BIOL229 - Comparative Physiology
Lecture notes

Lecture 2: Prokaryotes, eukaryotes, the rise of multicellularity and endosymbiosis

Prokaryotes

- Photosynthetic – Phototrophs, 3.5bil years ago
- Cyanobacteria – important in plants life systems, blue-green algae, produce own nitrogen
- Chemotrophs – don't need light to survive, use inorganic substances to synthesise carbon (lithotrophs)
    - CO_2 + hydrogen sulphide → carbohydrate + H_2O + sulphur
- All bacteria are heterotrophic when organic carbon is available for metabolism
- Living cells, make ATP, no internal membrane systems
- Achieve energy transformations by generating proton gradients across the plasma membrane that bounds cell
- Staphylococcus bacterium = super bug

Rise of Eukaryotes

- Heterotrophs - consume organic compounds
- Autotrophs – photosynthesise
- All cells must break down organic carbon to produce energy
- Mitochondria = ATP
- ATP synthesises macromolecules (polymers), generate new cells/grow/support metabolic processes

Consequences of endosymbiosis and multicellularity

- Confer metabolic flexibility on cells and tissues because of:
    - The separation of function inside cells leading to capacity to concentrate substrates and enabling catalysis
    - The specialisation of physiology between tissues (sensory/reproductive)
- Prokaryotes have a short generation time, small SA to V ration and simple genomes, gain resources quickly, populations mutate to respond to external conditions

Consequences of multicellularity

- Eukaryotes assemble into multicellular organisms through cell-cell interaction
- Dictyosteliym discoideum – lives as free cells for part of its life then assembles into multicellular structure for reproduction
- Specialisations enable larger and better adapted organisms to develop
- Transport mechanisms e.g. circulatory systems in animals (blood/lymphatic) and long-distance transport elements in plants (xylem/phloem)

Energy and life

- Thermodynamics dictate that energy must be inserted to sustain and build organisms – polymers/pumps absorb energy and lower entropy
- Energy – stored chemically in phosphate bonds or ATP
- High-energy molecules are present in small amount and turn over very quickly with the ATP pool disappearing then reforming – no change in pool size

Making energy in an aerobic world – ATP synthase

- Proton gradients – ATP synthase form a nanomotor and make ATP out of proton gradient
    - Core energy source in living things
    - Form from protons stripped off respired carbohydrates (respiration) or from protons being released during photosynthesis
- Gradient = source of potential energy, need mechanisms
- ATP synthase allows protons to pass through a channel in the protein complex = make ATP out of ADT by adding phosphate

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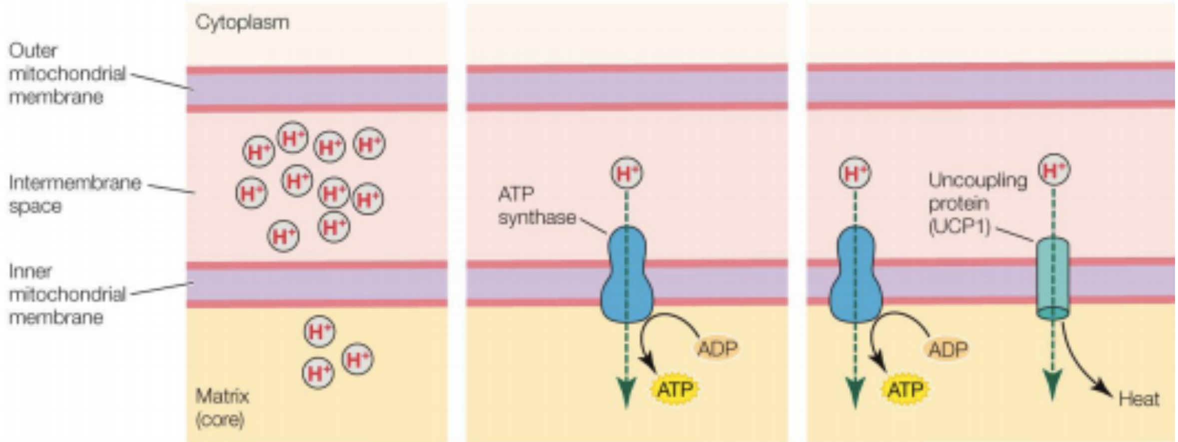

Animals, development and environment

- With multicellularity = complexity and opportunity
- Environment modifies gene expression (acclimation) – phenotypic plasticity
- Animal developmental programs are modified by environment
    - Short term – effects on life style
    - Long term – natural selection

Plants, development and environment

- Great need for developmental programs and high levels of phenotypic plasticity – must accumulate short term stresses
- Highly capable of adapting to new environments through gene-level changes (evolution of new alleles) and their much more varied ploidy that animals (diploids can be related to variants of polyploids)
- Polyploidy = robustness and versatility through allelic variation

Acclimation and adaptation

- Acclimation = short term change in an organism in response to an external factor enhancing survival – gene activity and expression of new proteins
- Acclimatisation = indicate changes over longer periods, involve genes but new phenotypes may be different
- Adaptation = change in the genetic complement over many generations that leads to better adapted species

Lecture 3: Autotrophy

The essence of autotrophy

- Autotrophy: generation of reduced carbon compounds (CO2 → carbohydrates then organic compounds in the form of hydrocarbon bonds
- Why does this conversion from C=O bond to a C-H bond matter so much?
- The bond requires input of energy and breaking it releases energy
- The energy to make the hydrocarbon bond comes the chemical energy in reduced compounds such as H2S or the sun in phototrophs
- Pigments trap light and use its energy (photons) to make high-energy intermediates that drives the reduction of carbon → carbohydrates

Primitive photoautotrophs make organic carbon in light

- Photoautotrophs = use light to form organic carbon compounds
- Use water to supply hydrogen atoms and electrons required for carbon reduction but primitive bacteria are an exception
- Primary pigment = bacteriochlorophyll and chlorophyll molecules + light-harvesting pigments
    - Use light to split water and make hydrocarbon bonds from products
- Primitive photoautotrophs – only have 1 out of the 2 photosystems that cyanobacteria/plants have
- Green and purple sulphur bacteria are anaerobic phototrophs using H2S to reduce carbon
    - Use organic compounds for reduction
- Photoautotrophs include cyanobacteria/plants
- 2 components to make organic molecules: