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Lecture 1: Introduction to Biology

1st Foundation of Biology

- Evolution through natural selection:
  - all life evolved from pre-existing life
  - homology – comes from a shared character/derived from a common ancestral feature (same evolutionary origin)
  - fossils
- Fossil record is strong evidence for evolution – observe increasing complexity with passage of time.
- Ontogeny recapitulates phylogeny, which literally means development is a fast action replay of ancestry.
- Biogeography also supports evolution – unique Australian flora and fauna due to protracted evolution on isolated continent.
- Darwin's three observations:
  1. Individuals in a population vary → fitness. (variability)
  2. Pass on traits (fitness) to offspring → heredity. (genes)
  3. Never enough resources → competition for survival and reproduction.

  Natural selection = survival of the fittest!

1. Evolution is a two-step process:
   1. Variability
   2. Ordering that variability by Natural Selection

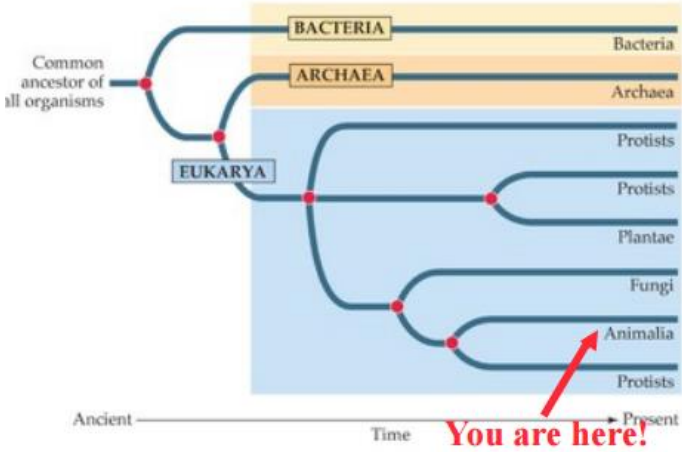
2nd Foundation of Biology

2. Unity of biochemical processes: all organisms share main biochemical reactions (because of homology).
3. Example of the unity of biochemical reactions:
   1. All organisms have genetic material, the DNA, which contains the instructions that the organism will develop.
   2. Organisms also have hardware to carry out the instructions – the proteins.
   - Francis Crick was the co-discoverer of the DNA structure.

3rd Foundation of Biology

- Cell theory (Schleiden & Schwann):
  - All known living things are made up of one or more cells.
  - All living cells arise from pre-existing cells by division.
  - The cell is the fundamental unit of structure and function in all living organisms.
  - Cells contain heredity information (DNA) which is passed from cell to cell during cell division.
- Robert Hooke invented the first microscope, by looking at cork cells. Pauling and Zuckerkandl recognised that DNA contains the history of evolution.

- Studying the evolution (relatedness) of all life:
  - All organisms have genes (DNA).
  - DNA contains a history of evolution.
  - Compare genes to define relationships.
  - Study of cell morphology gave a paradigm where we recognised the main types of cells: prokaryotes vs eukaryotes.



Lecture 2: An introduction to the prokaryotes, features, importance and cell biology.

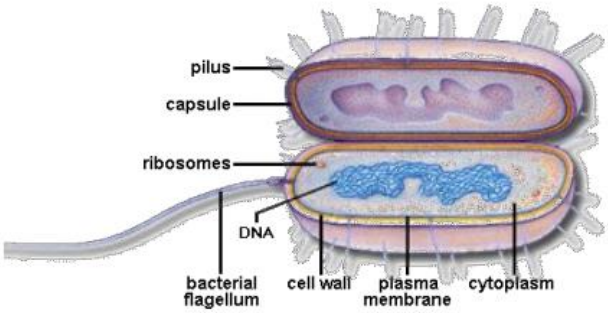
Life Depends on Prokaryotes

- Archaea allow herbivores to break down the sugars in plants.
- Bacteria in our intestines help to make essential vitamins.
- Harmless bacteria in our skin protect us from attack by other invaders.

- Prokaryotes are used in food production:
  - Fermented foods: produced via the action of microbes, e.g. yoghurt, cheese, wine, beer, vinegar, sauerkraut, salami, tempeh, kimchi, soy sauce, etc.
- More than 50% of the earth's free oxygen is generated by bacteria through photosynthesis.
- About 70% of biologically available nitrogen is possessed by bacteria.
- Some diseases caused by bacteria include: Legionnaire's, typhus, Lyme disease, TB, gangrene, leprosy, meningitis, pneumonia, cholera, dysentery, syphilis, gonorrhoea, and anthrax (weaponised disease) (others incl. pharyngitis, impetigo, dental caries, cellulitis). Archaea on the other hand do not cause any diseases.
- A problem with bacteria is their ability to develop antibacterial resistance – Darwin's theory of natural selection.

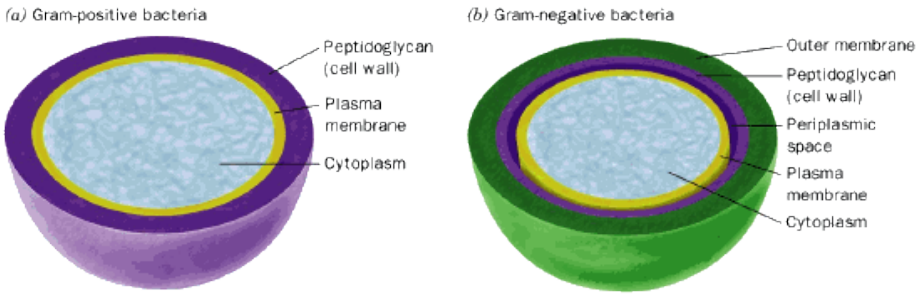
Prokaryotic Cells

- usually microscopic (1-10 µm)
- DNA is a single, circular chromosome ('nucleoid')
- no proteins are attached to DNA in Bacteria
- proteins ('histones') are attached to DNA in Archaea
- cell wall is made of peptidoglycan



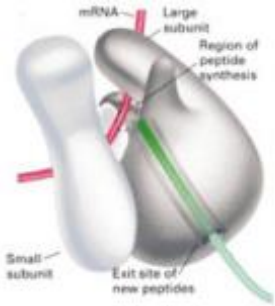
Bacteria Cells

- Cells typically have a wall – peptidoglycan.
- One surrounding membrane → Gram +. (rod-shaped, purple, fat peptidoglycan layer therefore more contrast)
- Two surrounding membranes → Gram -. (pink/faint)



Ribosomes

- all cells have ribosomes (~75-100) (ancestral character/evidence for evolution)
- small machines composed of numerous proteins and several RNAs
- site of translation (protein synthesis)
- take mRNA sequence and 'translate' it to a protein sequence
- prokaryotic ribosomes are small (17-23 µm)
- eukaryotic ribosomes are larger (25-30 µm)



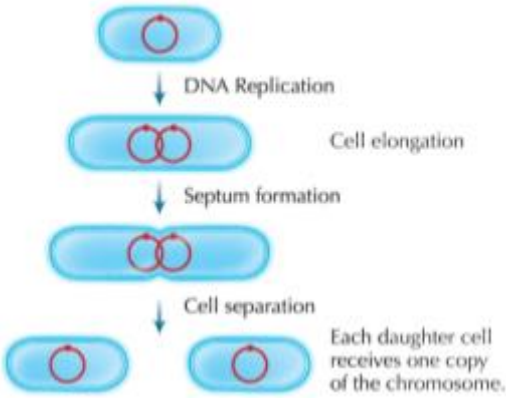
- Bacterial ribosomes are different to eukaryotic ribosomes. They are sensitive to drugs like chloramphenicol, erythromycin and tetracycline – antibiotics. Therefore they can be used to inhibit ribosomes and thus protein synthesis in a bacterium but not human beings.

Prokaryotic Flagellum

- motility appendage
- long thin filament
- corkscrew action
- one of only two rotating shaft designs in biology
- composed of flagellin protein
- extracellular – not inside the cell membrane
- 6,000 rpm but often a lot slower (~200 rpm) due to drag (of water) and energy loss

Prokaryotic Division

- Prokaryotes divide by binary fission.
- Constricting ring pinches parent cell into two…

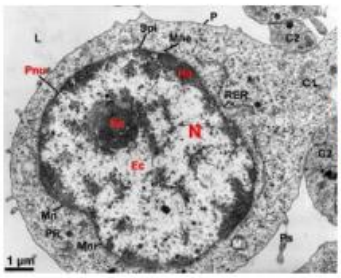


Lecture 3: Eukaryotic Cells

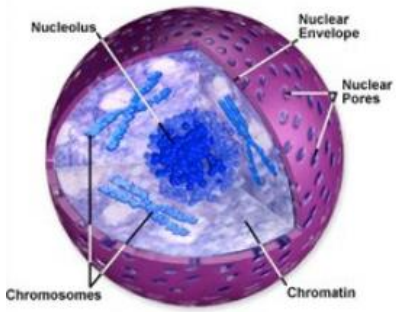
- division of labour in the cytoplasm
- nucleus and histones
- endomembrane system
- endoplasmic reticulum (reticulated network of membranes inside the cell)
- Golgi complex
- cytoskeleton
- microtubules
- microfilaments
- intermediate filaments
- motor proteins and movement

Features of the Eukaryotic Nucleus

- Surrounded by a double membrane or nuclear envelope.
- Presence of nuclear (annular) pores (75 nm in diameter).
- DNA in long, linear strands covered with histones = chromatin (not a closed, covalently bonded circle!).
- Different organisms have different numbers of chromosomes (humans = 46, Arabidopsis (cress) = 10).
- The nucleolus is a subregion of nucleus where ribosomal genes are transcribed.
- RNA transcribed from DNA leaves nucleus via pores and goes out into the cell to be translated.



N: Nucleus
Pnu: Nuclear pore
Nc: Nucleolus
Ec: Euchromatin
Hc: Heterochromatin



Pores

- Pores lined with proteins (regulate what enters and leaves the cell).
- Pore attached to lamina (nuclear skeleton).
- Pores evenly spaced over nuclear envelope.
- Traffic of proteins and RNAs out of nucleus.
- Traffic of proteins and RNAs into nucleus.
- Pore is located at site where inner membrane curls around to become outer membrane, i.e. membrane is continuous (Note: The ER is continuous with nuclear envelope.).