</i>	12
<i>Cytology and Biochemistry: Cytochemistry.....</i>	13
<i>Ultrastructure and Molecular Biology.....</i>	14
LITERARY SOURCES IN CELL BIOLOGY.....	15
REFERENCES.....	15
<b>CHAPTER 2 – General Structure of the Cell.....</b>	<b>17</b>
OBSERVATION OF THE LIVING CELL.....	17
<i>Shape.....</i>	17
<i>Size.....</i>	18
<i>Structure.....</i>	18
OBSERVATION OF THE FIXED CELL.....	20
<b>CHAPTER 3 – Introduction to the Study of the Nucleus and Chromosomes.....</b>	<b>25</b>
THE NUCLEUS.....	25
<i>Morphology.....</i>	25
<i>General Structure of the Interphase Nucleus.....</i>	26
Mitosis and Meiosis.....	27
<i>Mitosis.....</i>	27
<i>Meiosis.....</i>	27

CHROMOSOMES.....	29
<i>Morphology</i> .....	29
<i>Chromonema and Chromonema Cycle</i> .....	35
<i>Euchromatin and Heterochromatin</i> .....	37
<i>Chromomeres</i> .....	38
Giant Chromosomes.....	39
<i>Polytene Chromosomes</i> .....	39
<i>Lampbrush Chromosomes</i> .....	41
REFERENCES.....	42

**PART TWO    MOLECULAR COMPONENTS AND METABOLISM  
                 OF THE CELL**

<b>CHAPTER 4 – Chemical Components of the Cell.....</b>	<b>47</b>
MOLECULAR POPULATION OF THE CELL.....	47
<i>Water, Free and Bound</i> .....	48
<i>Salts and Ions</i> .....	48
Macromolecules.....	49
<i>Amino Acids and Proteins</i> .....	49
<i>Carbohydrates</i> .....	56
<i>Complex Polysaccharides, Mucopolysaccharides,           Mucoproteins and Glycoproteins</i> .....	57
<i>Lipids</i> .....	57
<i>The Nucleic Acids</i> .....	60
<b>CHAPTER 5 – Enzymes, Cell Metabolism and Bioenergetics.....</b>	<b>67</b>
ENZYMES.....	67
<i>Nomenclature</i> .....	68
<i>Specificity</i> .....	68
<i>Chain Reactions</i> .....	68
<i>Factors That Affect Enzyme Activity</i> .....	69
<i>Coenzymes and Prosthetic Groups</i> .....	69
<i>Active Site of the Enzyme</i> .....	70
<i>Isoenzymes</i> .....	70
ENZYLE KINETICS.....	71
<i>Enzyme Inhibition</i> .....	72
<i>Enzyme Activators</i> .....	73
<i>Regulation of Enzymic Activity. Allosteric Transformations</i> .....	73
CELL METABOLISM.....	74
<i>Energy Cycle</i> .....	74
<i>Energy Transformation</i> .....	74
BIOENERGETICS.....	78
<i>Concept of Entropy</i> .....	78
<i>Oxidation and Reduction</i> .....	79
Cell Respiration.....	80
<i>Anaerobic Respiration (Fermentation)</i> .....	81
<i>Krebs Cycle and Oxidative Phosphorylation</i> .....	83
REFERENCES.....	83

## PART THREE METHODS FOR THE STUDY OF THE CELL

✓ CHAPTER 6 – Instrumental Analysis of Biological Structures.....	87
<i>Resolving Power of the Microscope</i> .....	87
METHODS FOR INCREASING CONTRAST.....	88
Phase Microscopy.....	88
Interference Microscopy.....	91
Darkfield Microscopy.....	92
Polarization Microscopy.....	92
Electron Microscopy.....	95
<i>Preparation of Biological Material for Electron Microscopy</i> .....	97
X-ray Diffraction.....	99
REFERENCES.....	102
✓ CHAPTER 7 – Methods for Cytologic and Cytochemical Analysis.....	103
EXAMINATION OF LIVING CELLS.....	103
<i>Tissue Culture</i> .....	103
<i>Microsurgery</i> .....	104
FIXATION.....	104
<i>Osmium Tetroxide</i> .....	105
<i>Freezing-Drying</i> .....	106
<i>Freezing-Substitution</i> .....	107
Embedding and Sectioning.....	107
CYTOLOGIC STAINING.....	108
<i>Mechanism of Staining</i> .....	108
<i>Metachromasia</i> .....	109
HISTOCHEMISTRY AND CYTOCHEMISTRY.....	109
Cell Fractionation Methods.....	111
<i>Differential Centrifugation</i> .....	113
<i>Gradient Centrifugation</i> .....	113
<i>Zonal Centrifugation</i> .....	114
Microchemistry and Ultramicrochemistry.....	115
Cytochemical and Histochemical Staining Methods.....	115
<i>Detection of Proteins</i> .....	116
<i>Detection of Aldehydes</i> .....	116
<i>Detection of Nucleic Acids</i> .....	116
<i>Periodic Acid-Schiff (PAS) Reaction</i> .....	118
<i>Detection of Lipids</i> .....	118
<i>Detection of Enzymes</i> .....	119
Histochemical Methods Based on Physical Determinations.....	123
<i>Cytophotometric Methods</i> .....	123
<i>Microincineration (Spodography)</i> .....	124
<i>Fluorescence Microscopy</i> .....	125
<i>Immunocytochemistry</i> .....	125
<i>Radioautography in Cytochemistry</i> .....	128
REFERENCES.....	131

**PART FOUR UNITS OF STRUCTURE AND THE PLASMA MEMBRANE**

✓ CHAPTER 8 – <b>Elementary Units of Structure in Biological Systems</b> .....	137
FUNCTION OF ELEMENTARY STRUCTURES.....	137
<i>Molecular Shape of Proteins</i> .....	138
<i>Collagen as an Example of a Fibrous Unit</i> .....	138
<i>Blood Clotting</i> .....	141
<i>Physicochemical Forces</i> .....	141
<i>The Macromolecular Organization of Particulate Glycogen</i> .....	141
ELEMENTARY MEMBRANOUS STRUCTURES .....	142
<i>Monolayer Films</i> .....	142
<i>Lipid-Water Systems</i> .....	143
<i>Myelin Figures</i> .....	144
REFERENCES.....	146
✓ CHAPTER 9 – <b>The Plasma Membrane</b> .....	147
ISOLATION OF THE PLASMA MEMBRANE.....	147
<i>Chemical Composition</i> .....	148
MOLECULAR STRUCTURE OF THE PLASMA MEMBRANE .....	150
<i>Models Based on a Lipid Bilayer</i> .....	151
<i>Other Membrane Models</i> .....	151
<i>Fine Structure of the Plasma Membrane</i> .....	152
<i>Specializations of the Unit Membrane</i> .....	152
<i>Interpretation of the Electron Microscopic Image</i> .....	154
<i>The Myelin Sheath</i> .....	154
<i>Retinal Rods and Cones</i> .....	156
DIFFERENTIATIONS AT THE CELL SURFACE .....	158
<i>Desmosomes</i> .....	158
<i>Tight Junctions</i> .....	162
<i>Tight Junctions and Electrical Coupling</i> .....	162
EXTRANEIOUS COATS OF THE CELL MEMBRANE.....	165
<i>Glycocalyx in the Gastrointestinal Mucosa</i> .....	165
REFERENCES.....	166

**PART FIVE THE CYTOPLASM AND CYTOPLASMIC ORGANOIDS**

✓ CHAPTER 10 – <b>The Cytoplasm</b> .....	171
<i>Historical Notes on the Cytoplasm</i> .....	171
<i>Early Submicroscopic Studies of the Cytoplasm</i> .....	173
<i>Some Physicochemical Properties of the Cytoplasmic Matrix</i> .....	174
<i>Chemical Organization of the Cytoplasmic Matrix</i> .....	176
<i>Ultrastructure of the Cytoplasmic Matrix</i> .....	176
THE CYTOPLASMIC VACUOLAR SYSTEM .....	177
General Morphology of the Vacuolar System.....	178
<i>Endoplasmic Reticulum</i> .....	180
<i>Microsomes</i> .....	183

Functions of the Vacuolar System.....	187
<i>Mechanical Support</i> .....	187
<i>Exchange</i> .....	187
<i>Enzymic Activities</i> .....	187
<i>Membrane Flow and Circulation</i> .....	188
<i>Protein Synthesis and Segregation of Products</i> .....	189
<i>Functions of the Agranular or Smooth Endoplasmic Reticulum</i> .....	189
The Golgi Complex (Dictyosomes).....	190
<i>Morphology</i> .....	190
<i>Cell Secretion and the Golgi Complex</i> .....	192
<i>Cytochemical Studies</i> .....	193
<i>Isolation of the Golgi Complex. Biochemical Studies</i> .....	195
<i>Golgi Complex and Secretion of Glycoproteins</i> .....	196
REFERENCES.....	196
<b>CHAPTER 11 – Mitochondria</b> .....	<b>199</b>
EXAMINATION IN VIVO .....	200
<i>Volume-Shape Changes</i> .....	200
MORPHOLOGY .....	200
LOCALIZATION .....	202
STRUCTURE AND COMPARTMENTATION .....	202
<i>Structural Variations</i> .....	204
MITOCHONDRIAL FUNCTIONS .....	209
<i>The Mitochondrial Enzyme System</i> .....	211
<i>Asymmetry and Ultrastructural Localization of the Coupling Factor and the Respiratory Chain</i> .....	212
<i>Separation and Properties of the Mitochondrial Membranes</i> .....	213
<i>Permeability of the Mitochondrial Membranes</i> .....	217
<i>Conformational Changes in Mitochondria</i> .....	218
<i>Swelling and Contraction</i> .....	218
<i>Cation Accumulation in Mitochondria</i> .....	220
MITOCHONDRIA AS SEMIAUTONOMOUS ORGANOIDS.....	222
<i>Mitochondrial DNA</i> .....	222
<i>Protein Synthesis and Ribosomes in Mitochondria</i> .....	224
<i>Biogenesis of Mitochondria</i> .....	224
<i>The Prokaryotic Origin of Mitochondria</i> .....	226
REFERENCES.....	226
<b>CHAPTER 12 – The Plant Cell and the Chloroplast</b> .....	<b>229</b>
<i>Cell Walls</i> .....	229
<i>Plasmodesmata: Continuity of Cytoplasm</i> .....	231
<i>Cytoplasmic Matrix and the Vacuolar System</i> .....	233
<i>The Golgi Complex and Dictyosomes</i> .....	233
<i>Mitochondria</i> .....	237
PLASTIDS.....	237
Chloroplasts .....	238
<i>Morphology</i> .....	238
<i>Chemical Composition</i> .....	240
<i>Ultrastructure and Grana</i> .....	241
<i>Origin of the Lamellar Structure of the Chloroplast</i> .....	243
<i>Function of Chloroplasts. Photosynthesis</i> .....	244

<i>Correlation between Structure and Function in Chloroplasts</i> .....	247
<i>The Quantasome Concept</i> .....	247
<i>Chloroplasts as Semiautonomous Organelles</i> .....	249
REFERENCES.....	250

## PART SIX CELLULAR BASES OF CYTOGENETICS

CHAPTER 13 – <b>Cell Division: Mitosis and Meiosis</b> .....	255
MITOSIS .....	256
The Cell Center in Mitosis .....	260
<i>Centriole Cycle during Mitosis</i> .....	262
Mitotic Apparatus .....	263
<i>Cyclic Changes in Birefringence</i> .....	263
<i>Electron Microscopic Studies</i> .....	265
<i>Isolation and Biochemical Studies of the Mitotic Apparatus</i> .....	267
Role of the Mitotic Apparatus .....	269
<i>Cytokinesis (Cell Cleavage)</i> .....	270
MEIOSIS.....	271
Analysis of Meiosis.....	273
<i>Meiotic Division I</i> .....	273
<i>Meiotic Division II</i> .....	279
REFERENCES.....	280
CHAPTER 14 – <b>Cytogenetics. Chromosomal Bases of Genetics</b> .....	282
LAWS OF HEREDITY .....	282
Law of Segregation .....	282
<i>Genotype and Phenotype</i> .....	284
Law of Independent Assortment.....	285
LINKAGE AND CROSSING OVER .....	286
<i>Crossing Over, Chiasmata and Genetic Maps</i> .....	287
<i>Recombination Index</i> .....	289
<i>Crossing Over and Recombination in Neurospora</i> .....	289
ALTERATION OF THE CHROMOSOMES AND THEIR MECHANISM OF REORGANIZATION.....	291
Mutation.....	291
Aberrations .....	292
<i>Deficiency or Deletion</i> .....	292
<i>Duplication</i> .....	293
<i>Translocation</i> .....	293
<i>Inversion</i> .....	294
VARIATIONS IN CHROMOSOME NUMBER .....	296
<i>Haploidy</i> .....	296
<i>Polyploidy</i> .....	297
<i>Allopolyploidy</i> .....	298
<i>Aneuploidy</i> .....	298
<i>Endomitosis, Polyteny, Polysomaty and Somatic Reduction</i> .....	298
<i>Somatic Variation in Chromosome Number</i> .....	300

CYTOGENIC EFFECT OF RADIATION .....	300
<i>Chromosomal Aberrations</i> .....	301
<i>Somatic Mutations and Cancer</i> .....	304
<i>Germ Cell Mutations</i> .....	304
CYTOGENETIC ACTION OF CHEMICAL AGENTS.....	304
<i>Chemical Agents That Act at Prophase and Interphase</i> .....	305
<i>Chemical Agents That Act at Metaphase and the Following Phases</i> .....	305
<i>Mutagenic Action of Chemicals</i> .....	305
<i>Stimulating Agents</i> .....	306
CYTOGENETICS AND EVOLUTION .....	306
REFERENCES.....	308

## CHAPTER 15 – Sex Determination and Human Cytogenetics ..... 310

SEX DETERMINATION .....	310
<i>Sex Chromosomes</i> .....	310
<i>Sex Chromatin and Sex Chromosomes</i> .....	312
<i>The Single-X Nature of Sex Chromatin</i> .....	314
<i>Heteropycnosis of the Sex Chromosomes</i> .....	315
<i>Sex Vesicle</i> .....	315
<i>Neo-XY System of Sex Determination</i> .....	316
<i>Gynandromorphs</i> .....	317
<i>Genic Balance in Sex Determination</i> .....	317
SEX-LINKED INHERITANCE.....	318
<i>Genes Linked to the X Chromosome</i> .....	319
<i>Genes Linked to the Y Chromosome</i> .....	319
<i>Genes Localized in the Homologous Segments of Both X and Y Chromosomes</i> ...	319
HUMAN CYTOGENETICS .....	320
<i>The Normal Human Karyotype</i> .....	320
<i>Abnormal Human Karyotypes</i> .....	322
<i>Chromosomal Aberrations in the Human</i> .....	323
<i>Autosomal Aberrations</i> .....	323
<i>Aberrations of Sex Chromosomes</i> .....	324
REFERENCES.....	326

## PART SEVEN MOLECULAR BIOLOGY

### CHAPTER 16 – Ultrastructure of the Nucleus and Chromosomes. The Nucleolus ..... 331

THE NUCLEAR ENVELOPE AND NUCLEAR PERMEABILITY .....	331
<i>Nuclear Pores and Annuli</i> .....	332
<i>Permeability of the Nuclear Envelope</i> .....	333
ULTRASTRUCTURE OF THE INTERPHASE NUCLEUS .....	334
<i>Localization of the Nuclear Ribonucleoproteins</i> .....	336
<i>Macromolecular Organization of Deoxyribonucleoproteins</i> .....	336
STUDIES OF CHROMOSOMAL STRUCTURE.....	339
<i>A Folded Fiber Model of Chromosome Structure</i> .....	339
<i>Fine Structure of Heterochromatin</i> .....	341
<i>Fine Structure of the Centromere</i> .....	341
<i>The Synaptonemal Complex of Meiotic Chromosomes</i> .....	342

THE NUCLEOLUS .....	344
<i>Isolation of the Nucleolus</i> .....	344
<i>Cytochemistry</i> .....	344
<i>Fine Structure</i> .....	345
REFERENCES .....	346
<b>CHAPTER 17 – Cytochemistry of the Nucleus. DNA Duplication</b> .....	<b>349</b>
CYTOCHEMICAL STUDY OF THE NUCLEUS .....	349
Nuclear Proteins .....	351
<i>Nucleoprotamines</i> .....	351
<i>Nucleohistones</i> .....	352
<i>Nonhistone or Acidic Proteins</i> .....	353
<i>Nuclear Enzymes</i> .....	353
Other Nuclear Components .....	354
DNA Content of the Nucleus .....	354
<i>DNA Content and Length of the DNA Molecules</i> .....	356
DNA Duplication and the Life Cycle of the Cell .....	356
<i>Asynchrony in DNA Duplication</i> .....	357
<i>Molecular Mechanism of DNA Duplication</i> .....	358
<i>Semiconservativeness of DNA Duplication</i> .....	360
<i>DNA Duplication in Eukaryons</i> .....	362
<i>DNA Synthesis in Meiosis</i> .....	364
Nuclear RNA and the Origin of Cytoplasmic RNA .....	365
<i>RNA Species Involved in Genetic Transcription and Protein Synthesis</i> .....	365
Proteins in the Life Cycle of the Cell .....	367
REFERENCES .....	368
<b>CHAPTER 18 – Structure and Biogenesis of Ribosomes</b> .....	<b>370</b>
THE RIBOSOME .....	370
<i>Number and Concentration</i> .....	370
CLASSES OF RIBOSOMES .....	371
<i>Ribosomal Subunits</i> .....	372
<i>Ribosomal RNAs; 28S, 18S and 5S</i> .....	373
<i>Ribosomal Proteins</i> .....	374
<i>Reconstitution of Ribosomes</i> .....	375
BIOGENESIS OF RIBOSOMES IN EUKARYOTIC CELLS .....	376
<i>Nucleolar Organizer and Ribosomal DNA</i> .....	377
<i>Isolation of the rDNA Cistrons</i> .....	377
<i>Amplification (Redundancy) of the rDNA Cistrons</i> .....	378
<i>Steps in rDNA Processing in the Nucleolus</i> .....	379
<i>Synthesis of Ribosomal Protein and Ribosomal Assembly</i> .....	380
<i>Correlation Between Nucleolar Ultrastructure and Biogenesis of Ribosomes</i> .....	382
<i>Cytochemical Demonstration of rDNA in Oöcytes</i> .....	382
<i>Electron Microscopic Observations of rDNA-RNA Transcription</i> .....	382
<i>Passage of rRNA into the Cytoplasm</i> .....	384
REFERENCES .....	386



<b>CHAPTER 19 – Protein Synthesis and Molecular Genetics</b> .....	<b>388</b>
<b>MOLECULAR EXPRESSION OF GENIC ACTION</b> .....	<b>389</b>
<i>Phenylketonuria and Other Human Diseases</i> .....	389
<i>Genes and the Structure of Proteins. Sickle Cell Anemia</i> .....	390
<b>GENES AND PROTEIN SYNTHESIS</b> .....	<b>392</b>
<i>Messenger RNA (mRNA)</i> .....	394
<i>Informosomes</i> .....	395
<i>Transfer RNA (tRNA)</i> .....	396
<i>The Genetic Code</i> .....	398
<b>RIBOSOMES AND PROTEIN SYNTHESIS</b> .....	<b>399</b>
<i>Polyribosomes and Protein Synthesis</i> .....	400
<i>Ribosome-Polysome Cycle. Association and Dissociation of Subunits</i> .....	402
<i>Role of the 30S Subunit in the Initiation Complex</i> .....	402
<i>Initiation of Protein Synthesis</i> .....	404
<i>Elongation of the Protein Chain</i> .....	405
<i>Role of the 50S Subunit</i> .....	405
<i>Chain Termination</i> .....	407
<i>Role of the 60S Subunit in Ribosomes Attached to Endoplasmic Reticulum</i> .....	407
<i>Action of Antibiotics in Protein Synthesis</i> .....	407
<b>THE FINE STRUCTURE OF GENES</b> .....	<b>408</b>
<i>Recombination in Bacteriophages</i> .....	408
<b>REGULATION OF GENIC ACTION</b> .....	<b>410</b>
<i>Enzyme Induction and Repression</i> .....	411
<i>Regulatory Genes</i> .....	411
<i>Operator Genes. Operon</i> .....	411
<i>Gene Regulation at the Transcription Level</i> .....	412
<b>REFERENCES</b> .....	<b>413</b>
<b>CHAPTER 20 – Cell Differentiation and Cellular Interaction</b> .....	<b>416</b>
<b>CELL DIFFERENTIATION</b> .....	<b>416</b>
<b>Nuclear Control of the Cytoplasm</b> .....	<b>417</b>
<i>Nuclear Control of Differentiation in Acetabularia</i> .....	418
<i>Control of Nuclear Activity in Early Development</i> .....	419
<b>Cytoplasmic Control of DNA Synthesis</b> .....	<b>420</b>
<i>Repetitious or Redundant DNA and Gene Amplification</i> .....	420
<b>Control of Gene Expression in Higher Cells</b> .....	<b>422</b>
<i>Role of Histones</i> .....	422
<i>Role of Nonhistone Proteins and RNA</i> .....	423
<i>Differences in Regulation of Bacteria</i> .....	423
<i>Control of Gene Activity in Polytene Chromosomes</i> .....	424
<i>Cell Division and Cell Differentiation</i> .....	427
<b>Renewal of Cell Populations</b> .....	<b>427</b>
<i>Cell Populations in Embryonic Life</i> .....	428
<i>Classification of Cell Populations</i> .....	428
<b>CELLULAR INTERACTION</b> .....	<b>429</b>
<i>Cell Adhesion</i> .....	430
<i>Cellular Communication and Electrical Coupling</i> .....	430

<i>Cell Dissociation and Reassociation</i> .....	431
<i>Contact Inhibition, Cancer Cells</i> .....	431
REFERENCES.....	432

## PART EIGHT CELL PHYSIOLOGY

<b>CHAPTER 21 – Cell Permeability, Phagocytosis, Pinocytosis and the Lysosome</b> .....	<b>437</b>
✓ <i>Osmotic Pressure and Physiological Solutions</i> .....	437
✓ <i>Ionic Concentration and Electrical Potentials Across Membranes</i> .....	438
DIFFUSION OR PASSIVE PERMEABILITY .....	439
✓ <i>Diffusion of Ions</i> .....	439
CELL PERMEABILITY AND ACTIVE TRANSPORT .....	440
✓ <i>Properties of Active Transport</i> .....	441
✓ <i>Active Transport of Ions; Membrane Potentials</i> .....	441
✓ <i>Mechanism of Ionic Transport. Pores in the Cell Membrane</i> .....	444
✓ <i>Permease Systems</i> .....	445
✓ <i>Penetration of Larger Molecules</i> .....	445
✓ <i>Mechanism of Active Transport</i> .....	446
ENDOCYTOSIS.....	446
✓ Phagocytosis .....	447
Pinocytosis .....	448
✓ <i>Extraneous Coats and Pinocytosis</i> .....	449
✓ <i>Micropinocytosis</i> .....	449
✓ <i>Pinocytosis and Active Transport</i> .....	452
THE LYSOSOME .....	452
✓ <i>Stability and Enzymic Content of the Lysosome</i> .....	452
✓ <i>Polymorphism of the Lysosome</i> .....	453
✓ <i>Lysosomes and the Concept of an Exoplasmic Space</i> .....	458
MICROBODIES OR PEROXISOMES .....	459
REFERENCES.....	460
<b>CHAPTER 22 – Cilia, Centrioles, Microtubules and Ameboid Movement</b> .....	<b>462</b>
CILIA AND CILIARY MOTION .....	462
✓ <i>Ultrastructure of the Cilia and Flagella</i> .....	463
✓ <i>Fine Structure of Basal Bodies (Kinetosomes) and Centrioles</i> .....	465
✓ <i>Biochemistry of Cilia</i> .....	466
✓ <i>Physiology of Ciliary Movement</i> .....	467
✓ <i>Ciliary Derivatives</i> .....	468
Origin of Cilia, Basal Bodies and Centrioles .....	471
MICROTUBULES .....	473
✓ <i>Functions of Microtubules; Contraction and Mobility</i> .....	474
CYTOPLASMIC STREAMING .....	475
AMEBOID MOVEMENT.....	476
✓ <i>Mechanisms of Ameboid Movement</i> .....	480
REFERENCES.....	480

CHAPTER 23 – <b>Molecular Biology of Muscle</b> .....	482
<i>Myofibrils. Macromolecular Organization</i> .....	483
<i>Macromolecular Changes during Contraction</i> .....	487
<i>Other Types of Macromolecular Organization</i> .....	487
<i>Structural Proteins of Muscle</i> .....	487
MUSCLE CONTRACTION .....	491
<i>The Sliding Filament Model</i> .....	491
<i>Energetics of Contraction</i> .....	492
SARCOPLASMIC RETICULUM .....	493
<i>Role of the Sarcoplasmic Reticulum</i> .....	493
<i>Muscle Relaxation</i> .....	495
REFERENCES .....	496
CHAPTER 24 – <b>Cellular Bases of Nerve Conduction and Synaptic Transmission</b> .....	497
<i>The Reflex Arc. Action Potentials</i> .....	497
<i>General Organization of a Neuron</i> .....	498
<i>Biosynthetic Function of the Perikaryon</i> .....	499
<i>Nerve Fibers: Diameter and Conduction Velocity</i> .....	500
<i>Structure of the Axoplasm. Neurofibrils and Neurotubules</i> .....	500
<i>Conduction of the Nerve Impulse</i> .....	505
<i>Saltatory Conduction</i> .....	506
<i>Graded Responses in the Neuron. Generator and Synaptic Potentials</i> .....	507
SYNAPTIC TRANSMISSION .....	508
<i>Chemical and Electrical Transmission</i> .....	509
<i>Excitatory and Inhibitory Synapses. Synaptic Potentials</i> .....	509
<i>Structure of the Synaptic Region. The Synaptic Vesicles</i> .....	510
<i>The Synaptic Membranes</i> .....	511
<i>Synaptic Vesicles and Quantal Units in Transmission</i> .....	516
<i>Isolation of Nerve Endings and Synaptic Vesicles. Acetylcholine System</i> .....	517
<i>Separation of the Nerve-Ending Membranes and Junctional Complexes.</i> <i>Central Receptors</i> .....	518
REFERENCES .....	521
CHAPTER 25 – <b>Cell Secretion</b> .....	523
<i>The Secretory Cycle. Methods of Study</i> .....	524
<i>Some Cytologic Aspects of the Secretory Cycle</i> .....	526
<i>Submicroscopic Morphology of Secretion in the Adrenal Medulla</i> .....	526
<i>Exocytosis and Secretion of Catecholamines in the Adrenal Gland</i> .....	529
<i>The Pancreatic Cell</i> .....	530
<i>Isolation and Significance of Zymogen Granules</i> .....	531
<i>Ultrastructure of Pancreatic Secretion</i> .....	531
<i>Time Sequence in the Intracellular Secretion Process</i> .....	531
<i>Role of the Golgi Complex in Intracellular Transport</i> .....	536
<i>Metabolic Requirements for Transport and Excretion</i> .....	536
<i>Mechanisms of Protein Synthesis and Secretion in the Pancreas</i> .....	537
REFERENCES .....	538
INDEX .....	541