

EXPANDED LEARNING OBJECTIVES

These put in more detail—practically the lecture--than very generalized objectives

Lecture 14 Learning Objectives

Understand/know/focus on/note

- The structure of mitochondria: matrix, inner membrane, intermembrane space, outer membrane, cristae. Know what the function or purpose and features of those parts, what metabolic pathways happen in matrix and inner membrane in particular
- The TCA or Krebs cycle: that it is a series of many oxidation reactions in which TWO NADH and ONE FADH₂, ONE GTP and TWO CO₂ molecules are produced by ONE TURN of the cycle.
- Know that 2-carbon acetyl-CoA enters the cycle and forms 6-carbon citrate by combining with 4-carbon oxaloacetate (OAA), and that the release of CoA high energy bond with acetyl-CoA drives the synthesis
- Know what the difference is between substrate-level phosphorylation and oxidative phosphorylation is
- Know what the electron transport system (or electron transport chain) is: that it is a series of protein complexes and lipids that are embedded in the inner membrane of the mitochondria
- Know that the sequence NADH → CoQ → cytochrome → O₂ is the sequence of electron transfers that pump protons (H⁺) from the mitochondrial matrix, and that 3 ATP are produced from the oxidation-reduction reactions from 1 NADH
- Know that the sequence FADH₂ → CoQ → cytochrome → O₂ is the sequence of electron transfers that pump protons (H⁺) from the mitochondrial matrix, and that 2 ATP are produced from the oxidation-reduction reactions from 1 FADH₂
- Know that in building of the H⁺ chemical potential (concentration difference) between the intermembrane space and matrix separated by the inner membrane, 3 protons (H⁺) will transport across the F-type ATPase in the inner membrane and be coupled to the synthesis of 1 ATP molecule
- Know what an oxidation is. Know what a reduction is. (That it's about electrons being taken and being given)
- Understand the term chemiosmotic gradient
- ATP accounting:
 - Substrate level phosphorylation: 2 ATP from glycolysis + 2 ATP from Krebs/TCA
 - Oxidative phosphorylation: 6 ATP (2 NADH) from glycolysis +
 - 6 ATP (2 NADH) from pyruvate → acetyl-CoA reaction +
 - 18 ATP (6 NADH) from TCA/Krebs + 4 ATP (2 FADH₂) from TCA/Krebs
 - = 38 ATP
 - but we lose 2 ATP for 2 glycolysis NADH transported into from cytosol into matrix to utilize them
 - = net 36 ATP for 1 glucose (C₆H₁₂O₆) molecule

Lecture 15 Learning Objectives

- Endoplasmic reticulum: what it is, its structure (cisternae, lumen) what features make it up: membrane, its purpose/function: making plasma membrane and membrane proteins particularly glycoproteins, proteins for secretory vesicles, proteins for lysosomes
- What rough ER is, continuity with nuclear envelope
- what smooth ER is and differences with rough ER, continuity with it: what cell types would have it (steroid-making cells/tissues, hepatocytes detoxifying toxicants)
- the role of the smooth ER in detoxifying toxicants: what is cytochrome P450, and why it tries to make nonpolar/lipophilic substances polar by putting –OH groups on them
- Golgi complex: its structure and purpose in cell physiology: cis face gets vesicles from ER, processes particularly glycoproteins by modifying their oligosaccharide parts, and then buds off vesicles from trans faces which will go to one of three described fates
- Described fates are (1) constitutive secretion (2) regulated secretion (3) lysosome formation: be able to explain what these are
- Describe the two Golgi trafficking models
- Lysosomes: what are they, what do they contain, how are they activated, what is the role of a proton pump in the membrane, what are the lysosomal vesicle contents?
- What do terms heterophagy and autophagy refer to?
- Peroxisomes: what reactions take place in these membranous organelles, which is why the enzymes catalase and SOD are present. What are the reactants of catalase and SOD? Know that peroxisomes deal with long chain fatty acids and unusual amino acids. Know what reactive oxygen species means.

Lecture 16 Learning Objectives

- Be able to describe / define term cytoskeleton and what 3 types of cellular elements make it up
- Know the structure and function of the microfilament and that it is dynamic: G-actin polymerizes to F-actin and that it can make the terminal web and structures like a microvillus and that it can interact with unconventional myosin to effect cell shape changes, extend pseudopodia (that we saw in phagocytosis) and that it can create a contractile ring as part of the cleavage furrow in cell division
- Intermediate filaments: structure is made of different proteins. One model shows IFs created from a dimer with two polypeptides twisted around each other, and two dimers form a staggered interaction called a tetramer, and then a series of tetramers go end-to-end with each other to form a protofilament, and then a protofilament joins with 7 other filaments to form the intermediate filament
- Keratins make up IFs in epidermal (skin) cells; lamins make up the IFs that give shape to nuclear envelope and help direct substances for export to nuclear pores
- Microtubules: made up of a pair of tubulin proteins, alpha and beta, which form a dimer to each other and then are added to the plus (+) end to elongate the MT; MTs are dynamic, so they disintegrate as alpha-beta tubulin dimers off the minus (-) end. Simultaneous assembly/disassembly is called treadmilling
- MTs are stiff and somewhat flexible hollow rods that give cell shape
- MTs also are tracks along which organelles and vesicles can be moved within the from one point to another with the assistance of “motor protein complexes” containing dyneins or kinesins which utilize ATP energy to change conformation of these proteins that permit them to slide or “walk” along the MT
- MTs originate from microtubule organizing centers (MTOCs), namely the centrosome
- Each cell has a centrosome, which is composed of two centrioles perpendicularly positioned to each other
- Centrioles are special arrangements of MTs in a 9 +3 structure: 9 triplet fusions of MTs circularly arranged as a pinwheel: MTs extend from them to radiate outward to cell membrane
- In mitosis, the two centrioles will separate to opposite poles with aligned chromosomes at the equator, extending spindles made of MTs to the chromosomes and cause the separation of chromosomes prior to formation of two daughter cells
- Nucleus: largest of the organelles, and with a bi-membrane envelope; it isolates and protects the DNA from cytoplasm; it is made of chromatin, which is the DNA and the proteins associated with the DNA that read the code and which compact the long DNA molecules in chromosomes to fit in nucleus
- Nuclear envelope is bi-membranous with a perinuclear space, and is continuous with the ER; it also has nuclear pores with proteins that make up an annulus consisting of 8 protein subunits arranged to make the pore and regulate what goes in and out, there are about 3000-4000 pores in a nucleus
- Nucleoli are special regions of the nucleus with heavy synthesis of RNA to be used for ribosomes (ribosomal RNA, rRNA) and the proteins that make them up: we know that ribosomal subunits (40S & 60S) made in nucleoli make their way to nuclear pores and into the rough ER

- Some cells are multinucleated: skeletal muscle cells, which form multinucleate cells when myocytes in fetal development fuse to form mature skeletal muscle
- Other cells must shed/disintegrate their nucleus when they differentiate into a mature form, such as red blood cells that must decrease their size so they can go through capillaries and must pack their structure with hemoglobin protein to be efficient O₂ transporters. Anucleate cells commit to being short-lived
- Stem and progenitor cells—namely cells that are actively proliferating—will have single nuclei that are indeed almost the entire volume of the cell, with a very small amount of cytoplasm, because their function as stem or progenitor cells is to do nothing but go through the cell cycle quickly and efficiently
- Cell Cycle: introduced as an interphase with a G₁, S, and G₂ phases, and in proliferating cells, as having cytological processes that prepare the cell (G₁) for active DNA synthesis (S) and prepare the cell (G₂) for separation of replicated chromosomes in mitosis and the division of cytoplasm (M)
- Mitosis phases: introduction of prophase, metaphase, anaphase and telophase as the microscopically observed stages of cell division
- How cells differ as to whether they are capable of mitosis or what state of proliferation they are in: labile cells, stable cells, permanent (post-mitotic) cells

Lecture 17 Learning Objectives

- Define/describe nucleic acids and genes: know that nucleic acids are DNA and RNA
- Know what nucleotides are: they can be 2-ringed purines (A, G) or 1-ringed pyrimidines (C, U, T) and that their structure is a base, sugar pentose, and phosphate. Know difference between DNA and RNA: sugar pentose is a 2'-deoxyribose in DNA and DNA has T base, while RNA has ribose as sugar pentose and a U base that holds the same position as T base in DNA
- Know that RNA and DNA in solution are highly negatively charged (anionic) and that it has significance in their biology
- Know DNA structure in cell: double-stranded helix due to two strands forming hydrogen bonds: 3 H-bonds with G-C pairing, 2 H bonds with A-T pairing
- DNA has grooves: major and minor grooves as a result of its helix, and that proteins bind to DNA that are groove specific
- DNA has a polarity of 5' to 3' and this has biological significance
- DNA has at least two types: B-DNA which is the classical form of the double helix, and Z-DNA which has a zig-zag form and is involved in reducing transcription (reading of DNA to make RNA)
- DNA can be denatured and denaturation involves breaking hydrogen bonds making the double helix; enzymes in the nucleus have the natural ability to break DNA H-bonds and open the helix up to single strandedness for replication or transcription
- DNA can be denatured by heating it up in solution (boiling) and in going from double-stranded to single-strandedness, its UV absorption at 260 nm which can be monitored by a spectrophotometer, and the midpoint of increase is called the melting temperature (T_m)
- Know the functions of DNA: has system (enzymes, other proteins) for its maintenance/repair and copying/duplication, that it codes on genes for proteins and RNA, and that it has sequences to regulate that expression

- Chargraff's Rule: $%A = %T$ and $%G = %C$ and $100\% = %A + %T + %G + %C$
- Structure, function and types of RNA: single-stranded, made from DNA, exported, mRNA, rRNA, and tRNA
- Know what a genome is and how it is sized
- Know what a chromosome is and its relationship to the genome
- Know that humans have a genome of about 3 billion base pairs on 23 pairs of chromosomes and that these code for about 21,000 proteins and that only 2% of the genome actually has genes
- Know what a chromatid, sister chromatide, and centromere are
- Know what a nucleosome is and its purpose function
- Know what histones are and that 8 of them make up a nucleosome core
- Know what a chromating fiber is and a solenoid
- Know what a packing ratio is and how to calculate it depending on how much coiling or compaction occurs
- Know the details of DNA synthesis (replication) as it occurs in S phase: polymerases involved, nucleotide forms, polarity of synthesis, the need for RNA priming, what a replication bubble and origin of replication are,