* Poi
  + …
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* Micro Level
  + Genes: sequence, expression
  + RNA: sequencing
  + Proteins: sequence, structure, interaction with other proteins
  + Mass Spectrometry

**Molecules of Life I**

* Atoms and periodicity: An atom as the smallest unit of matter that forms a chemical element (pure substance made of only one atom and is the building block of chemistry and life)
  + Atoms cannot be created or destroyed
  + Atoms of the same element are alike in every way
  + Atoms combine to form molecules
  + Most important atoms in the body: H, C, O, N since they can form a lot of bonds
  + Periodic table makes it easier to identify the properties of elements through the periods (rows) and groups (columns) of the table
    - Proton number as the indicator of what the element is
    - Sub-shells can take electrons of counts 2,8,8… (as each sub shell increases)
  + Find out how different elements can combine together throw Lewis dot structures that display the element and the number of electrons in the atom’s outermost shell
    - Dots as the remaining unbonded electrons
    - Lines as bonds formed between molecules
  + Octet rule: that elements in groups 1-2 and 13-18 tend to bond such that each atom has 8 electrons in its outer shell 🡨 H and He prefer to have 2 electrons in their outer shells.
    - Transition metals (groups in between) as a bit more complicated
  + Types of bonds: covalent (most stable, when electrons are shared equally between two nonmetals), ionic (where metal gives electrons to nonmetal and ionic charges result) and hydrogen (weakest, when hydrogen reacts with other molecules 🡨 if bonding with more electronegative/atoms with extra unused electrons like O, there is a dipole moment)
    - Polar covalent bond vs H bond:
* Carbon: forms the most types of molecules in the human body, since it can take 4 bonds
  + Can draw them with skeletal formula; draw lines instead of letter C or the condensed structural formula; drawing out all the letters
* Water: all life as dependent on water. Ensures high cohesion due to being tightly bound together, leading to high surface tension that lets other things like insects walk on them, it is adhesive that lets it bond with loads of structures and is a good solvent
  + Hydrophilic substances: alcohol, sugar, salt 🡨 salt makes it easy to transport the compound
  + Hydrophobic substances: oils, fats, alkanes (hydrocarbons like methane)

Categories of molecules: we need carbohydrates, lipids and proteins to survive

* Carbohydrates: source of energy, made up of sugars.
  + Simplest sugar are monosaccharides aka single sugar: glucose (C6H12O6), fructose (C6H12O6) and deoxyribose (C5H10O4) 🡨 important in DNA
  + Other sugar forms include disaccharides (sucrose) and polysaccharides (cellulose found in plants, starch that we eat and glycogen that stores energy but are depleted within a day; for longer term energy storage, lipids are used)
* Lipids: used for longer term energy storage
  + Main categories include fatty acids, triglycerides, phospholipids and steroids
    - Fatty acids: can be (1) saturated with H atoms and cannot form any more bonds and is also solid at rtp like butter 🡨 hydrogenation/saturation increases the shelf life since kinks and bends are removed and they become transfats aka H atoms on opposite sides, (2) monounsaturated aka there is one C bond where you can add H bonds and tends to be less solid at rtp since can move around a bit more when stacked together, (3) polyunsaturated/essential fatty acids like linoleic acid and alpha-linoleic acid aka omega-3 🡨 unsaturated as more ‘healthy’
    - Triglycerides: fats stored in adipocytes or fat cells. Broken down when needed to glycerol + 3 fatty acids. The fatty acids can combines with albumin and are carried in blood stream to sites where energy is needed.
      * Also used for padding and insulation of organs like liver and intestines
    - Phospholipids: Formed with 2 fatty acid tails + 1 phosphate group. Found in membranes (phospholipid bilayers that keeps water in and out but not in between 🡨 cholesterol usually found in hydrophobic part of bilayer).
    - Steroids: made of 17 carbon atoms that are arranged in four rings. Include adrenal cortical hormones, sex hormones, sterols (C17H28O) and bile acids
  + Usually nonpolar and …
* Proteins: powerhouse of life as they perform a vast variety of functions
  + Protein types
    - Antibodies like immunoglobulin
    - Enzymes that catalyze reactions
    - Protein hormones like insulin
    - Structural like collagen
    - Help cells interact with environment and respond to signals like rhodopsin (light)
    - Transport molecules
  + Proteins are made up of amino acids (20 of them) and all amino acids have the same backbone of a H, carboxyl group, amino group and a side chain
  + Levels of protein structure: primary: least stable form, secondary: H bonding of peptide backbone causes amino acids to fold into repeating pattern, tertiary: 3D folding due to side chain interactions and quaternary: >1 amino acid chain
  + Alpha fold: use NN to predict what the folded protein would look like

**Molecules of Life II (Nucleic Acids)**

* Genome as the underlying source of proteins
* Nucleic acids (long macromolecule formed of thousands of nucleotides): naturally occurring chemical compounds that act as primary information carrying molecules in cells and make up the genetic material required for life. They are required for protein synthesis and main classes of these are DNA (deoxyribose on C2; ATCG) and RNA (ribose; AUCG), composed of nucleotides (phosphate + pentose aka a 5 carbon sugar + base aka AUTCG).
  + Nucleotides bond together to form chains that we call nucleic acids; one nucleotide being called a monomer and many bound together being called a polymer
  + Pentose bonds covalently to phosphate; very strong bond
  + Purines and Pyrimidines: purines have 2 C rings (AG) while pyrimidines have 1 C ring (CUT); pure as gold
    - U/T bond with A with 2 H bonds
    - C pairs with G with 3 H bonds
    - These inter base H bonds are what are separated when trying to separate DNA’s two strands
    - H bond as weaker than covalent bond?
* DNA and RNA: central dogma says DNA 🡪 RNA 🡪 protein, with DNA having a double stranded sugar phosphate backbone while RNA always has a single strand
  + DNA packaging: DNA 🡪 eight histones + nucleosomes 🡪 chromosomes 🡪 nucleus 🡪 cell
  + Somatic cells: 46 chromosomes (23 pairs) for body cells aka diploid
    - Replicate via mitosis; 46 chromosomes 🡪 92 before being split into two identical cells
  + Gametes: 23 chromosomes for sex cells aka haploid; Y smaller than X.
    - Replicate via meiosis
  + Chromosomes 1-22 are autosomes (non-sex chromosomes), while chromosome 23 is a sex chromosome.
  + DNA replication: (1) conservative theory where you pair (new new) and (old old) or (2) semi-conservative theory where (new old) and (new old) or (3) dispersive theory where you have alternating old and new in each of the four strands. Meselson and Stahl’s experiment using isotope (same atomic number and position in periodic table but different masses and properties aka different neutron number) proved that semi-conservative theory is the right one.
* Adenosine TriPhosphate (ATP): most important and abundant energy “currency” that fuels other cells and only has adenine (A) base + pentose sugar + three phosphates
  + Used in cell respiration, muscle contraction, nerve firing, DNA replication and transcription
  + When we eat sugars, energy is released from the sugars so the required bodily chemical processes can occur
* Heredity and genetics: how traits are passed from parent to child
  + Early hypotheses: 6000 year old pedigree (a record of ancestry or purity of the breed) 🡪 Hippocrates (proposed ‘bricks and mortar’ hypothesis that parents bodies have seeds that are passed onto their children like a bodybuilder giving his son buff arms 🡪 Aristotle who believed blood enabled hereditary and that sperm is highly purified blood that meets with a woman’s menstrual blood to pass traits to a child
  + First Law of Genetics: there are discrete hereditary units of genes. Discovered by Gregor Mendel who used pea plant experiments via artificial pollination to identify the pattern of inheritance from round, wrinkled, yellow, green, short and tall seeds, pods and plants.
  + Gene: heritable factor that consists of length of DNA and influences one or many characteristics (genetic traits like blood type, eye colour)
    - One gene influences one trait if mendelian gene (like Huntington’s Disease)
    - One gene influences many traits if pleiotropic gene.
    - Many genes influence one trait if polygenic trait (like height, dementia)
    - All genes are coding but not all DNA is coding
    - A gene occupies a specific position (locus) on the chromosome
    - Allele: one specific form of gene and differs from other alleles by one or more bases like CACCAGCAACCC (color vision) vs CACCAGTAACCC (color blind). We get one allele from each parent, forming a gene pair.
  + Punnett grid of second filial generation (F2): monohybrid cross between two heterozygotes (Aa and Aa where heterozygote has two different alleles of a particular gene)

|  |  |  |
| --- | --- | --- |
|  | A | a |
| A | AA (homozygous dominant) | Aa |
| a | Aa (heterozygous) | aa (homozygous recessive) |

* + Second Law of Genetics: independent assortment of separate gene pairs at gamete formation states that a pair of traits segregates independently of another pair during gamete formation, by Mendel’s findings where he performed dihybrid crosses; dihybrid is heterozygous for alleles of two different genes aka FfRr.
  + Genetic Material: identified via Hershey-Chase experiments where bacteriophages were labelled with radioisotopes (isotopes with unstable nuclei that dissipate excess energy in form of alpha, beta and gamma ray radiation) on their DNA phosphate or on the sulfur in their protein coat, and grown in different environments to determine if bacteriophages infect bacterium and reproduce, through DNA (true if radioactivity found in bacterium progeny assuming DNA labelled) or protein coat.

**Cells**

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**The Central Dogma I**

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**The Central Dogma II**

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