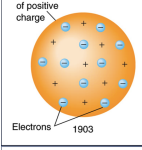
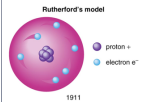
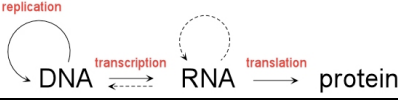


1. Unifying Principles of Science	<ul style="list-style-type: none"><li>Speed: Distance travelled by time; Velocity: Vector (with direction); Acceleration: Speed + <b>dir. change</b></li><li>1. Moving (stationary) object continue move in a st. line at a const. speed (rest), unless acted on by unb. F</li><li>2. Acc. on body is parallel to force, magnitude: (F=ma) (unb. F)</li><li>3. Every force, reaction (forces in pairs)</li></ul> <p>Energy (J, kwh, calorie, eV) (WD=Fs) vs Power (P=E/t, W): KE (motion), PE (store, release) (g, chem, EM)</p> <ul style="list-style-type: none"><li>Heat/Thermal E.: Atoms and molecules are in <b>constant random motion</b> (Kinetic theory) (KE of atom)<ul style="list-style-type: none"><li>Temp: Average KE of molecules; K = °C + 273.15; Abs. 0: cannot extract anymore heat from atoms</li></ul></li><li>Waves: Transport energy without transporting matter: Mechanical (thr. KE of medium) vs EM (vacuum)</li><li>Interchangeability of Energy (within forms): Bungee jump: G.PE → G, KE, TE → E.PE, TE → G, E, TE</li></ul> <p>1<sup>st</sup> law thermodynamics: Closed systm: no exchange matter/energy w. surroundings → <b>total eg. conserved</b></p> <ul style="list-style-type: none"><li>Transfer: Conduction (collision contact), Convection (cyclic process of bulk motion of fluid), Radiation (EMW)</li></ul> <p><b>Entropy</b> (2<sup>nd</sup> law): Irreversible (spontaneous) process: Materials of two temp in contact, vacuum expand, gas mix</p> <ul style="list-style-type: none"><li>Heat will not flow <b>spontaneously</b> from a cold to hot body; You cannot construct an engine that does nothing but convert heat to useful work; <b>Every closed system becomes more disordered with time</b><ul style="list-style-type: none"><li>Warming up cold drink on hot day: ΔEntropy (ΔS) of cold drink &gt;0, ΔS of air &lt;0, <b>total ΔS &gt;0</b></li></ul></li><li>Entropy of a closed system remains constant or <b>increases with time</b> (time has specific dir., ≠ space)</li></ul>													
	2. Forces of Nature													
<p><b>Gravitation:</b> <b>attractive between masses</b>, <math>m_1m_2/r^2</math>; Mass: Tendency to resist change; Weight: <math>F_g</math>, reaction</p> <p><b>Electromagnetism:</b> Attractive or repulsive <b>btw charged bodies</b>: Like repel, opp. attract; bind <math>e^-</math> to nuclei</p> <ul style="list-style-type: none"><li>When electric effects are present in a system, g. attraction can be safely ignored (<b>S&gt;EM&gt;W&gt;G</b>); <math>P=VI</math></li><li>Magnetic force: Force could act without contact; Exist in pairs, <b>no monopoles in nature</b> (≠ charges)</li><li>Magnetism created by <b>steady</b> current; Current created by <b>changing</b> magnetic field (moving magnet)</li></ul> <p><b>Strong force:</b> <b>Attract protons (quarks) in nucleus (p/n)</b>, <b>length (range) &lt; atom nuclei</b> vs inf. length (g, EM)</p> <p><b>Weak force:</b> Responsible for <b>beta decay</b> of subatomic particles, length <b>&lt; individual nucleons</b> (<math>p^+</math>, <math>e^-</math>)</p>														
3. Classical Atomic Models	Dalton	Elements cannot be broken down, identical properties; Compounds: combination of atoms Chemical reactions: Rearrangement of atoms, do not destroy or create matter												
	Thomson	All atoms contain $e^-$ , atoms made up of smaller components, neutral: Plum pudding model												
	<div><p>Thomson's model</p><p>Spherical cloud of positive charge</p><p>Electrons 1903</p><p>Rutherford's model</p><p>1911</p></div>	Discovery of +ve nuclei, $e^-$ orbit around +ve nucleus (solar system): Bombard very thin sheet of gold with $\alpha$ particle beams → most passed right through, <b>some were greatly deflected</b>												
		No. of protons in nuclei different for different elements; <b>Mass number (neutrons), isotopes</b>												
		More elementary particles are discovered through cosmic ray and particle accelerators:												
		<table><tr><td>Leptons x6</td><td>do not take part in holding together nucleus</td><td>electron, neutrino, 4+</td></tr><tr><td>Hadrons x6</td><td>participate in holding nucleus tght., 4 forces</td><td>proton, neutron, 200+</td></tr><tr><td>(std. model)</td><td>particles with same mass, opp. charge, prop.</td><td>positron (antimatter <math>e^-</math>)</td></tr><tr><td>Antiparticles</td><td colspan="2">Particle &amp; anti-particle collide → quickly convert mass into energy (<math>E=mc^2</math>)</td></tr></table>	Leptons x6	do not take part in holding together nucleus	electron, neutrino, 4+	Hadrons x6	participate in holding nucleus tght., 4 forces	proton, neutron, 200+	(std. model)	particles with same mass, opp. charge, prop.	positron (antimatter $e^-$ )	Antiparticles	Particle & anti-particle collide → quickly convert mass into energy ( $E=mc^2$ )	
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Quarks, (gauge bosons x4)	Many elementary particles with various mass, charge, magnetic prop. discovered → why so? Hadrons composed of smaller constituents: Shoot $e^-$ beams at $p^+$ , some scatter → Quarks Have fractional amount of e. charge: d,c,b: -1/3; u,s,t: +2/3; <b>same charge, different properties</b> No isolated quark observed in nature, found as ingredients of other elementary particles Proton (2 up quark, 1 down), Neutron (1u 2d), Electron		charm, strange, bottom, up											
Higgs bos.	Explain why some particles have masses, while others don't + why that mass value													
4. Quantum	Diff. elements under flame → diff. pattern of discrete spectral lines (light freq.) could be identified → goes against Rutherford model (continuous atomic spectra should be emitted) + Atoms of RM not stable													
	Bohr: Fit H gas spectra Intuitive	$e^-$ can only stay in allowed orbits at specific distance from nucleus; <b>distance → energy level</b> $e^-$ can exist for long time in allowed orbit <b>without giving off radiation</b> (X explain/Maxwell EM) $e^-$ <b>can move btw energy levels</b> : move lower → emit photon; <b>discrete</b> amount absorb/emitted												
	<p><b>Heisenberg uncertainty principle:</b> Sample/Energy Source/Detector: <b>probe energy &lt;&lt; energy of object</b></p> <p>Quantum (atomic) scale: Any measurement significantly alters object being measured: <b><math>\Delta x * \Delta v &gt; h/m</math></b></p> <p>Cannot know particle's exact pos &amp; vel simultaneously, <b>can only know probability</b>: B: <b>specific orbit</b> → cloud</p> <p><b>Wave-particle duality:</b> Light can be absorbed as photons → Light as quanta of energy → Particle nature</p> <ul style="list-style-type: none"><li>Quantum level: All matter has prop. of both waves and particles: <math>\lambda = h/(mv)</math>, <b>daily life: <math>\lambda</math> too small</b></li><li>Wave nature of matter only practical with atoms or subatomic particles, when <math>\lambda</math> comparable to size</li></ul>													

1. Origin of Elements	<p>1. <b>Big bang</b> (Early universe) → High temp → nuclear fusion → <b>Light elements</b>: [H, D, He] (abundant), Li</p> <ul style="list-style-type: none"> <li><math>N_p = N_n</math> (high energy, can freely exchange) → Free n begin to decay rate &gt; production rate</li> <li>Deuterium becomes stable, so n quickly combine to produce deuterium then He, stopping n decay</li> <li>Star formation: H, He drawn together, fused new elements, eventually have Fe core, <u>supernova</u> (<math>\propto</math> step 3)</li> </ul> <p>2. <b>Stellar nucleosynthesis: Nuclear fusion</b> (p, n, He) form lighter elements nuclei (<math>Be &lt; ? \leq Fe</math> (heaviest))</p> <ul style="list-style-type: none"> <li>Fe: <u>Most</u> mass loss (into binding energy) per nucleon, <math>\uparrow</math> stable; <b>Combined m. &lt; individual, diff = energy</b></li> </ul> <p>3. <b>Supernova</b> → provide n, intense heat → Fe <b>nucleus capture n</b>, nuclear decay → form heavier elements</p> <ul style="list-style-type: none"> <li>S-process (slow addition of n): Add <u>few</u> n, produce heavier <u>isotope</u> → emit <math>e^-</math> (<b>beta decay</b>) (<math>n \rightarrow p + e^-</math>)</li> <li>R-process (rapid addition of n): Add <u>many</u> n before b. d. occur → beta decay → very heavy element (U)</li> </ul> <p><b>Mendeleev</b>: Properties of elements (valencies) predicted from atomic weights (same/AS weight <math>\propto</math> prop);</p> <ul style="list-style-type: none"> <li>New elements/weight correction: Designated by name of lower odd/even elements in group (eka, dvi)</li> <li>Application: 1. Estimate element atomic weight; 2. Determine prop. of undiscovered element</li> </ul> <p><b>Current periodic table</b>: Elements listed in order by atomic number rather than atomic weight (Mendeleev)</p> <ul style="list-style-type: none"> <li>Groups (column): Patterns in atomic radius, ionization energy, electronegativity; Periods (rows) <ul style="list-style-type: none"> <li>I (alkali metals): Shiny, silver-colored, very soft, low m.p., low density, high reactivity, soluble</li> <li>II (alkaline earth metals): Silvery, fairly low density, higher m.p., less reactive than g1, insoluble</li> <li>VII (halogens): Colored vapors, poisonous, react with metals form salt; 0 (noble gas): color/odorless</li> </ul> </li> <li><math>\searrow</math>: Atomic radius, Metallic character; <math>\nearrow</math>: Electron affinity, Ionization energy, Nonmetallic character</li> </ul>
2. Reactions	<p>Molecule: Made up of atoms held together by chemical bonds, may be unstable (includes free radicals)</p> <p><b>Types of reactions</b>: Chemical (rearrange atoms, bonds) vs Physical (change appearance, not composition)</p> <ul style="list-style-type: none"> <li><u>Combination</u>: 2 or more elements/compounds bond together to form 1 product (<math>2H_2 + O_2 \rightarrow 2H_2O</math>)</li> <li><u>Decomposition</u>: A compound breaks up into two or more separate substances (<math>CuCO_3 \rightarrow CuO + CO_2</math>)</li> <li><u>Displacement</u>: Elements in compound (single: x1, double: x2) replaced by other element</li> </ul> <p>Reaction <b>spontaneous</b> <math>\propto \Delta</math>Energy/Entropy: Product energy <math>\downarrow</math>, Stability <math>\uparrow</math>; <b>Prefer: <math>\downarrow</math> energy, <math>\uparrow</math> entropy</b></p> <ul style="list-style-type: none"> <li>Entropy: Gas &gt; Liquid &gt; Solid, large molecule &gt; small, complex &gt; simple; Calculation: <b>Change</b>, not direct</li> <li>Gibbs free energy: <math>\Delta G</math> (&gt;0: non-sp.; 0: eqm.; &lt;0: sp.) = <math>\Delta H</math>(exo/endergonic) – T (a.temp.)*<math>\Delta S</math> (entropy)</li> </ul> <p>Water to steam: Steam entropy &gt; water, but need absorb heat of vaporization (<math>\Delta H</math> +ve) → <math>T &lt; 373K</math>: not sp.</p> <p>Reaction <b>rate</b> (<math>\Delta C/\Delta t</math>) (<math>k_{rct}</math>): <math>\propto</math> R. conc. <math>\uparrow</math> [c], Temp <math>\uparrow</math> [k], (+ve) Catalyst (alt. pathway, <math>\downarrow</math> activation egy.)</p> <p>Maxwell-Boltzmann db.: N/e (KE), <math>T \uparrow</math>, <math>\uparrow</math> fraction react (eff. coll. p. unit time); Ea: peak-base, PE, r. cordnte</p> <p>Diamond to graphite: Spontaneous, but <math>\uparrow</math> Ea → <math>\downarrow</math> rate const. → slow, neglect rate; <math>k = Ae^{(-E_a/RT)}</math></p>
3. Bonding	<p><b>Covalent bond</b>: Sharing <math>e^-</math>, similar electronegativity; <b>Ionic</b>: Transferring/<b>extreme sharing</b> of <math>e^-</math>, diff. elngv.</p> <p><b>Van der Waals force</b>: Correlation in <b>fluctuating polarization</b> of particles ; <b>H-bond</b>: H with elngv atom (NOF)</p> <p><b>Octet</b>(<math>8e^-</math> valence sh)/ <b>AO</b>(pairs: s: 1x1, p: 2x3, d: 4x5; diag) <b>MO</b> (<math>\sigma, 2\pi, \delta</math>); <b>BO</b>: (<math>B-AB(\uparrow^*)</math>)/2, <b>paramagnetic</b></p> <p><b>Selective bond dissociation</b>: Weak: Long (ns) pulse (egy redistribution IVR); Specific: Wide, Strong, <math>\lambda</math>, Short (fs) p.</p> <p><b>Functional group</b>: Predict molecule <b>properties</b>; identify with IR spectroscopy (<math>\propto</math> vibration spectrum)</p> <p><b>VSEPR</b>: Predict molecule <b>shape</b> (nuclei pos.); Bond &amp; lone <math>e^-</math> pair in valence shell repel, <math>\downarrow</math> force: <math>LL &gt; LB &gt; BB</math></p> <p><b>Isomers</b> (shape): Same m. frml.; Structural: Diff. bond; Stereo: Diff. orientation (enantiomer, conformers)</p> <p>Protein folding: Long chain amino acids to 3D struct., complicated → sometimes fails → disease</p>
4. H <sub>2</sub> O & C allotropes	<div> <div> <p><b>Amorphous</b>: X crystalline; coal/charcoal/soot → ink, paint, rubber, d. cell core; Activated: porous, <math>\uparrow</math> sf.a.</p> <p><b>Graphite</b>: (1 to 3), hex. stack; conductor, lubricant</p> <p>Graphene: 1 layer: flexible, <b>conductor</b>, +plastic strong</p> <p><b>Fullerenes</b>: C<sub>60</sub>: diagnostic tool, drug delivery vessel, <b>Super/semiconductor</b>, catalyst, lubricant; symmetric</p> <p><b>Diamond</b>: Hard, inert, crystalline (1 to 4); Synthetic: <math>\uparrow</math> press/temp (yellow, impure) / CVD: specify shape</p> </div> <div> <p><b>H<sub>2</sub>O</b>: V-shape, polar, s. molecular, 104.45°, <b>H-bond</b></p> <ul style="list-style-type: none"> <li><math>\uparrow</math> m/b.p., Heat capacity, Heat of vaporization (moderating temp.), surface tension (drops): H.B.</li> <li><math>\uparrow</math> Solvent: (salt: <math>\therefore</math> polar; non-polar: <math>\therefore</math> H-bond)</li> <li>Density: Freeze → expand; (lakes not freezing up)</li> </ul> <p><b>C nanotube</b>: Rolling up graphene layer, <math>\approx</math> fullerene</p> <ul style="list-style-type: none"> <li>Electronic: <math>\uparrow</math> Conductivity → Microscopic tweezer</li> <li>Optical: LED, optics, photonics, photo-detectors</li> <li>Mechanical: Struct. Composite appl. (hard &amp; light)</li> <li>Capillary effects: <u>H storage</u>: Condense gas in high density (H bond to C); <u>no need condense to liquid</u> <ul style="list-style-type: none"> <li>Release H: slight temp. and pressure changes</li> </ul> </li> </ul> </div> </div>
5. Nano	<p>nm: <math>10^{-9}</math> (10x H atom), diameter of C<sub>60</sub></p> <p><b>Gold nanoparticles</b> [Large Au: Unreactive, soft]</p> <ul style="list-style-type: none"> <li>Quantum (4-15nm): Highly active, size <math>\propto</math> color</li> </ul> <p>Catalytic cvtr (<math>CO + O_2 \rightarrow CO_2</math>, <math>C_xH_y + O_2 \rightarrow CO_2 + H_2O</math>)</p>

1. Classification	<b>Definition of Life:</b> "Living beings are autonomous systems with open-ended evolutionary capacities" <ul style="list-style-type: none"> <li><u>Semi-permeable active boundary:</u> Keep in good, keep out bad (packaged into membrane-enclosed cells)</li> <li><u>2 types of functionally interdependent macromolecular components:</u> <b>Records</b> (DNA: Adaptive changes), <b>Catalysts</b> (Protein/Enzymes: activities mostly inside cell); <u>Energy transduction apparatus:</u> set currencies</li> <li><u>Evolutionary capacities:</u> Able to change &amp; adapt in response to environment (cells grow, reproduce)</li> </ul>	
	<b>Naming:</b> Binomial Nomenclature (Kingdom Phylum Class Order Family Genus Species) [Homo Sapiens] <b>Classification:</b> (Phylogenetic) <u>tree of life</u> (relation to other life) [cladograms], from appearance + physiology	
	<b>3 domains of life forms</b> (same basic unit 'cell')	<b>Eukaryotic:</b> <b>Eukarya</b> (Animals, Plants, [Microbes])
	<b>Prokaryotic (1<sup>st</sup>):</b> <b>Bacteria</b> [oldest dom., ULCA], <b>Archaea</b> 1 organism = 1 cell (small, simple); No distinct nucleus: Lack "organelles" found in mammalian cells (viruses: no cells, exist only as parasites of cells)	Contain structures evolved from prokaryotic cells 1 organism = 1/many cells (10x larger, complex) Distinct nucleus: Contain hereditary material and multiple complex organelles for various functions
2. Origin	<b>Probiotics and the microbiome:</b> # bacterial cells living in our body outnumber human cells by 10x <ul style="list-style-type: none"> <li>Some bacteria not inert: Make us sick, also keep us alive (nervous, immune, endocrine system comm.); Fat + gut bacteria consider as organ, active manage; Antibiotic side eff.: Change our biome → Yeast infection/stomach prbl</li> </ul>	
	<b>Key life molecules:</b> Building block molecules [in water] (e.g. CO <sub>2</sub> , ammonia, methane) contain CHONSP, + Energy (Lightning), favorable conditions → life molecules: Raw building blocks + energy → life molecules	
	<b>Primitive Earth Simulator:</b> Circulated boiling water vapor through atmosphere: (CH <sub>4</sub> , NH <sub>3</sub> , H <sub>2</sub> ) (CO CO <sub>2</sub> ok) → Passed thr. electric spark, condensed back to liquid → Red (1-10% C) developed in liquid <b>(amino acid)</b>	
	<b>Earth life timeline:</b> Earth Formation (unstable) (4.5B) → Stable hydrosphere (H <sub>2</sub> O) → Prebiotic chem. (4.2) (Miller-Urey exp.) → (4.0) Pre-RNA world, (3.8) RNA world (evolution), (3.6) 1 <sup>st</sup> DNA/protein life, LUCA 1. RNA as self-replicator, viral genomes [fold to complex structures > DNA] 2. DNA takes over, more stable <b>LUCA:</b> Oldest fossils resemble modern day cyanobacteria, live off H <sub>2</sub> , CO <sub>2</sub> , N <sub>2</sub> (anaerobic autotroph, no O <sub>2</sub> )	
3. Molecules (Structure → Function)	<b>Water:</b> Dissolve nutrients (deliver to cells), dissolution/exit waste products; Anomalous: Max density 4°C <ul style="list-style-type: none"> <li>Linking up reaction involves loss of H<sub>2</sub>O molecule (condensation, peptide bond) / Hydrolysis (break up)</li> <li>Carbon: Basis of life (all life molecules contain C), essential for molecular structure/function</li> </ul>	
	<b>Lipid (fat):</b> ≤3 fatty acid chain to glycerol → diff. fat; Energy storehouse: 2x calories protein/carbohydrates <ul style="list-style-type: none"> <li>Saturated (full with H) (solid) [MUFA mono], Unsaturated (C=C bond) (liquid (oil) at r. temp) [PUFA poly]</li> <li>Saturated: Less healthy, increased risk of cardiovascular disease (atherosclerosis) storage polymer</li> </ul>	
	<b>Carbohydrates (sugar):</b> Ribose, Glucose (Starch, Cellulose), Glycogen; Monosaccharide (1), Polysaccharide (2+)	
	<b>DNA (string of nucleotide, nucleic acid):</b> Double stranded; 2-Deoxyribose; <b>Stable information storage template</b> <ul style="list-style-type: none"> <li>Structure: Sugar-phosphate backbone + Base form H-bond with partner on opp. strand: A-T, G-C; (Re: BP)</li> <li>Nucleotide = Ribose sugar + Nitrogenous base (AGCT (U in RNA)) + Phosphate group; Read triplet code</li> </ul>	
4. DNA (Carrier of hereditary info)	<b>RNA:</b> Single strand (hairpin), Ribose sugar; Info. carrier + catalyst; <b>Intermediary molecule for protein translation</b>	
	<b>Protein (string of amino acids, polypeptide chain):</b> Hormone (receptor), substance channel, signaling network,... <ul style="list-style-type: none"> <li>Amino acids: Polar, Nonpolar, Electrically charged (Acidic/Basic); Chain: H-bond support structure</li> <li>Quaternary structure: Proteins can get tgt into multi-member functional units (hemoglobin in RBC O<sub>2</sub>)</li> <li>Eg. Mongoose NACh receptors: Snake venom toxin insensitive; "Gene encodes protein enables function"</li> </ul>	
	<b>Replication:</b> 5' phosphate 3' hydroxyl; Protein catalyst; Semi-conservative; DNA strands separate, filled in with complementary nucleotide pair <ul style="list-style-type: none"> <li><b>Mitosis:</b> Regenerate body cells (skin, stomach lining, blood cells, etc);</li> <li><b>Meiosis:</b> Generate cells (sperm/egg) with half amount of DNA (somatic)</li> </ul>	 <p>Self repl.: RNA ok, Protein no</p>
	<b>Transcription:</b> Making RNA from DNA template: <ul style="list-style-type: none"> <li>Transcription factors + RNA polymerase assemble on DNA strand → Enable produce RNA from DNA</li> <li>RNA polymerase (protein): Enzyme, place to react</li> <li>Diff. cell in body with diff. function: Same DNA, Diff. transcriptional programs, RNA, Proteins</li> </ul>	<b>Translation:</b> Synthesis protein from mRNA template: <ul style="list-style-type: none"> <li>transferRNA (tRNA) brings along amino acid, read codons (3B, a.acid) to growing polypeptide chain</li> <li>A site: Acceptor, where tRNA first comes in dock</li> <li>P site: Contains growing peptide chain</li> <li>Ribosome: Connect A site amino acids to P site amino acids to make chain (key molecular 'engine')</li> <li>RNA created by transcription and later used for translation: Messenger RNA (mRNA) (intermediary)</li> </ul>
4. DNA (Carrier of hereditary info)	<b>Genetics (Punnett Sq.):</b> Organize hereditary info. Alleles (alt. form of gene); Dominant: override/mask Homo-: single type; Hetro-: Multiple type	



4. DNA Structure	<p>DNA will assume a helical secondary struct. and also a higher order structure – a <b>chromosome</b> (fork-like)</p> <ul style="list-style-type: none"> <li>• <b>Histone</b>: Protein that DNA wraps itself around</li> <li>• <b>Nucleosome</b>: 8 histones + associated DNA wrapped around</li> <li>• <b>Chromatin</b>: Collection of DNA + Histones, can further condense to chromosome</li> <li>• <b>Chromosome</b>: Ultimate 3D structure of DNA, millions of base pairs + associated histones</li> </ul> <p><b>Genomics</b>: Focus on struct. &amp; func. of entire genomes (<b>entire DNA content present in a cell</b>)</p> <p><b>Griffith exp.</b>: Pneumococcus bacteria need protein coat → harmful (smooth strain), Heating SS denatures proteins → not harmful; Heat-killed SS + Rough strain = harmful, <b>One type bacteria transforming the other</b>; <b>Avery, McLeod, McCarty</b>: DNA discovery: Make x-ray pattern (x shape → helix, rungs (ladder, 2 strands)); <b>Meselson-Stahl experiment</b>: DNA replication: Label starting DNA with heavy N isotope, Heavy DNA single strand filled with normal weight nucleotides, 4 templates: 2 heavy, 2 normal → starting heavy is gone, Semi C; <b>Conservative</b>: Heavy band stay; Dispersive: Equal weight bands at early stage, no separation/unpredictable; <b>Microscope</b>: Hooke (no lens) → Light (ocular, condenser, objective lens) → Electron; <b>Fluorescence microscopy</b>: Lasers excite fluorophores attached to antibodies attached to various cell struct.</p>
5-6. Cells and systems	<p><b>Cell theory</b>: All life composed of 1+ cells (basic unit of struct.) (diff. function); No spontaneous generations</p> <p><b>Plant cell</b>: Cell wall (stiffness/struct), chloroplast (Photosynthesis: <math>\text{CO}_2 + \text{H}_2\text{O} \rightarrow (\text{light}) \text{Sugar} + \text{O}_2</math>)</p> <p><b>Animal + plant cell</b>: Nucleus (DNA), Golgi apparatus (modify some proteins and marking them for secretion outside the cell), Rough endoplasmic reticulum (protein synthesis), smooth e.r. (site of lipid and steroid synthesis), mitochondrion (respiration, energy production)</p> <p><b>Cell membrane</b>: Phospholipid bilayer: [Polar head group (hydrophilic), nonpolar tails (hydrophobic)], Cytoskeleton (struct.), Cholesterol (membrane fluidity), glycolipids/glycoproteins (cell recognize/migrate), <b>proteins</b> (hormones/drug receptor, ion channels)</p> <p><b>Glucose transporter</b> (food → inside cell); Transporters, receptors, channels: responsive to curr. conditions;</p> <p><b>Receptor</b> (tissues/cells) chemicals/drugs: Chemical (<b>agonist</b> stimulator) vs <b>antagonist</b> (blocker), signal, effect</p> <p><b>Nerve cells</b>: Excitable, pass ions to turn on/off; Receptor: Signal put glucose transporter on cell membrane</p> <p><b>Negative feedback cycles (PID)</b>: <b>Homeostasis</b> (physiology): body's internal env. regulated around a set-pt.</p> <ul style="list-style-type: none"> <li>• <b>Blood pressure</b>: (baroreceptors) [low bp → increase cardiac output, decrease blood vessel diameter, prevent water loss]</li> <li>• <b>HPA axis</b> (Hypothalamus, Pituitary, Adrenal + Hormones): <math>\text{H} \rightarrow (\text{CRH}) \text{P} \rightarrow (\text{ACTH}) \text{A} \rightarrow (\text{Cortisol}) \text{bloodstream}</math> <ul style="list-style-type: none"> <li>○ Hormones: Chem. released by cell/gland in one part of body, send out message affect cells in other part</li> </ul> </li> </ul> <p><b>Cortisol</b> (how use fuel / metabolic effect): Breakdown of glycogen to glucose, Stimulate gluconeogenesis</p> <ul style="list-style-type: none"> <li>• Too little: Addison's disease (not enough glucose, weakness, bp problem); Too much: Crushing syndrome</li> </ul> <p><b>Positive feedback cycles</b>: Blood clotting, ovulation, birth-muscle contradictions, Heat stroke, hypovolemic shock</p> <p><b>Brainbow</b>: Combinatorial expression of several fluorescent proteins (XFPs) in neurons, color tagging of individual cells</p> <p><b>Optogenetics</b>: control nerve/specific neurons using light, faster than drugs and more precise than electrical stimulation</p>
7-8. Evolution	<p><b>Importance</b>: Origin of humans, reveal species bio. connections with organisms (diff kinds), disease cure</p> <p><b>Darwin</b>: All life was not created separately in their present forms, but evolved (common descent, tree)</p> <p><b>Natural selection</b> ("survival of the fittest"): <b>Individuals more suited to environment more likely reproduce</b> → Diversification (diff variants (mutated DNA) advantageous α situation), Design of organisms, Evolution</p> <p><b>Evolution</b>: FeReSuValhDieAp (Mutation [<b>random</b> changes to DNA, heritable variation], Natural selection)</p> <p><b>Species</b>: Largest group of organisms in which two individuals can reproduce fertile offspring (interbreed)</p> <p><b>Speciation</b>: Geographical separation: Isolated populations undergo genotypic/phenotypic divergence (env)</p> <p><b>Genes build bodies</b>: <b>Body patterned</b> (pos. info. imparted to diff. region, follow appropriate dev. programs)</p> <p>Hox genes: Organism basic struct. and orientation (anterior vs posterior), structure placement, can mutate</p> <p>Homologous/vestigial structures: evidence for evolution: Whales/snakes small "vestigial" hip/leg bones</p> <p>Atavism: Gene that gets turned on that isn't supposed to be on (expression of feature from prev. ancestor)</p> <p><b>Fossil record</b>: Preserved remains of animal/plant from distant past (<math>&gt;10^4\text{y}</math>) → radioisotope dating, C14</p> <p><b>Humans</b> (<math>2 \times 10^5\text{y}</math>, 0.1%) not evolve direct from chimp, LCA hominid (4-6M y); Multi-regional vs Single origin</p> <p><b>Genetic diff.</b>: Diff # of chromosome with chimpanzee → X share DNA, but examining 2 genomes → share SNP (polymorphism): <b>Variation in single nucleotide</b> (ATGC) in specific pos. of genome → breast cancer</p> <p>RFLP (r. fragment length p.): Paternity test: <b>Restriction enzyme cut DNA seq.</b> → diff size, Gel electrophoresis</p>
9. Ecosystem	<p><b>Nature's 3 principles of sustainability</b>: Reliance on solar energy, Biodiversity, Chemical/nutrient cycling</p> <p><b>Solar energy</b> + carbon → Producer (plants) (autotrophs) → sugar → Consumers (organisms) (heterotrophs)</p> <p>Trophic level: Position organisms occupy in food chain; Decomposer vs Detritivore; 10% rule each level</p> <p>Primary consumer: herbivore (plant eater); Secondary: Consumer eat herbivore; Tertiary: Eat carnivore</p> <p><b>Biodiversity</b>: Variety and adaptability of natural systems and species: <b>Ecosystem diverse → better function</b></p> <p>↑ resource capture/nutrient recycling/biomass production/decomposition: biodiversity ↓ → efficiency ↓</p> <p><b>Rivet hypothesis</b>: 1-2 pieces of ecosystem could be altered without seeing considerable change, but with more rivets removed, the higher the danger of catastrophic collapse: Lyme disease (Possum kill tick &gt; mice)</p> <p><b>Chemical cycling</b>: Tracing carbon atoms in cells from food / water cycle / rock cycle</p>

1. Earth system	<p><b>Earth (open system):</b> Exchange energy (sun/radiation) + matter (space/gas escape atmosphere)</p> <p><b>Earth's interior</b> (Fe, O, Si, Mg): Layers with diff prop &amp; mineral/rock compositions; Interior density &gt; surface</p> <ul style="list-style-type: none"> <li>Theoretical model, observation (major seismic events), lab work (matter prop. at high pressure/temp)</li> <li>Rock sample formed at 100km depth carried to surface in molten lava (Peridotite)</li> <li>Seismic evidence: Measure arrival behaviors of various kind of wave from same earthquake at diff sites             <ul style="list-style-type: none"> <li>P wave through liquid and solid; S wave through solid [shadow zone: outer core]</li> </ul> </li> <li>Core: Fe, Ni [Inner: solid, high press., 5000K] [Outer: liquid] Mantle: rocky, Si/O/Mg/Fe</li> <li>Crust: Oceanic crust is thinner (8km), Continental crust is thicker (70km thick); O, Si, Al, Fe</li> </ul>
	<p><b>Plate tectonics:</b> Earth's surface broken into a dozen large pieces (tectonic plates), [@crust, ..upper mantle]</p> <ul style="list-style-type: none"> <li>Plate shift on surface (timescales M y), ∴ forces generated by mantle convection (heat transfer);             <ul style="list-style-type: none"> <li>Surface temp &lt; interior → HE outward, energy source ∴ earthquake/volcano (conc. on boundary)</li> <li>Volcano: subsurface magma concentrated in upper mantle/lower crust break to surface</li> <li>Earthquake: Stressed rock suddenly snap along a fault (flat surface), release PE (seismic wave)</li> </ul> </li> <li>Rocks in mantle heated s.t. can flow like liquid (20mm/year, solid) → convection cells in mantle</li> </ul>
	<p><b>Continental drift theory:</b> Americas and Europe/Africa were once joined (Panagaea), then torn apart</p> <ul style="list-style-type: none"> <li><u>Mesosaurus fossil</u> found only in South Africa/Brazil + Rocks in South Africa/SE Brazil <u>similar age/struct</u></li> <li><u>Ocean floor:</u> not flat, have steep walled canyons / lofty mountains [longest m. range: <u>Mid-Atlantic Ridge</u>]</li> <li><u>Rock ages:</u> Radioactive isotopes in oceanic crust volcanic rocks [MAR young (&lt; few M)], find erupt time</li> <li><u>Magnetic Reversals:</u> Magnetic measurement of sea floor → // stripes of rocks, mag. dir. alternated;             <ul style="list-style-type: none"> <li>Earth m. field changes direction sporadically over time (flipping the poles); When lava flows out of Earth crust, contain iron oxides/ore (magnetized), aligned by m. field, frozen when lava hardens; → Only way to get stripes: seafloor getting wider as new molten rock erupts (Seafloor spreading)</li> </ul> </li> <li><u>Direct measurement of Motion:</u> Distance between two radio telescopes, (comparing time of arrivals of crest of same radio wave from distant galaxies (quasars)); North America and Europe separate 5cm/y</li> </ul>
	<p><b>Earth age:</b> Radiometric Dating → Accurate nuclear physics, finding oldest rock (4.0B)/mineral (4.4B)</p> <p>Asteroid in solar system unaltered, formed time ≈ solar system → oldest material on meteorite is 4.57B</p>
	<p><b>Atmosphere:</b> Thin layer with 90% air within 16km of Earth's surface; Curr: N<sub>2</sub>, O<sub>2</sub>, other ingredients (few)</p> <p>Earth cool in formation: Water vapor, CO<sub>2</sub>, NH<sub>3</sub> → N<sub>2</sub>, H<sub>2</sub>, gone from interior via volcano fissures (<u>outgassing</u>)</p> <p>Atmospheric cycle: Weather (short-term variation), Climate (long-term pattern)</p> <ul style="list-style-type: none"> <li><u>Greenhouse effect:</u> Selective absorption IR radiation by atmosphere: GHG (CO<sub>2</sub>/H<sub>2</sub>O/Ozone/Methane): small components of atm., inhospitable -19C (eqm) (15) if no GH eff.; <u>energy trap in atm., heat surface</u></li> <li>Blackbody radiation: High temp object emit more radiation, at higher freq; sun absorb = earth emit</li> </ul> <p>CO<sub>2</sub>: Some dissolved in ocean, carbonate rock, skeletons sea animals, marine sediments/sedimentary rock</p>
	<p><b>Hydrosphere:</b> Comprising all of Earth's water and ice, surface + underground (excluding water vapor), 71%</p> <p>Water: Strong moderating effect on weather, high specific heat, <u>ocean current redistribute heat energy</u></p> <p>Ice caps: Ice layer at N/S pole; Glacier: Large bodies of ice slowly flow down slope/valley → gw. [ice age]</p> <p>Hydrologic cycle: Water molecule cycle through many diff. [reservoirs: Ocean 96%, groundwater 98% fw.]</p>
2. CCST9012	<p><b>Night sky:</b> Stars trace out circles in sky in 23h56m → celestial sphere: (this or earth is spinning?); Ecliptic</p> <p>Planets: move relative to stars (W to E, same as sun); Uranus/Neptune not visible; retrograde motion, opp.</p>
	<p><b>Ptolemaic system:</b> <u>Geocentric</u>, sun/planets move in uniform (same speed) motion on concentric sphere</p> <ul style="list-style-type: none"> <li>Epicycles for retrograde motion: highly successful to predict position and eclipse</li> </ul> <p><b>Copernican system:</b> <u>Heliocentric</u>; earth daily rotation, earth/planets uniform on circ. orbit (still epicycle)</p> <ul style="list-style-type: none"> <li>Tycho: design and built vastly improved observational instruments (e.g. quadrant) (2x accurate)</li> <li>Kepler law: 1. ellipse orbit 2. line join planet &amp; sun sweep equal area (fast when close) 3. <math>r^2=kt^3</math> <ul style="list-style-type: none"> <li>Improvement: simpler (no epicycles), more accurate, heliocentric simple retrograde; <u>how, not why</u></li> </ul> </li> </ul> <p><b>Galileo:</b> first person to use a telescope to observe the sky; discovered 4 moons orbit Jupiter, Venus phase</p> <p><b>Newton:</b> Law of universal gravitation, <u>kepler derive from newton laws of motion</u>; eclipse change (other g)</p>
	<p><b>Seasons:</b> ecliptic tilted from celestial equator (earth rotation axis not perpendicular to orbital plane (23.5))</p> <p>Northern hemisphere is tilted towards sun near summer solstice, away near WS, perpendicular in VE &amp; AE</p>
3. Stars	<p>Analyze light or EM radiation from stars: Telescope (visible light: 400-700nm); AU: avg earth-sun dist</p> <p>Each element/molecule emits and absorbs light at a unique set of wavelengths; Find temp, chem comp.</p> <p>Spectroscopy: [Dense object: continuous], [Cool transparent gas: absorption], [hot transp. gas: emission]</p>

3. Solar System	<p>All planets orbit sun on nearly circular orbits, same dir, in almost same plane as sun eqt; rotating gas disk;</p> <p><b>Terrestrial planets:</b> Inner solar system, small size, iron-nickel core, rocky shell [Venus atm., Mars water]</p> <p><b>Giant/Jovian planets:</b> Outer solar system, large size, mostly gas/liquid [Giant red spot]</p> <p><b>Satellites (moons):</b> All planets \ {Mercury, Venus}; Moon formation: Earth collide with Mars-size proto planet</p> <ul style="list-style-type: none"> <li>Europa: Moon orbiting Jupiter, global ocean of liquid water underneath a thin ice shell</li> </ul> <p><b>Asteroids:</b> Rocky and metallic bodies in inner solar system [Asteroid belt] [Kuiper-Belt objects: Pluto]</p> <ul style="list-style-type: none"> <li>Meteorites: Solid particles (fragments of asteroids) land on Earth; Extrasolar planet (another sun star)</li> </ul> <p><b>The Sun:</b> 74% H, 25% He; Core hot for thermonuclear fusion (energy) (H to He), missing mass: <math>E=mc^2</math></p> <ul style="list-style-type: none"> <li>Star forms from cloud of gas &amp; dust, collapses on itself due to gravity until core temp high for H fusion</li> <li>More massive stars are much brighter, and live much shorter, some smaller stars lifetime &gt; universe age</li> <li>Main sequence (H <math>\rightarrow</math> He, 10B) <math>\rightarrow</math> Red giant (0.25B, core contracts, heats up, outer layer expands/cool) <math>\rightarrow</math> [He <math>\rightarrow</math> C &amp; O in core, shell H fusion, 0.1B] <math>\rightarrow</math> Outer layer eject planetary nebula, remain white dwarf/neutron star/black hole <math>\rightarrow</math> Core collapse, supernova <math>\rightarrow</math> throw elements [stellar nucleosynthesis], recycle</li> </ul>
4. Cosmology	<p><b>Olber's paradox:</b> "If universe is static AND infinite in size AND infinite in age, night sky should not be dark"</p> <p>Measure astronomical distance: parallax with standard candles; finite and big speed of light <math>\rightarrow</math> study distant object <math>\rightarrow</math> study universe past; Galaxy: large assemblages of stars, interstellar gas and dust, and dark matter</p> <p><b>Doppler effect:</b> Absorption/emission lines in spectrum are shifted to longer wavelengths if it is moving away/toward observer (red/blueshift), shift <math>\propto</math> <u>speed</u> along line of sight; (dynamics, spectroscopy)</p> <ul style="list-style-type: none"> <li>Hubble's Law: <math>V=Hd</math>, all distant galaxies are moving away from us <math>\rightarrow</math> Universe is expanding</li> </ul> <p>Big bang: Cosmic background of radiation with temp. of a few (2.725) Kelvin, remnants of big bang</p> <ul style="list-style-type: none"> <li>Big bang theory: why H is most abundant element in universe, 1/4 of mass in He :: nucleosynthesis</li> <li><b>Unification of forces:</b> At start of time, have grand unified theory / theory of everything (G, S, EM/W)</li> </ul>