

Origins of cells **HL only**

Why was there no ozone layer on early Earth?

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Why were temperatures higher on early Earth?

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Miller-Urey experiment: what was used and what formed?

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Two limitations of the Miller-Urey experiment

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Why are cells the smallest units of self-sustaining life?

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Three reasons viruses are considered non-living

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Four requirements for the evolution of the first cells

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Why are hypotheses about the origin of cells hard to test?

Higher concentrations of carbon dioxide and methane caused a strong greenhouse effect.

There was no free oxygen, and ozone forms from oxygen. So ultraviolet light reached the surface.

The early atmosphere was probably less reducing (more CO_2 and N_2), and only monomers formed, not polymers or cells.

Water vapour, methane, ammonia and hydrogen with electric sparks as lightning. After about a week, amino acids and other carbon compounds had formed.

They are not cells (no cytoplasm), have no metabolism of their own, and cannot reproduce outside a host cell.

A cell can carry out all the functions of life on its own; nothing smaller can.

Pre-biotic conditions cannot be replicated exactly, and the first protocells did not fossilise.

Catalysis, self-replication of molecules, self-assembly and compartmentalisation.

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How do fatty acids form vesicles?

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Why was a membrane-bound compartment needed?

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Why is RNA presumed to be the first genetic material?

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What is a ribozyme? Give an example.

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What is LUCA?

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Two pieces of evidence for LUCA

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Why do no other early forms of life survive?

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How does a molecular clock estimate dates?

It allows internal chemistry to become different from that outside the compartment.

In water, amphipathic fatty acids coalesce spontaneously into spherical bilayers, with hydrophobic tails inside the bilayer.

An RNA molecule with catalytic activity, such as the rRNA in ribosomes that catalyses peptide bond formation.

It can be replicated and has some catalytic activity, so it could act as both genes and enzymes.

The universal genetic code and genes shared across all organisms.

The last universal common ancestor: the most recent organism from which all living organisms are descended.

Base differences in conserved genes build up at a roughly constant rate; calibrated with dated fossils, they estimate when lineages split.

They probably evolved but became extinct due to competition from LUCA and its descendants.

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Evidence that LUCA lived near hydrothermal vents

Cell structure

Cell theory: three statements

Cell structure

How is cell theory used to make predictions?

Cell structure

Three structures common to all cells

Cell structure

Magnification formula

Cell structure

How is an eyepiece graticule calibrated?

Cell structure

Coarse or fine adjustment at high power?

Cell structure

Stains for temporary mounts

All organisms consist of one or more cells;
cells are the basic structural unit of life;
cells only arise from pre-existing cells.

Microbe-like fossils in ancient sea-floor
vent precipitates, and conserved genes for
anaerobic, hot, hydrogen-using life with
iron-sulfur proteins.

DNA as genetic material, a cytoplasm
composed mainly of water, and a plasma
membrane composed of lipids.

By deduction: a newly discovered organism
is predicted to consist of one or more cells.

Line it up against a stage micrometer for
each objective lens, then calculate the
length of one eyepiece unit.

magnification = image size $\div$ actual size, so
actual size = image size $\div$ magnification
(both in the same units).

Iodine for plant cells (starch, nuclei);
methylene blue for animal cells (nuclei).

Fine adjustment only. The coarse
adjustment is used first, at low power.

Cell structure

**Main advantage of electron
microscopes**

Cell structure

Freeze fracture

Cell structure

Cryogenic electron microscopy

Cell structure

Immunofluorescence

Cell structure

**Five components of a Gram-positive
bacterium**

Cell structure

**Two examples of Gram-positive
eubacteria**

Cell structure

Structure of the eukaryotic nucleus

Cell structure

**What makes up the eukaryotic
cytoskeleton?**

A rapidly frozen sample is split along membranes; a replica viewed by electron microscopy shows proteins spanning the bilayer.

Much higher resolution, because electrons have a shorter wavelength than light, so ultrastructure is visible.

Antibodies tagged with fluorescent markers bind specific proteins, showing where they are in the cell under a light microscope.

Rapid freezing in glass-like ice; many images combined by computer give 3D protein structures at near-atomic resolution.

Bacillus and *Staphylococcus*.

Cell wall, plasma membrane, cytoplasm, naked DNA in a loop and 70S ribosomes.

Microtubules and microfilaments.

Chromosomes of DNA bound to histones, enclosed in a double membrane with pores.

Cell structure

The eight functions of life

Cell structure

How does Paramecium carry out homeostasis?

Cell structure

How does Chlamydomonas respond to light?

Cell structure

Cell wall composition in plants and fungi

Cell structure

Vacuoles in plant and animal cells

Cell structure

Which eukaryotic cells have centrioles?

Cell structure

Atypical cells with many nuclei

Cell structure

Atypical cells with no nucleus

Contractile vacuoles collect and expel excess water that enters by osmosis.

Homeostasis, metabolism, nutrition, movement, excretion, growth, response to stimuli and reproduction.

Plants: cellulose. Fungi: chitin. Animal cells have no cell wall.

An eyespot detects light, and two flagella move the cell towards it.

Animal cells. Centrioles are absent from flowering plants and most fungi.

Plants: a large permanent central vacuole of cell sap. Animals: small, temporary vacuoles.

Mature mammalian red blood cells and phloem sieve tube elements.

Aseptate fungal hyphae (no cross walls) and skeletal muscle fibres (formed by fusion of cells).

Cell structure

How do you identify a mitochondrion in an electron micrograph?

Cell structure

Rough versus smooth ER in an electron micrograph

Cell structure

Annotation for the Golgi apparatus

Cell structure

Label versus annotation

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Endosymbiosis: which organelle came first?

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Three pieces of evidence for endosymbiosis

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Which prokaryotes became mitochondria and chloroplasts?

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Basis of cell differentiation

Rough ER: flattened sacs studded with ribosomes. Smooth ER: tubular membranes without ribosomes.

Oval, with a double membrane; the inner membrane is folded into cristae.

A label names a structure; an annotation adds a brief note, such as its function.

Processes proteins and packages them into vesicles, for example for secretion.

Mitochondria and chloroplasts have 70S ribosomes, naked circular DNA and the ability to replicate.

Mitochondria, in the ancestor of all eukaryotes; chloroplasts later, in some lineages only.

Different patterns of gene expression, often triggered by changes in the environment.

An aerobic bacterium became the mitochondrion; a cyanobacterium became the chloroplast.

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Two advantages of multicellularity

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Which groups are multicellular?

Viruses **HL only**

Five features common to all viruses

Viruses **HL only**

Structure of bacteriophage lambda

Viruses **HL only**

Structure of a coronavirus

Viruses **HL only**

Structure of HIV

Viruses **HL only**

Stages of the lytic cycle

Viruses **HL only**

What do viruses rely on host cells for?

All plants and animals, and many fungi and eukaryotic algae. Multicellularity evolved repeatedly.

Larger body size and cell specialisation.

Double-stranded DNA in an icosahedral protein head on a long tail; not enveloped; infects *E. coli*.

Small, fixed size; DNA or RNA as genetic material; a protein capsid; no cytoplasm; few or no enzymes.

Two copies of single-stranded RNA and reverse transcriptase in a cone-shaped capsid, inside an envelope with glycoproteins.

Single-stranded RNA in a helical capsid, inside an envelope of host membrane with spike glycoproteins.

Energy supply, nutrition, protein synthesis and other life functions.

Attachment, injection of DNA, replication and protein synthesis using host resources, assembly, then lysis and release.

Viruses **HL only**

What is a prophage?

Viruses **HL only**

What triggers a lambda prophage to enter the lytic cycle?

Viruses **HL only**

Why might the shared features of viruses be convergent evolution?

Viruses **HL only**

Evidence linking viruses to cellular life

Viruses **HL only**

Three reasons some viruses evolve rapidly

Viruses **HL only**

What is antigenic drift?

Viruses **HL only**

Why is HIV treated with a combination of drugs?

Stress to the host, such as DNA damage by ultraviolet light (induction).

Viral DNA integrated into the host chromosome in the lysogenic cycle, copied each time the host divides.

The genetic code is shared between viruses and living organisms.

All viruses share extreme obligate parasitism, so similar features may have evolved separately in different lineages.

Gradual mutations change influenza's H and N antigens, so existing antibodies bind less well; the vaccine is updated yearly.

High mutation rates (no proofreading), short generation times and huge numbers of virus particles.

A variant would need resistance to several drugs at once, which is very unlikely.