THE SYNTHESIS OF LIVING MATTER: ENERGY AND INFORMATION

Lectures 10/14, 10/19. Respiration

Make a "black box" diagram showing the inputs and outputs of the three main reaction blocks in aerobic respiration; give stoichiometric relationships.

Cite the locations of the glycolytic system, the citric acid cycle, and the electron transport system in the cell.

Compare respiration with the simple combustion of glucose, and explain the advantage of respiration over combustion in living cells.

Describe how a cell maintains its energy supply when it runs out of oxygen.

Explain why aerobic respiration is more efficient than fermentation.

Describe the arrangement of electron carriers in a mitochondrial electron transport chain.

Identify the reaction block in respiration that yields the greatest proportion of the ATP that is produced in respiration.

Identify the point in respiration where \( \text{O}_2 \) enters, and describe what will happen if \( \text{O}_2 \) is prevented from entering.

With diagrams, show what happens to the hydrogen ions and electrons brought in by NADH + H\(^+\) and FADH\(_2\) as they pass along the electron transport system.

Identify "cytochromes" and state what happens if they are prevented from working.

Explain the role of chemical/electrical ("chemiosmotic") gradient and describe the effect if these gradient are lost.

Indicate which of these groups—prokaryotes, fungi, plants, protists, and animals—have members that can perform respiration and rely on it for the production of metabolic energy.

Lectures 10/21-24. Photosynthesis

Indicate which of these groups—prokaryotes, fungi, plants, protists, and animals—have members that can perform photosynthesis.

Identify the site in the cell where photosynthesis occurs (for both prokaryotes and eukaryotes).
Write the structural formula for glucose.

Write the overall equation for photosynthesis in green plants; make a "black box" diagram showing the inputs and outputs of the light and dark (light-independent) reactions in green plant photosynthesis; give stoichiometric relationships.

Cite the locations of the light and dark reactions within the chloroplast.

Identify the essential photosynthetic pigment and describe its function; explain the role of "accessory pigments."

Describe the arrangement of electron carriers in a photosynthetic electron transport chain; explain the difference between the photosynthetic and mitochondrial electron transport chains.

Describe the role of electron transport in the formation of ATP and NADPH; make a diagram to show how ATP is made in a chloroplast by the chemiosmotic mechanism.

Identify the role of the "Calvin" or "Calvin-Benson" cycle; describe the roles that ATP and NADPH play in forming sugar from CO₂.

Explain the advantages and disadvantages that result from having glucose rather than ATP and NADPH as the final products of photosynthesis.

Show, in a black box diagram, how photosynthesis and respiration may couple to provide a complete carbon cycle; name the main product of this coupled system, and explain where the original light energy has gone.

Lecture 10/26. Information for cell synthesis

Referring to the previous lectures on protein structure and enzyme catalysis, explain why information is needed in the formation of proteins and the synthesis of enzymes.

Cite and explain evidence to support the contention that DNA carries information; give an alternative hypothesis regarding the location of information for biological synthesis and provide an experiment to test it.

Interpret an experiment to test for transformation in bacteria.

Describe the life cycle of a virus (bacteriophage), indicating how genes are involved; explain how one can distinguish between DNA and protein using radioactive isotopes.
Lecture 10/28. Cell components: DNA

Define and distinguish between: nucleic acid, DNA, RNA; nucleotide, nucleoside, base; 5’ end, 3’ end.

Diagram a nucleotide, a dinucleotide.

Give the relationship between the frequency of different bases in a DNA molecule.

Diagram a DNA molecule; recognize the correct components in a diagram of a DNA molecule.

Given the two chains of a double helix, describe (and count) the bonds that would hold them together; given two or more chains, identify the ones with the highest and lowest melting temperatures (temperatures at which the chains separate).

Recognize when two polynucleotide chains are complementary.

Explain the calculation of the length of a DNA chain, given its number of base-pairs, or given its molecular weight.

Identify the nature of "information" in a DNA molecule.

Explain why the structure of DNA suggests how it can be "easily" duplicated using the materials at hand in a cell.

Contrast three hypothetical mechanisms of DNA replication: “conservative”, “semi-conservative”, and “dispersive.” Explain the evidence that identifies the mechanism of chromosome duplication.

List the materials needed for duplication of DNA (substrates, enzymes, templates); with diagrams, show how each contributes to the process.

Point out differences between the synthesis of DNA and the synthesis of RNA.

Lecture 10/31. Protein synthesis: RNA

Define and distinguish between: DNA, RNA (3 differences); messenger, transfer, and ribosomal RNA; ribosomal RNA and ribosomes; codons, anticodons.

Given the sequence of a messenger RNA, write the sequence of its DNA template.
Define and distinguish between: nucleoside triphosphate, nucleotide; RNA polymerase.

Outline the synthesis of RNA; identify the components involved; describe an "activated" form of a nucleotide; explain why an activated form is needed and how it participates in the RNA synthetic reaction.

State the functions of mRNA, tRNA and ribosomes.

Estimate (in approximate terms) how many different kinds of mRNA, tRNA, and rRNA molecules might be found in any one cell.

Lecture 11/2. Protein synthesis: translation

Define and distinguish between: amino acyl-tRNA synthetase (amino acid activating enzyme); amino acid, aa-tRNA, peptidyl-tRNA; polysome, polygenic messenger; protein, polypeptide.

Identify and describe these stages of protein synthesis: initiation, elongation, termination.

Given a genetic code chart and an mRNA sequence, determine the polypeptide chain coded by the mRNA.

Diagram (in outline form) the motions of ribosomes, mRNA, tRNAs, and amino acids during the steps leading to the addition of one amino acid to a growing polypeptide chain.

List the sources of energy and the materials needed for protein synthesis; describe the points in the synthesis of a protein where a source of energy is needed.

Diagram a polysome; explain how a block in initiation, elongation, or termination would affect the structure of polysomes in a cell.


Define, and explain the significance of, the following types of mutations: silent, mis-sense, nonsense, frame shift, transposon insertion, chromosome breakage and rejoining.

Explain why it is necessary to consider where in a chromosome mutations occur: in structural or control regions of DNA, or elsewhere.
Describe at least two types of DNA base modifications that would affect transcription; describe repair processes that can alleviate the effect of these modifications.

Explain some positive and negative aspects of an assay that can detect the presence of an allele associated with a genetic disease.

Explain the argument that the structure of the genetic code reduces the effects of random mutation.