MODULE OUTLINES AND STUDY OBJECTIVES FOR BIOLOGY 124

(2010)

The module is based on the prescribed text (Biology by Campbell & Reece. 8th Edition, Pearson International Edition). The numbers in brackets represent the relevant pages in the book. Information from other sources will be specified accordingly. Additional reading will be made available through WebCT.

CYTOLOGY: MODULE OUTLINE

The study material as presented in the 8th Edition of Campbell & Reece is spread-out in several chapters.

Theme 1: The origin and early history of life (Chapters 1, 4, 25, 26, 27)

Lecture 1 – The scientific approach (18- 26, mostly self-study); Characteristics and properties of life. Theories about the origin of life. Where did life start? (58; 507-515). The Miller-Urey experiment (58-59; 508), Geological Timetable (510-515).

Lecture 2 - Theories on the origin of cells (509-510). The earliest prokaryotic cells (509; 514; 556). Archaebacteria (566) & Eubacteria (567). The first eukaryotic cells (98-99; 516; 575-577). The endosymbiosis theory (516-517; Fig 25.9; 576-577, Fig 28.2). Multicellularity (517). Asexual and sexual reproduction. The kingdoms of life (12-14; 551-553, Fig 26.71).

Theme 2: Cell structure (Cytology) (Chapter 6)

Lecture 3 - The cell theory (fundamental units of life) (94). To study cells: Microscopy and cell size; cell fractionation (94-97). Surface-to-volume ratio (99). The organelles of the cell: Prokaryotic vs eukaryotic cells (98-101). Plant and Animal cells (66-67).

Lectures 4 & 5 – Organelles of the eukaryotic cell (99-101); cell membrane glycocalix (125-130); nucleus & nucleolus (102); central dogma (87, Fig 5.26); ribosomes (102); endomembrane system (104); golgi apparatus (105-107); lysosomes (107-108); vacuoles (108); mitochondria (109); chloroplasts (110); peroxisomes and glyoxisomes (microbodies) (110-111). Support for the endosymbiosis theory.

Lecture 6 - The cytoskeleton (112-114), extracellular structures and movement (114-118). Plant cell walls (118-119). Exstracellular matrix secreted by animal cells (119); intercellular junctions (120-121).

CYTOLOGY: STUDY OBJECTIVES

Following your study of this module you should be able to:

1. Discuss the fundamental properties of life, including heredity.
2. Name/discuss the ideas about the origin of life.
3. Describe and discuss the Miller-Urey experiment, as well as give the conclusions that may be reached from the results.
4. Name/discuss the most important points of Oparin's so-called "Bubble" Theory and the origin of cells.
5. Name the important milestones (regarding cell evolution) in the geological record.
6. Name the characteristics and differences of prokaryots and eukaryots.
7. Say something about the possible origin of the nuclear membrane and the ER, golgi apparatus and other organelles. Describe and discuss the endosymbiosis theory.
8. Discuss the significance of multi-cellularity and sexual reproduction.
9. Name the six Kingdoms into which all organisms are classified and say something about each.
10. Define the modern Cell Doctrine (cell theory).
11. Say what is meant by the following (regarding microscopy): SEM, TEM, ultrastructure, electron micrograph, resolution, ocular, and objective.
12. Explain why cells cannot be smaller than a certain minimum size or larger than a certain maximum size. Explain the surface-to-volume ratio and discuss the implications for cell size.
13. Explain what is meant by cell fractionation and its use in biology.
14. Describe the structural organization of prokaryotic cells. In this case you will also be able to state what is meant by the following: Plasmids (and their value to modern biology) and Gram staining.
15. Describe and discuss the structural organization of eukaryotic cells.
16. Mention the most prominent differences between plant and animal cells.
17. Discuss the structure of all the cell organelles and list their most important function(s).

18. Define the following: Chromatin, histones, gene, transcription, and translation. Explain to what the "central dogma" refers to?
19. Sketch the role of cell organelles in the synthesis, modification and secretion of a protein such as insulin.
20. Discuss the composition, structure and functions of plant cell walls.
21. Discuss the structure and composition of the components of the cytoskeleton.
22. Name the main functions of the cytoskeleton.
23. Describe the important extracellular structures involved in the movement of cells
24. Describe the different intercellular junctions

BIOCHEMISTRY: MODULE OUTLINES

Lecture 1:

Chapter 2 The chemical context of life.

a) Elements, compounds and Atoms (pp. 31-33)
b) Electrons determine the chemical behaviour of atoms (pp. 35-37)
c) The formation and function of molecules is dependent on the chemical bonds between atomes (pp. 38-43)

Chapter 3 Water and the "fitness" of the environment.

a) Atomic structure of water (pp. 46-47)
b) Properties of water (pp. 47-52)
c) pH (pp. 52-56)
d) Buffers (p. 54)

Lecture 2:

Chapter 4 Carbon and the molecular diversity of life.

a) Chemical bonds with carbon atoms (pp. 60-61)
b) Molecular diversity of carbon containing compounds (pp. 61-62)
c) Functional groups of biological carbon containing compounds (pp. 63-65)

Chapter 5 Structure and function of large biological molecules.

a) Macromolecules are polimers assembled of monomers (pp. 68-69)

Lecture 3:

Chapter 5 Structure and function of large biological molecules.

b) Carbon serve as a fuel and as building material (pp. 69-74)

c) Lipids are a diverse group of hydrophobic molecules (pp. 75-77)

d) Proteins have many structures and a wide variety of functions (pp. 77-86)

e) Nucleic acids store and carry heritable information (pp. 86-89)

Lecture 4:

Chapter 7 Membrane structure and function.

a) Cellular membranes are fluid combinations of lipids and proteins (pp. 125-130)

b) Membrane structures allow selective permeability (p. 131)

Lecture 5:

Chapter 7 Membrane structure and function.

c) Passive transport across membranes (pp. 132-135)

d) Active transport across membranes (p. 135-138)

e) Mass transport across membranes (pp. 138-139)

Lecture 6:

Chapter 8 Introduction to metabolism.

a) The change of matter and energy by the metablism of an organism is dependent on the laws of thermodymics (pp. 142-145)

b) The free energy change of a reaction predicts whether the reaction will proceed spontaneously or not (pp. 146-149)

Lecture 7:

Chapter 8 Introduction to metabolism.

c) ATP is the driving force for cellular work through the coupling of exergonic reactions to endergonic reactions (pp. 149-151)

d) Enzymes accelerate metabolic reactions by lowering energy levels (pp. 151-156)

e) The regulation of enzyme activity helps to control metabolism (pp. 157-159)

Lecture 8:

Chapter 9 Cellular respiration – Harvesting chemical energy.

a) Catabolic paths release energy by oxidizing organic fuels (pp. 162-167)

Lecture 9:

Chapter 9 Cellular respiration – Harvesting chemical energy.

b) Glycolysis harvests chemical energy by oxidation of glucose to pyruvate (pp. 167-169)

Lecture 10:

Chapter 9 Cellular respiration – Harvesting chemical energy.

c) The citric acid cycle completes the energy delivering oxidation of organic molecules (pp. 170-172)

Lecture 11:

Chapter 9 Cellular respiration – Harvesting chemical energy.

d) Chemiosmosis links electron transport to ATP synthesis during oxidative phophorylation (pp. 172-177)

Lecture 12:

Chapter 9 Cellular respiration – Harvesting chemical energy.

e) Fermentation and anaerobic respiration allows cells to produce ATP without the use of oxygen (pp. 177-179)

f) Glycolysis and the citric acid cycle link up with other metabolic cycles (pp. 180-182)

BIOCHEMISTRY: STUDY OBJECTIVES

At the end of the Biochemistry sub-module you should be able to perform the following:

Chapter 2 The chemical context of life.

a) Give the names and be able to describe the subatomic particles and be able to indicate which of these is involved in the formation of isotopes (pp. 32-35)

b) Describe and discuss the energy levels (electron shells) of atoms in general and more specifically be able to describe and discuss the orbitals of the first two energy levels(pp. 35-37)

c) Sketch a simplified diagrammatic representation of the atomic structure of any atom with an atomic number of 20 or less (pp. 36)

d) Distinguish between ionic and covalent bonds and give and draw an example of an ionic and a covalent bond (pp. 38-40)

Chapter 3 Water and environmental health.

a) Describe the chemical properties of water and explain the importance of water for living organisms (pp. 46-52, Fig. 3.2)

b) Describe the ionization of water (p. 52)

c) Calculate the hydrogen ion concentration of a solution (p. 54)

d) Give the definitions of an acid and a base, describe the pH scale and perform a calculation of pH (pp. 53-54)

e) Explain what the importance is of buffers in living systems (pp. 54-55)

f) Describe what environmental health is in terms of the water quality on earth (pp. 54-55)

Chapter 4 Carbon and the molecular diversity of life.

a) Discuss the different bonds that carbon can form and illustrate these with examples (pp. 61-63)
b) Recognize the different functional groups which occur in cellular material (pp. 63-65)

Chapter 5 Structure and function of large biological molecules.

a) Explain the differences between the hydrolysis of polymers and the condensation of monomers (pp. 68-69, Fig. 5.2)
b) Give examples and functions of monosaccharides, disaccharides and polysaccharides (pp. 69-74)
c) Recognize the molecular and structural formula of glucose (pp. 70-73, Fig. 5.4b)
d) Give examples of different lipids and their functions (pp. 74-77)
e) Recognize the structural formulas of a saturated fatty acid, an unsaturated fatty acid and a fat. (pp. 74-76, Fig. 5.11)
f) Explain how phospholipids can form lipid bilayer structures as a result of their hydrophobic and hydrophylic portions (pp. 76-77)
g) Give examples of proteins and their functions (p. 78, Table 5.1)
h) Recognize an amino acid and show how a peptide bond is formed (pp. 79-80, Fig. 5.18)
i) show the relationship between the four levels of protein structure and the chemical bonds that are relevant to each level (pp. 81-83, Fig. 5.21)
j) relate primary structure with protein function and that changes in amino acid sequence are associated with a loss of protein function (p. 84)
k) relate protein folding to protein function and that denaturation or unfolding brings about a loss of protein function (pp. 85-86)
l) give examples of nucleotides and nucleic acids as well as their respective functions (pp. 86-88)
m) name the molecular components of a nucleotide and explain how these monomers are coupled to form a nucleic acid (p. 87, Fig. 5.27)
n) explain how genetic information in the form of DNA is transferred to RNA to specify protein synthesis (the so-called “central dogma”) (pp. 86-87)
o) discuss the structure of DNA and its replication through which genetic information is maintained (pp. 88-89)

Chapter 7 Membrane structure and function.

a) describe membrane structure in terms of the "fluid mosaic model" by giving the particulars that support this structure (pp. 126-128, Fig. 7.7)
b) describe the arrangement of the lipid components in the membrane and assign a function to each one in the membrane and how this can result in membrane fluidity (pp. 126-128)
c) describe arrangement of the protein components in the membrane

and assign a number of functions to each type of membrane protein (pp. 128-129, Fig, 7.9)

d) define osmosis and diffusion and explain the importance each one in the biology of the cell (pp. 131-134)

e) describe the appearance of both plant and animal cells in isotonic, hypotonic, and hypertonic solutions (p. 133, Fig. 7.13)

f) name two types of transport that take place by means of carrier proteins and give examples of each (pp. 136-137)

g) compare endocytosis and exocytosis as well as to give the name of 3 forms of endocytosis while clearly differentiating between them (pp. 138-139)

Chapter 8 Introduction to metabolism.

a) give the two energy laws which have important consequences for all life forms (pp. 144-145)

b) recognize the structure of ATP and name its components (p. 149, Fig. 8.8)

c) describe the formation of ATP, explain why ATP can serve as an energy storage molecule and how ATP can be used to drive energy requiring (endergonic) reactions (pp. 149-151)

d) explain on the basis of these two laws why all life forms need an external source of energy (pp. 152-153)

e) describe the structure and function of enzymes as well as the conditions that influence the rate of product formation in enzyme reactions (pp. 151-155)

f) describe the regulation of enzyme reactions by means of inhibition and specifically make a comparison between competitive, non-competitive, and feedback inhibition (p. 156)

g) describe how the regulation of enzyme activity controls metabolism (pp. 157-159)

Chapter 9 Cellular respiration – Harvesting chemical energy.

a) Describe energy flow through ecosystems (p. 162)

b) Describe how catabolism releases energy by oxidation of organic fuels (pp. 162-163)

c) Identify the reduced and oxidized components of a given reaction (p163)

d) Describe the function of the coenzyme NAD^+ (p. 165)

e) describe the general functioning of cellular respiration (p. 166)

f) discuss glycolysis and in the discussion explain substrate level phosphorylation as well as give the starting and end products of that reaction in glycolysis (pp. 167-169)

g) give an account of the aerobic and anaerobic processing of pyruvate (p. 170)

h) How the product of glycolysis (pyruvate) is converted to acetyl-CoA (p. 170, Fig. 9.10)

i) discuss the Krebs cycle and give an explanation as to how compounds

cycle through it as well as indicate what the starting and end products are (pp. 170-171)

j) discuss the electron transport chain and how it contributes to the formation of ATP (pp. 172-177)

k) describe the arrangement of the electron carriers in the mitochondrial inner membrane and explain how chemiosmotic ATP synthesis functions (pp. 173-175)

l) calculate the net ATP production for both glycolytic and cellular respiration (pp. 176-177)

m) describe both lactate and alcoholic fermentation and give an account of the evolutionary importance of the process (pp. 177-179)

n) explain the metabolism of both fats and proteins and at the same time how they contribute to the energy yielding metabolism (p. 180)

o) explain the regulation of aerobic respiration according to the energy requirements of the cell (p. 181)

GENETICS: MODULE OUTLINE

Chapter 12: Cell Division (p228-245)

Lecture 1
- Eukaryotic chromosomes are highly ordered structures
- Mitosis is a key phase of the cell cycle
- Cell cycle control: The three checkpoints

Chapter 13: Sexual Reproduction and Meiosis (p248-261)

Lecture 2
- Meiosis produces haploid cells from diploid cells
- Unique features of meiosis
- The sequence of events during meiosis involves two nuclear divisions

Chapter 14: Patterns of Inheritance (p262-285)

Lecture 3
- Discovery of the Laws of Inheritance
- Mendel and the garden pea

Lecture 4
- Mendel's model of heredity
- Monohybrid and Dihybrid Crosses
- Mendelian Inheritance is not always easy to analyse
- Multiple alleles (ABO blood groups)
- Genes are on chromosomes

Chapter 16: DNA: The Genetic Material (p305-323)

Lecture 5
- Experiments which revealed the nature of genetic material
- The structure of DNA

Lecture 6
- DNA replication

Chapter 17: Genes and how they work (p325-350)

Lecture 7
- The Central Dogma: DNA → RNA → Protein
- Genes encode information in three-nucleotide code words

Lecture 8
- Genes are first transcribed, then translated

Lecture 9
- Eukaryotic gene transcripts contain introns that are spliced (modification)

Chapter 18: Regulation of Gene Expression (p351-380)

Lecture 10 Transcription of the *lac* operon of *E.coli* is controlled by combining ON and OFF switches

GENETICS: STUDY OBJECTIVES

Your study of this sub-module will be complete when you can:

Chapter 12: Cell Division

1) Describe the cell cycle
2) Annotate a diagram of a human chromosome
3) Explain "supercoiling" of DNA into chromosomes
4) Distinguish between somatic and germline cells i.t.o. chromosomes
5) Identify the stages of Mitosis
6) Recognise cell cycle checkpoints

Chapter 13: Sexual Reproduction and Meiosis

1) Describe Meiosis I and II
2) Compare Mitosis and Meiosis
3) Explain the importance of meiosis
4) Explain diversity and similarities amongst humans

Chapter 14: Patterns of Inheritance

1) Explain how a trait can disappear in one generation to reappear in the next
2) Briefly outline Mendel's experiments
3) Define homozygous, heterozygous, dominant, recessive
4) Distinguish between genotype and phenotype
5) Explain the use of a Punnet square
6) List 5 factors that influence Mendelian segregation of alleles (provide examples)

Chapter 16: DNA: The Genetic Material

1) Outline an experiment which demonstrates that genetic material is stored in the nucleus
2) Discuss the significance of Griffith's experiments on live, non-pathogenic and heat-killed pathogenic *S.pneumoniae*
3) Outline the structure of a DNA molecule
4) List components and their role in DNA replication

Chapter 17: Genes and how they work

1) Define "the Central Dogma" of Biology.
2) Outline transcription
3) Outline translation
4) Describe the "Genetic Code"
5) Define intron, exon and mRNA
6) List 5 differences between bacterial and Eukaryotic gene expression

Chapter 18: Regulation of Gene Expression

1) Discuss the *lac* operon of *E.coli*
2) Define CAP site, lac repressor and inducer

EVOLUTION: MODULE OUTLINE

The evolution sub-module covers Chapters 22-25 and pages 536-547 of Chapter 26 in the prescribed handbook, Campbell & Reece (8th edition). We work directly out of the handbook because it teaches you certain skills. The handbook is the key to the sub-module and the lectures explain how the lock works.

Chapter 22 DESCENT WITH MODIFICATION

Lecture 1 – Artificial selection, natural selection and adaptation; Evidence for evolution, amongst others, direct observations, the fossil record, homology, and biogeographical evidence.

Chapter 23 THE EVOLUTION OF POPULATIONS

Lecture 2 – Mutation and sexual reproduction produce the genetic variation that makes evolution possible; The Hardy-Weinberg equation; Natural selection, genetic drift and gene flow.

Lecture 3 – Examples of genetic drift such as founder and bottleneck effects; Natural selection as the only mechanism that consistently causes adaptive evolution.

Chapter 24 THE ORIGIN OF SPECIES

Lecture 4 – The biological species concept; Reproductive isolation; other definitions of species.

Lecture 5 – Allopatric speciation; Sympatric speciation; Hybrid zones; Tempo of evolution.

Chapter 25 THE HISTORY OF LIFE ON EARTH

Lecture 6 – Conditions on early Earth and the origin of life; The fossil record documents the history of life; The first single-celled organisms.

Lecture 7 – The origin of multicelled organisms and the colonization of land; Continental drift, mass extinctions, and adaptive radiations; Evolutionary effects of developmental genes; The evolution of development; Evolution is not goal-oriented.

Chapter 26 PHYLOGENY AND THE TREE OF LIFE

Lecture 8 – Binomial nomenclature; Hierarchical classification; Classification and phylogeny; Phylogenies are inferred from morphological and molecular data; Cladistics including shared ancestral and shared derived characters, proportional branch lengths, maximum parsimony and Maximum Likelyhood (pages 536-547).

EVOLUTION: STUDY OBJECTIVES

This sub-module will enable you to:

1. Use the handbook effectively as a reference guide.
2. Understand and explain the working and importance of evolution.
3. Discuss the relationship between the various subsections of evolution.
3. Distinguish between hypothesis and theory.
4. Considerably extend your vocabulary of scientific terms.