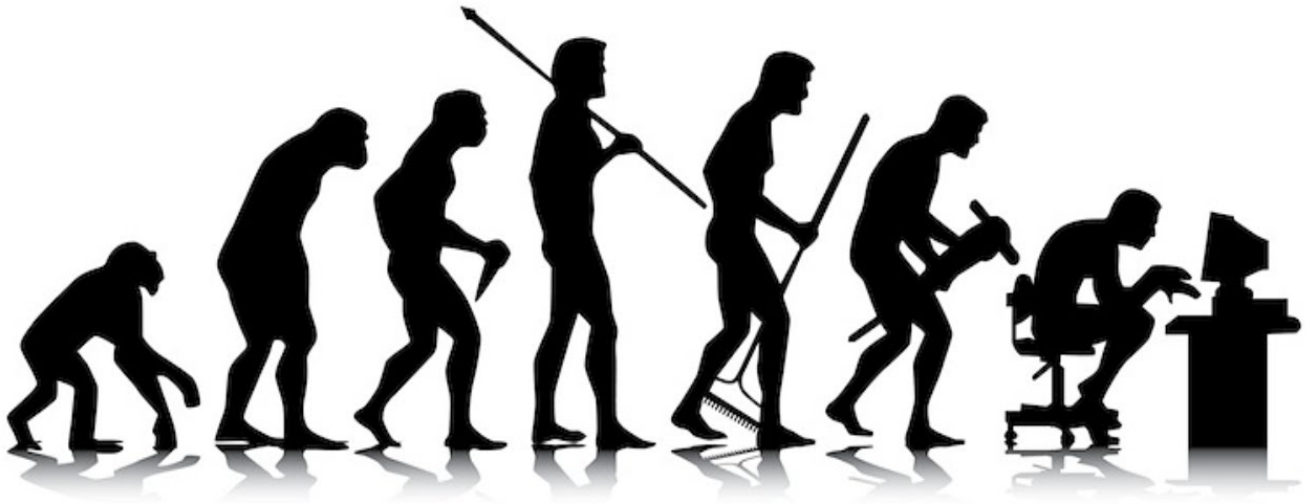
04 – EVOLUTION

4.1 Evolution of Life



Evidence of Early 'Simple' Life

4.1.2 Evidence shows that life has existed on Earth for around 3.5 billion years, during which time it has diversified.

4.1.3 Existing cells are the products of evolution.

Feature	Description
Cell membrane	All cell types have a membrane that encloses the cell. The membranes of all cells are composed of lipids.
Nucleic acids	All cell types contain the nucleic acids DNA and RNA that store and transmit genetic information.
Proteins	All cell types contain protein molecules that carry out life functions in the cell. All cell types synthesise proteins using the same 20 amino acids. Many proteins are present in all cell types from unicellular bacteria to multicellular animals and plants.
Water	All cell types are between 50 and 80% water by mass. Water has the same functions in all cell types.

Living thing	Oldest identifiable evidence (millions of years)
Prokaryotes	3 500
Eukaryotes	2 700
Marine animals	600
Land plants	500

What are some of the suggested theories about how this happened?

Spontaneous Membrane Formation

4.1.4 Membranes may have formed spontaneously and the first simple cells may have used RNA as genetic information. Ribozymes may have played a role in this development.

☑ Describe the possible roles of RNA and ribozymes in the first simple cells.

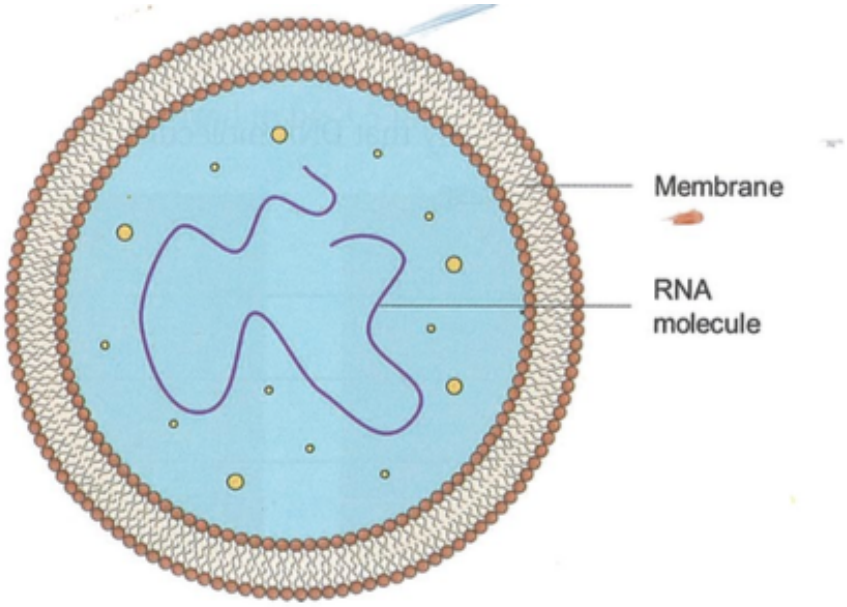
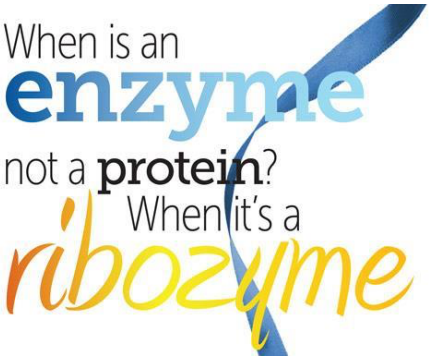


Figure 4.04: Hypothesised structure of the first simple cells.

Several assumptions were made in the development of the RNA world hypothesis.

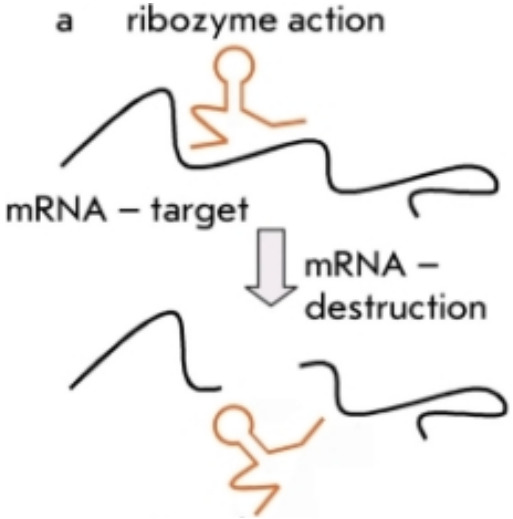
Assumption	Description
1	Genetic information was stored and transmitted by RNA rather than DNA in the first simple cells.
2	The replication of RNA in the first simple cells followed the same base pairing rules as modern cells (A with U, and C with G).
3	Metabolic reactions were catalysed by RNA molecules rather than enzymes in the first simple cells.

Ribozymes



RNA Polymerase synthesizes RNA molecules in the cell.

Some RNA molecules can be made that control key reactions in the cell - eg. rRNA



Evidence for Prokaryotic Cells First

4.1.5 There is evidence that prokaryotic cells existed before eukaryotic cells.

☑ Describe this evidence, including fossil evidence.

What suggests they were first?

Structural feature	Description
DNA	DNA in eukaryotes has higher levels of organisation than DNA in prokaryotes.
Compartmentalisation	Eukaryotic cells have membrane bound organelles in which different metabolic processes occur.
Size	Eukaryotic cells are larger than prokaryotic cells.

FOSSILS:

Prokaryotic Fossils
3.5 billion years old…
(stromatolites)

Eukaryotic Fossils
2.1 billion years old…

Biomarkers

☑ Describe this evidence, including fossil evidence.

Sterols as example of biomarker (found in 1990's in soil reported to be 2.7 byo)

Endosymbiosis

☑ Explain how the ancestry of most existing eukaryotic cells probably involved endosymbiotic events.

Symbiosis:

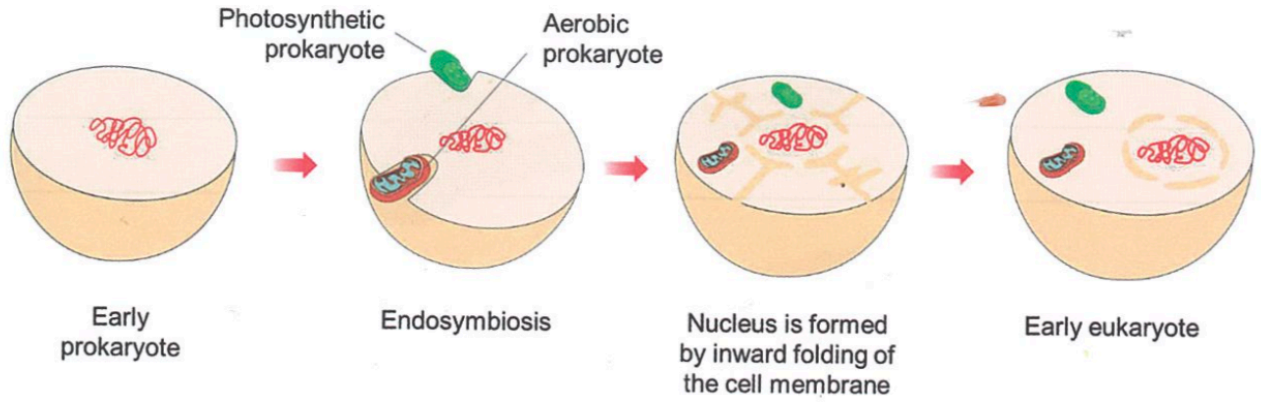


Figure 4.08: Formation of eukaryotic cell from endosymbiosis of prokaryotic cells.

Endocytosis

NOTE: infolding membranes may have formed nucleus, ER, Golgi body, etc.

Evidence for Endosymbiosis

☑ Explain how the ancestry of most existing eukaryotic cells probably involved endosymbiotic events.

Evidence	Description
Independent replication	Mitochondria and chloroplasts replicate independently of the host cell through the process of binary fission.
Double membrane	Mitochondria and chloroplasts have a double membrane which are structures present in some prokaryotes.
Ribosomes	Mitochondria and chloroplasts have their own ribosomes that translate mRNA into proteins. Ribosomes in mitochondria and chloroplasts have a similar size and structure to those in prokaryotes.
DNA	Mitochondria and chloroplasts contain single, circular DNA molecules which are also present in prokaryotes.
Membrane porins	The outer membranes of mitochondria and chloroplasts contain transport proteins called porins that are only found in prokaryotes.
Cardiolipin	The inner mitochondrial membrane contains a lipid named cardiolipin that is found in the cell membrane of prokaryotes.

Comparative Genomics

☑ Describe techniques for obtaining evidence including:

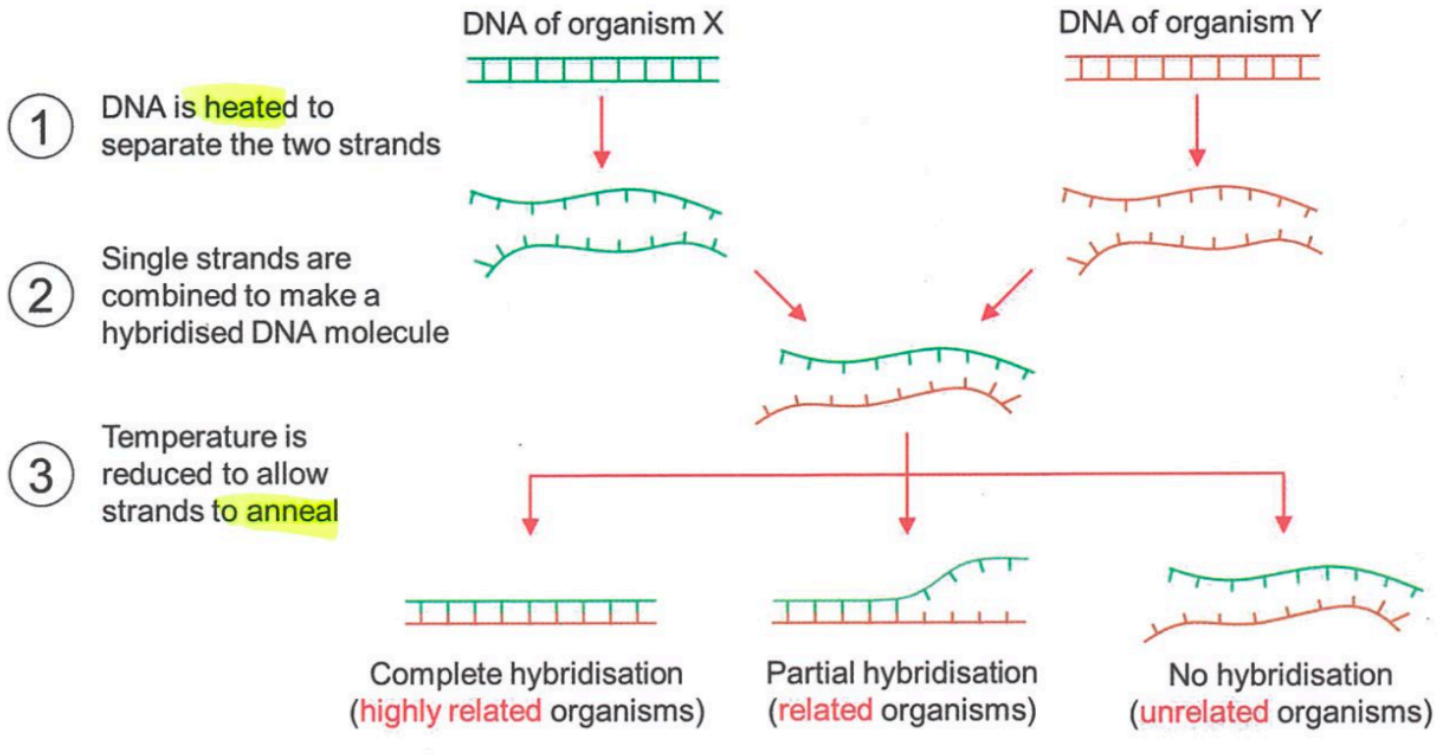
- sequencing of common proteins (e.g. cytochromes)
- DNA–DNA hybridization
- DNA sequencing.

1. **Amino Acid Sequencing** - Compare like proteins between species.

◆ More differences imply…

2. DNA-DNA Hybridization

Determine degree of hybridization by measuring temperature it takes to separate hybrid.

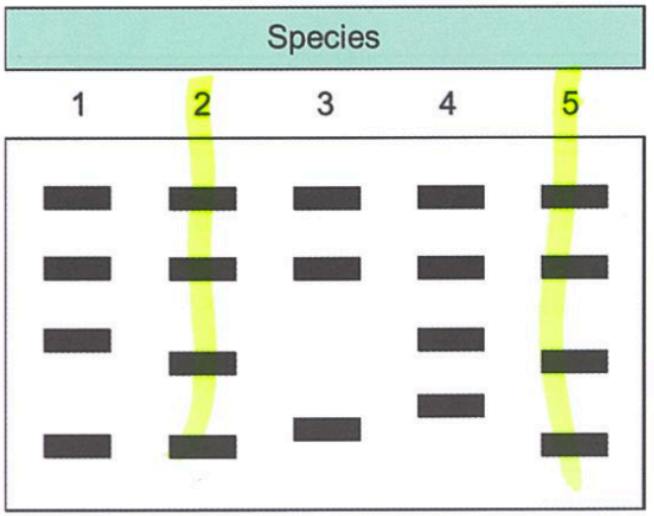


Comparative Genomics

3. DNA Profiling

- Compare similar genes between species *TARGET GENES* (eg. gene for DNA polymerase)
- Genes will be the same but will have different amount of VNTR's
- … this means they will be different lengths and will appear as different profiles in the DNA profile.

A DNA profile was produced to study the relatedness of five species of predatory cat. The DNA profile is shown below.



Species 2 and 5 are most closely related given the greater degree of similarity between the DNA fragments.

Summary

☑ Describe this evidence, including fossil evidence.

Summary:

1. **How Prokaryotic Developed into Eukaryotic**

   - **Lipid membrane spontaneous formation**
   - **Early RNA as genetic material and early catalysts (RNA World Hypothesis)**
   - **(Riboymes -)**

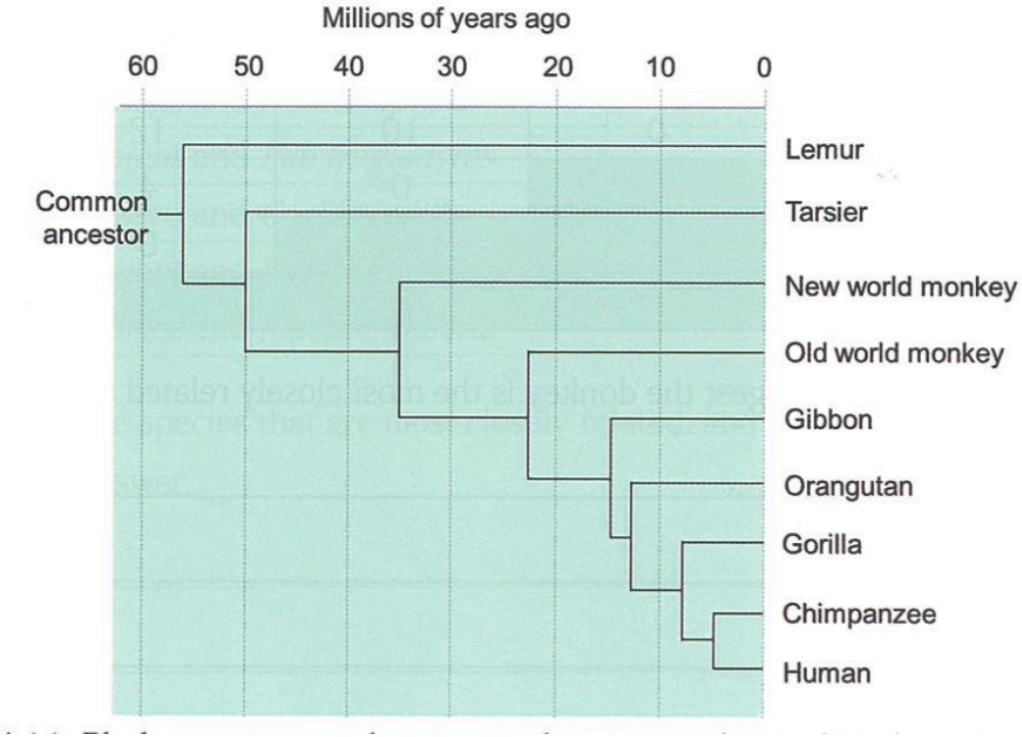
2. **Evidence of Prokaryotic Evolving into Eukaryotic**

   Increasing complexity
   DNA in all cells
   Fossils
   Biomarkers
   Endosymbiosis Events
   Comparative Genomics (amino acid sequence compare; DNA-DNA hybridization; DNA profiling)

Phylogenetic Trees

4.1.7 Phylogenetic tree diagrams represent evolutionary relationships.

☑ Draw and analyse simple phylogenetic tree diagrams to represent evolutionary relationships.



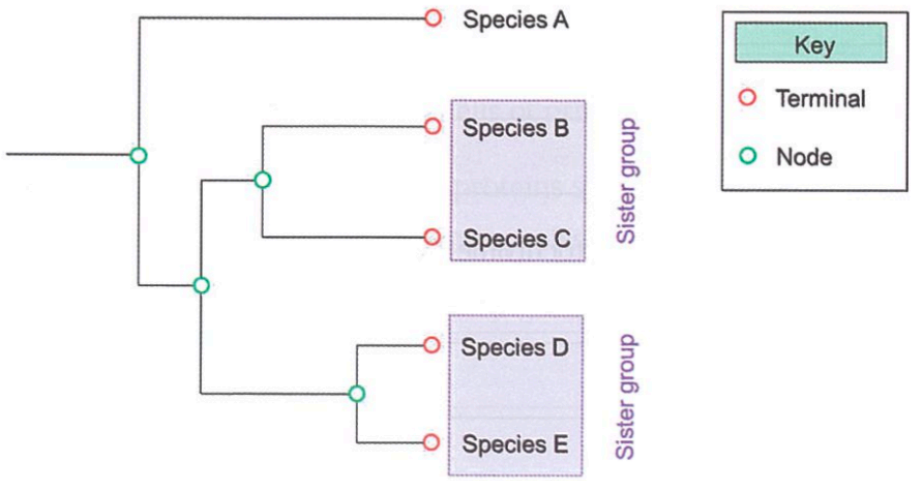


Figure 4.12: Common features of a phylogenetic tree.

Change over time and evolutionary relationships

4.1.8 Mutations accumulate over time.

4.1.9 More closely related species have fewer differences in their DNA sequences and have separated more recently than distantly related species.