

Study Notes:

Friday September 14th 2018

Life on Earth:

The first stage of life may have evolved through 4 stages:

1. The abiotic synthesis of small organic molecules such as amino acids
2. The joining of these molecules into polymers
3. The packing of these molecules into protocells, droplets with membranes that had a different chemistry than their surroundings
4. The origin of self replicating molecules that eventually made inheritance possible

Simulating Earth's Early Conditions:

- Oparin Haldane Hypothesis : organic molecules could have formed on the early earth
- 1953 The Miller-Urey Experiment : Miller set up an airtight apparatus with gases circulating to past an electrical discharge to simulate conditions on the early earth

Life's molecular diversity based on Carbon Properties:

By sharing electrons carbon can:

- Bond to 4 other atoms
- Branch in up to 4 different directions
- Methane (CH₄) is one of the simplest organic compounds

A carbon Skeleton is a chain of carbon atoms that can vary in:

- Length
- Branching
- Bond position
- Presence of rings

Isomers:

Structural Isomer: Same chemical formula, different bonding pattern

Cis-trans Isomer: The bonding is the same but the spatial arrangement (position of hydrogens)

Enantiomers: mirror images, happens if you have a asymmetrical atom

Panspermia: Is an idea that life was seeded on earth from space

- Developed by Chandra Wickramasinghe

Stage 2: The Joining of Monomers into polymers

- Hot sand, clay, or rock may have helped monomers combine to form monomers

Stage 3: Packing of polymers into proto cells

- Small membrane bounded sacs or vesicles form when lipids are mixed with water
- These abiotically created vesicles are able to grow and divide

Stage 4: Origin of self replicating molecules

- Today's cells transfer information from DNA to RNA to protein assembly, however RNA molecules can assemble spontaneously from RNA monomer
- RNA monomers in the presence of RNA molecules form new RNA molecules complementary to parts of the starting RNA
- Some RNA molecules called ribozymes can carry out enzyme like functions

September 17th:

Life in extreme conditions:

Extremophiles

Bacteria and archaea can survive in extreme conditions of

- Heat
- Pressure
- Desiccation
- Acid environment

Snottites:

- Colonies of single cell bacteria
- Derive energy from hydrogen sulfide
- Produce waste sulphuric

All organisms contain the same macromolecules:

- Carbohydrates
- Protein
- Lipids
- Nucleic Acids

Carbon must flow from the atmosphere to photosynthesizers to organisms

Carbohydrate CH_2O (always has the same ratio) ex. $C_6H_{12}O_6$, $C_5H_{10}O_5$

- Monosaccharide and disaccharide and polysaccharide
- To make a polysaccharide at least 2 monosaccharide must undergo dehydration synthesis
- Glycosidic bonds
- To break a polysaccharide: hydrolysis
 - ❖ All life forms use these process
 - ❖ Carbs are known for “energy supports”

Lipids:

- No monomer
- Hydrophobic
- Consists of mainly of carbon and hydrogen atoms linked by nonpolar covalent bonds
- Fats with maximum number of hydrogens are saturated
- Fatty acids that have one or more double bond are unsaturated fats (creates kinks)
 - ❖ Liquid at room temp
 - ❖ Hydrogenated fats are unsaturated fats that turn to saturated fats with the addition of hydrogen which creates trans fats

September 19

Steroids are lipids in which the carbon skeleton contains four fused rings

- Cholesterol is a common component in animal cell membranes, it ensures that the membrane is not too fluid but not too solid

Proteins:

- Chemical reactions are enabled by proteins (enzymes)
- Are polymers of amino acids
- Amino acids have an amino group and a carboxyl group and an R group (a side chain)
 - ❖ The “R” group is what makes each amino acid unique

Lipoproteins and Glycoproteins:

Glycoproteins: carbs and proteins, Receptors some hormones signaling molecules

Lipoproteins: Lipid plus protein, transport fats LDL vs HDL

- Bad vs Good Cholesterol
- Lipid is of a lower density than protein (ratio of lipid is higher)
-

September 21

Eukaryotic Cells:

The structure of these cells have 4 basic functions:

1. The nucleus and ribosomes are involved in the genetic control of the cell.
2. The endoplasmic reticulum, Golgi Apparatus, lysosomes, vacuoles, and peroxisomes are involved in the manufacture, distribution, and breakdown of molecules.
3. Mitochondrial cells and chloroplasts in plant cells are involved in energy processing.
4. . Structural Support, movement, and communication between cells are functions of the cytoskeleton, plasma membrane, and cell wall.

A cell is a informational Unit:

- Information for cell form and function is transferred through a linear array of bases in a strand of DNA to the synthesis, structure, localization, and function of macromolecules.

Macromolecules

Large biomolecules that are the center of life, generate to combine to four separate classes of molecule that separate life from inanimate matter

Bacteria and archaea are prokaryotic cells all other forms of life are composed of eukaryotic cells

- Cells must be large enough to house DNA, proteins, and structures needed to survive and reproduce
- Small enough to allow exchange with the environment
- As cell size increases, cell volume increases at a faster rate

The smallest Cell: Mollicutes

- Absence of cell wall
- Plasma membrane limiting boundary
- Parasitic/commensal

Genus Mycoplasma:

- Small size (150-250 nm)
- No DNA homology
- Low guanine and cytosine

Prokaryotic Cells:

- The DNA of prokaryotic cells is not surrounded by a nuclear membrane but instead is coiled into a region called the nucleoid
- The membrane itself may be surrounded by a chemical complex cell wall
- Made by polysaccharides

- Some may also have a capsule surrounding the cell wall
- Also often possess a variety of projections, short fimbriae that help attach to other cells or substrates
- Longer projections are called flagella

Bacteria & Infection:

Children & Young adults are the most affected by bacterial infections

- Antibiotics work in one of two ways : target certain bacteria and in different ways
- Either kill the bacteria directly - Bactericidal
- Or stop them from growing - Bacteriostatic

September 24:

Bacteria and our atmosphere:

One of the first bacteria to evolve:

Cyanobacteria

- Among the first groups of bacteria to evolve
- Obtain their energy through photosynthesis
- Oxygen produced as byproduct accumulated
- Oxidizing character of Earth's Atmosphere increased

The Centrosome AKA MTOC

- In an animal cell they have centrioles

Plant Cells:

- Have rigid cell walls
- Chloroplasts
- Central vacuole
- Plasmodesmata: channels between neighbouring plant cells allowing them to communicate

- Genetic Control of the Cell:

The nucleus:

- Contains most of the cell's DNA
- Controls cell activity by directing protein synthesis by making mRNA
- Surrounded by the nuclear envelope
- A double membrane (each a lipid bilayer)
- Perforated by pores
- DNA + Protein = Chromatin
- DNA gets wrapped around the histones which is called DNA compaction

Nuclear Lamina: Layers of protein that line the inside of the membrane, help hold the shape of the nucleus

- Nuclear Matrix; meshwork of proteins that extends throughout the nucleus

Ribosomes: are a cellular organelle, the only cytoplasmic organelle that prokaryotes have

- Responsible for joining amino acids together based on mRNA
- Are a mix of protein made by rRNA
- Produced in the nucleolus (dark part of the cell)
- Are either free ribosomes or bound

- Free Ribosomes: are suspended in the cytoplasm and are most likely involved in making proteins that function in the cytoplasm
- Bound Ribosomes: Are attached to the E.R

The Endomembrane System:

Endoplasmic reticulum:

- There are 2 types; smooth and rough
- Smooth ER: lacks attached ribosomes, is important in the synthesis of lipids
- Rough ER; ribosomes line in the outer surface of the membrane

Golgi Apparatus : serves as a molecular warehouse

- Products travel in transport vesicles from the ER to the golgi apparatus
- One side functions on reserving dock for the product and the other (trans face) as a shipping dock
- Products are modified as they go from one side of the golgi apparatus to the other and travel in vesicles to other sites

Lysosomes: A membranous sac containing digestive enzymes

- The enzymes are produced by the ER and transferred to the golgi apparatus for processing
- The membrane serves to safely isolate these potent enzymes from the rest of the cell

Vacuoles: are large vesicles that have a variety of functions

- Some protists have a central vacuole that help eliminate water from protist
- In plants they have digestive functions

Endomembrane System relies on transport vesicles successfully trafficking from one destination to another

- To facilitate this transport vehicles are coated with specific protein that designate their origin and destination

September 26:

Energy Processing: Mitochondria

Mitochondria have to internal compartments

1. The inner membrane space is the narrow region between the inner and outer membranes
2. The mitochondrial matrix contains; mDNA, ribosomes and enzymes that catalyze some of the reactions of cellular respiration

- Converts chemical energy of to the chemical energy of ATP which the cell uses
- They don't stay still, also change shapes and the number changes depending on the level of activity of that cell
- They can dive/ split or join together

Chloroplasts: Carries out photosynthesis (produces the sugars)

- Between the outer and inner membrane is a thin inner membrane space
- Inside the inner membrane is Stroma which contains the cDNA, ribosomes, enzymes a network of interconnected sacs called thylakoids
- Each stack is called a granum
- The DNA in the mitochondria and the chloroplast is much more similar to prokaryotes than eukaryotes

It is believed that the mitochondria and chloroplast were evolved by endosymbiosis; the theory states that once a upon a time the mitochondria and chloroplast were free living organisms. They were small simple and prokaryotes. A got engulfed by a early ancerty eukaryote type cell. Amd has since started this symbiotic relationship

The chloroplast and mitochondria can not be made by a cell, the only are made from the division of preexisting chloroplast or mitochondria.

Peroxisomes: Are specialized metabolic compartments bounded by a single membrane, it is still unknown how they are related to other organelles. Some believe that it is part of the endosymbiosis

- They contain enzymes that transfer hydrogen from various substrates to oxygen
- Some break fatty acids down to smaller molecules that are transported to the mitochondria for fuel

The cytoskeleton: is composed of three kinds of fibers

- Is constantly being broken down and built back up
- Microtubules are made from tubulin, gives the cell rigid and acts as tracks for organelle movement
- Microfilaments support the cells shape and are involved in motility (movement of the cell itself)
- Intermediate filaments reinforce cell shape and anchor organelles

Cilia and Flagella: Move when microtubules move

- A flagellum longer than cilia propels a cell by an undulating whip like motion
- Cilia work more like the oar of a crew boat
- Although the differences exist flagella and cilia have a common structure and mechanisms of movement

Cell junctions in animal tissue:

- Tight junctions prevent leakage of extracellular fluid across a layer of epithelial cells
- Anchoring junctions; fasten cells together into sheets
- Gap junctions; are channels that allow molecules to flow between cells

Plant tissue; A plant cell has a rigid cell wall

- protects and provides skeletal support
- Junctions and plasmodesmata

Extra matrix of animal cells:

Helps hold all the cells together in tissue and protects the plasma membrane

September 28

Cystic Fibrosis:

- Is caused by a mutation in the gene for the protein cystic fibrosis
- Regulates movement of chloride and sodium ions across membranes
- In the lungs effects of the disease are most devastating

Membranes:

- Phospholipids, the key ingredient of biological membranes, spontaneously self-assemble into simple membranes.
- The formation of membrane-enclosed collections of molecules was a critical step in the evolution of the first cells

- Phospholipids in plasma membrane can move within bilayer
- Most lipids and some proteins drift laterally
- Rarely a molecule flip-flops transversely

- Small molecules and ions move across the membrane in both directions:
 - ❖ Sugars, amino acids, and nutrients must enter

- ❖ Metabolic waste products must leave
- ❖ O₂ is taken for respiration ; CO₂ must leave
- ❖ Ion concentrations must be regulated
- Selective permeability of a membrane depends upon lipid bilayer barrier, and the specific transport proteins embedded within.

- Hydrophobic substances easily diffuse across a cell membrane.
- However, polar or charged substances do not, instead, move across membranes via specific transport proteins in a process called facilitated diffusion
 - does not require energy and
 - relies on the concentration gradient.

Diffusion: is the tendency of particles to spread out evenly in an available space

- Particles diffuse down their concentration gradient
- The concentration gradient itself represents potential energy for diffusion

Passive transport is diffusion across a membrane with no energy investment

- Molecules do not have to be small to passively diffuse ex steroids

Osmosis: is the diffusion of water across a membrane

Water balance between cells and their surroundings is crucial to organisms:

- Tonicity: is a term that describes the ability of a solution to cause a cell to gain or lose water
- It mostly depends on the concentration of a solute on both side of the membrane ex
- Hypotonic solution; causes the cell to swell up
- hypertonic ; causes the cell to shrink

Transport Proteins:

- Hydrophobic substances easily diffuse across a cell membrane
- However polar or charged substance do not, instead they move across membranes via specific transport proteins in a process called facilitated diffusion
- Does not require energy and relies on the concentration gradient
- When you increase the concentration you will get a very sharp increase and it will eventually plateau because all the transporters will be occupied (fallocted)

In active transport a cell must:

- Expend energy to move a solute against its concentration gradient
- Ex the sodium potassium exchange pump; maintains internal concentrations of Na⁺ and K⁺ that differ from extracellular conditions

Co-transport: is when the active transport of a solute indirectly drives the transport of other solutes

- Ex. plants commonly use hydrogen ion gradient to drive active transport of nutrients
- The gradient comes from a protein pump, which relies on ATP

Exocytosis: used to export larger molecules such as proteins out the membrane

Endocytosis:

- Used to import larger molecules important to its livelihood and in both case it uses vesicles to package the material
- **inocytocit** ; fluids are taken into small vesicles
- **Receptor mediated endocytosis**; uses receptor a receptor coated pit to interact with a specific protein initiating the formation of the vesicle
- **Phagocytosis** ; is the engulfment of a particle by wrapping cell membrane around it forming a vacuole

October 10th

Glucose-> (2ATP) -> G3P-> 2 Pyruvate (4ATP) -> AcetylCoA

+ Oxaloacetate ->6C -> 6NADH -> 2FADH - 2ATP -> ETC

Proton Gradient



Chemiosmosis

Anaerobic Respiration:

- Such organisms use a electron transport chain to generate a proton motive force that drives chemiosmosis, however
- Oxygen is not the final electronacceptor (hence 'anaerobic')
- A different electronegative molecule is used instead
- e.g. Sulphate-reducing bacteria use sulphate ion at the end of their chain.
- Hydrogen sulphide, rather than water is generated as a byproduct.

- Certain bacteria, and your muscle cells and can oxidize NADH through **lactic acid fermentation**, in which
- NADH is oxidized to NAD⁺ and
- pyruvate is reduced to lactate.
- In humans lactate is carried by the blood to the liver, where it is converted back to pyruvate and oxidized in the mitochondria of liver cells.

Monday October 29th

Prokaryotes division is very simple called binary fission

- One cell divides and creates a exact copy
- But everytime they do that they have to replicate dna
- They also have a lot of control of their gene expression
- Referred as DNA Doubling in prokaryotes and S phase in eukaryotes

Binary Fission:

Prokaryote will divide when it reaches double its original size

- There is only on chromosome and it is circular
- As these chromosomes are being replicated they are being distributed to sides of the cell
- Mitosis has evolved from binary fussion

Eukaryotic Cell Cycle:

A period of growth followed by nuclear division and cytokinesis

- Mitosis divides replicated by DNA equally and precisely
- Daughter cells are exact genetic copies
- A cell enters interphase when a daughter cell from a previous round of division enters the period of growth
- It duplicates the contents of the cell
- Start as G1 which is a growth phase then goes to the S phase which is synthesis (replicating dna) then G2 which is another growth phase and more copying
- And then mitosis
- Most cells stay in the G1 for a very long time or stage 0 the cell completely removes it self from the cycle

After S-Phase:

- Before s phase all the chromosomes are in long diffused strand
- After s phase all of the DNA in all of the chromosomes have been replicated and constit of 2 sister chromatids
- Are attached by a bunch of proteins called cohesins

- Every chromosomes have a centromere (a sequence of dna)
- There is a whole protein complex called kinetochore and binds to a centromere

G2:

- The chromosomes condense and the cell begins to assemble the machinery to pull the sister chromatids apart (spindle fiber)
- The spindle is generated by the centrosomes
- Which consists of a pair of centrioles and a glob of protein that surrounds it
- A G2 has two but G1 has only 1
- The centrosomes is the microtubule organizing center

Mitosis:

Begins when chromosomes condensation reaches a point where the individual chromosomes are visible

- Prophase/prometaphase
- The centrosomes being the spindle, the fibers are gonna lengthen and interact with each other
- Nucleus disappears
- Nuclear envelope starts to break down
- Microtubules from each pole start to interact
- At the same time the non kinetochore fibers interacting with each other and push simples out to the poles

Metaphase:

Chromosomes are pulled by opposite directions by kinetochore microtubules and assemble a metaphase plate

- The mitotic spindle; material for the spindle comes from disassembly of microtubules in the cytoskeleton
- The components of the spindle are the centrosomes fibers and asters
- The number of kinetochore microtubules attached varies according to species

Anaphase:

- To pull apart sister chromatids and become daughter chromosomes
- Separation begins when cohesion complex is cleaved by separese
- The kinetochore fibers start to shorten which is cell dependent affect
- To complete the separation the cell has to be elongated
- Non kinetochore microtubules move against each other to elongate it

Telophase:

- Elongation continues
- The vesicles of the nuclear membrane come back together
- Chromosomes start to decondense and the nucleus reappears
- Spindle apparatus is dismantled and used to make the cytoskeleton
- Cytoplasm begins to split
- In an animal cell cytokinesis there is a contractile ring of microfilaments and work like a belt
- Slides over itself and generates a cleavage furrow

Plant cell cytokinesis:

- Vesicles are produced that are full with cell wall material and are aligned around the midline where the division occurs
- Those vesicles fuse and form the cell plate (occurs more than once)
- And produces a new cell wall

Nov 2nd:

Chargaff's Rule:

First rule: ratio of nucleotides

- Adenine= Thymine
- Guanine= Cytosine
- Different for each species

Linus Pauling:

- Triple helix model
- Neutral phosphate groups

The double helix:

- Each full turn of a double helix is 10 base pairs
- Two strands are held together by base pairs
- Deoxyribose sugars are linked by phosphate groups to form a phosphate backbone
- 2 hydrogen bonds for A&T and 3 for C&G
- Antiparallel strands
- 5' to 3' & 3' to 5'

Dna replication:

- Hydrogen bonds break
- Strands unwind and separate
- Each strand acts as a template, used to produce a complementary strand
- Not exactly true

Semi Conservative Replication:

November 5th:

Assembling a complementary Chain:

- Polymers of nucleotides
- DNA is produced by DNA polymerase
- DNA chain growth is 5' to 3'
- Must add to pre-existing polynucleotide strand (mediated by base pairing)

November 7th:

Proofreading & Repair of DNA:

Initial pairings errors during replication occur at a rate of 1 in 10^5 nucleotides

Replicating the ends of chromosomes:

- During DNA replication the DNA pol enzymes cannot duplicate all the way to the 5' end of each daughter strand
- During each round of replication the end of the chromosome is shortened and is also staggered

Telomeres:

- Repetitive nucleotide sequence TTAGGG
- Protects the end of the chromosome
- "Disposable buffer"
- Is active during embryonic development
- Remains active in adult germ cells and stem cells
- After a certain point somatic cells cannot divide anymore, because the telomeres get too short and will no longer be able to protect the chromosomes

DNA organization:

- Dna is not stored as long strands
- It is stored by wrapping around proteins called histones
- Chromatin = dna complexed with histone and non histone proteins

The bacterial Chromosome:

- Closed circular molecule of DNA packaged into a nucleoid
- The plasma in many bacteria replicate independently of host chromosomes

Information Transformation: