Cells Eukaryotes and Prokaryotes

From CellBiology

Life - Eukaryotes and Prokaryotes

Movie - Neutrophil chasing Bacterium

Introduction

This current page is the science lecture Medicine Foundations 2016 Lecture Link

This lecture introduces the cell as the unit of life. Firstly, by the methods we use to see cells and biological structures and what we consider to be "alive". Then by looking at major differences between cell types and their organisation as unicellular or multicellular organisms. Finally, the presence or absence of a nucleus which is the definition of the major 2 classes of cells.

(Greek, Karyose = kernel, as in a kernel of grain)

2017 Lecture PDF


Objectives

- Introduction to biological molecules
- Understand the dimensions cells
- Understand differences between prokaryotes and eukaryotes
- Understand differences between unicellular and multicellular organisms
- Brief understanding of viruses and prions

About Human Body

Human Cells
- 210+ cell types in body
- total number of estimated cells in the body - $10^{13}$ (American Ten trillion/British Ten billion)

**Flora**
- bacteria, fungi and archaea (http://www.ucmp.berkeley.edu/archaea/archaea.html)
  - fungi are eukaryotes (include yeasts and molds)
- found on all surfaces exposed to the environment
  - skin and eyes, in the mouth, nose, small intestine
- most bacteria live in the large intestine
- 500 to 1000 species of bacteria live in the human gut
- total number of estimated flora ten times as many bacteria $10^{14}$ (American One hundred trillion/British One hundred billion)

**Cell Sizes**
- frog or fish egg are the largest individual cells easily visible, approx 1+ mm diameter
- human or sea urchin egg, approx 100 micron (µm) diameter
- typical somatic cell, approx 20 micron diameter
- plant cells are larger, approx 30 x 20 micron
- bacteria are smaller, approx 2 x 1 micron

**Divisions of Life**

Time scale of evolution (https://www.ncbi.nlm.nih.gov/books/NBK9841/figure/A93/?report=objectonly)

**Prokaryotic**
- bacteria and archaea (single-celled microorganisms previously called archaebacteria)
  - no cell nucleus or any other organelles within their cells
  - organisms that can live in extreme habitats
    http://www.ucmp.berkeley.edu/archaea/archaea.html

**Eukaryotic**
- animals
- plants
- fungi (yeast, unicellular)
- protists (not animals, plants or fungi)


**Unicellular and Multicellular**
- Unicellular
  - All prokaryotes and some eukaryotes
    - Yeast + budding, non-budding
    - Protozoa + classified by means of locomotion: flagellates, amoeboids, sporozoans, ciliates + often "feed" on bacteria

- Multicellular
  - Eukaryotes
  - Plants and Animals
  - Allowed development of specialized cells
  - functions and tissues

**Prokaryote**

![Escherichia coli bacteria](image1)

![Micrococcus luteus bacteria](image2)

Bacteria morphology

- bacteria are smaller, approx 2 x 1 micron (1x10^-6 m)
- not all bacteria are dangerous or disease causing

(MH - the adult human in addition bacteria to the skin surface and lining of the respiratory/digestive tract, also has intestines contains trillions of bacteria made up from hundreds of species and thousands of subspecies)

- biochemically diverse
- simple structure, classified by shape (rod-shaped, spherical or spiral-shaped)
- some prokaryotic cells have also been shown to have a "cytoskeleton", which is different from eukaryotic cells.
Bacterial morphologies

Prokaryote Membrane

Common to Eukaryote

- lipid bilayer - containing protein and phospholipid (about 3:1)
- lipid rafts - stabilised membrane regions containing flotillins
  - scaffolding proteins for processes - signalling, endo- and exocytosis, transport, protein translocation and cell division

Surface Specializations

- Flagella - flagella of motile bacteria differ in structure from eukaryotic flagella.
  - A basal body anchored in the plasma membrane and cell wall gives rise to a cylindrical protein filament (3 to 12 \( \mu \)m long, 12 to 30 nm in diameter).
  - The flagellum moves by whirling about its long axis.
  - The number and arrangement of flagella on the cell are clinically diagnostically useful.
- Pili - (Fimbriae) slender, hair-like, proteinaceous appendages on the surface of many (Gram-negative) bacteria.
  - required for adhesion to host surfaces.
  - more rigid in appearance than flagella
- Capsules - lies outside the cell wall, thick (up to 10 \( \mu \)m) outer capsule of high-molecular-weight, viscous polysaccharide ge
  - others have more amorphous slime layers.
  - Capsules confer resistance to phagocytosis.

Prokaryotic Motility

Some bacteria are highly motile and there are differing mechanisms of motility.
Prokaryotes Cell Wall

- Bacterial Shape - Bacterial shapes and cell-surface structures
- Bacterial Membranes - A small section of the double membrane of an E. coli bacterium
  - Bacterial outer membranes - outer membrane contains porins
- Bacterial cell walls - Bacterial cell walls (http://water.me.vccs.edu/courses/ENV108/clipart/cellwall.gif)
  - Gram-negative bacteria surrounded by a thin cell wall beneath the outer membrane
  - Gram-positive bacteria lack outer membranes and have thick cell walls

(MH - note that some unicellular eukaryotes can also have a cell wall)


- Molecular Biology of the Cell

- Medical Microbiology
  - Figure 2-6. Comparison of the thick cell wall of Gram-positive bacteria with the comparatively thin cell wall of Gram-negative bacteria (http://www.ncbi.nlm.nih.gov:80/books/bv.fcgi?db=Books&rid=mmed.figgrp.294)

Prokaryote Genetics

- multiple copies of circular DNA within the cytoplasm
- prokaryotic genome (http://collections.plos.org/prokaryotic-genome)
- Epigetics - DNA methylation and restriction enzymes act to protect the integrity of prokaryotic genomes. PLoS (http://journals.plos.org/plosgenetics/article?id=10.1371/journal.pgen.1005854)
  - restriction enzymes target foreign DNA for cleavage
  - DNA methylation protects the host genome from destruction

Prokaryote Division
Bacterial Replication - DNA replication and cell division in a prokaryote MCB - DNA replication and cell division in a prokaryote

Prokaryote Mycoplasmas

- smallest self-replicating organisms
- smallest genomes (approx 500 to 1000 genes)
- spherical to filamentous cells
- no cell walls
- surface parasites of the human respiratory and urogenital tracts
  - *Mycoplasma pneumoniae* infect the upper and lower respiratory tract
  - *Mycoplasma genitalium* a prevalent sexually transmitted infection
  - *Mycoplasma hominis* associated with bacterial vaginosis and pelvic inflammatory disease
  - *Mycoplasma hyorhinis* found in patients with AIDS

Prokaryote "Cytoskeleton"

Mycoplasma hominis infected Hela cells
Prokaryotic and Eukaryotic Cells

The following links describe the major differences between prokaryotic and eukaryotic cells, the way they divide and the way in which antibiotics have their action on prokaryotic cells.

- **The Cell- A Molecular Approach**

- **Molecular Cell Biology**
  - Figure 12-6. DNA replication and cell division in a prokaryote (http://www.ncbi.nlm.nih.gov:80/books/bv.fcgi?db=Books&rid=mcb.figgrp.3176)

- **Biochemistry**
  - Figure 28.15. Transcription and Translation (http://www.ncbi.nlm.nih.gov:80/books/bv.fcgi?db=Books&rid=stryer.figgrp.3980) two processes are closely coupled in prokaryotes, whereas they are spatially and temporally separate in eukaryotes.

**Plant Cell**

- Plant cells are larger than mammalian cells approx 30 x 20 micron
- Additional Organelles
  - Central Vacuole
    - tonoplast maintains cell's turgor
    - storage (water, ions, and nutrients such as sucrose and amino acids, and waste products)
  - Plastids
    - organelles found in plants and algae
    - chloroplasts for photosynthesis
    - Amyloplasts for starch storage
    - Chromoplasts for pigment synthesis and storage
    - Leucoplasts - can differentiate into more specialized plastids (Amyloplasts - starch storage, Elaioplasts - storing fat, Proteinoplasts - storing and modifying protein)
    - (MH - plastids and mitochondria and have own DNA)
- **Cell Wall**
  - Rigid structure outside cell membrane
  - No ability to move
  - Resist osmotic stresses
  - Structure - cellulose, hemicellulose, pectin

- **Specialized Adhesion Junctions**
  - plasmodesmata
  - cell-cell communication pathways
  - allow cell membrane and endoplasmic reticulum of adjacent cells are continuous Plasmodesmata

**Chloroplasts**
- disk-shaped and about 5-8 µm in diameter and 2-4 µm thick. A typical plant cell has 20-40 of them.

**Animal and Plant Cell**

**Virus**

<table>
<thead>
<tr>
<th>Dengue virus</th>
<th>Herpes virus</th>
<th>Zika virus</th>
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**Plant Plastid types**

**Plant organelles**
not a cell Latin, virus = toxin or poison
not alive
infects living cells
unable to grow or reproduce outside a host cell
Infect different hosts (animal, plant and bacterial)
Classified
- RNA or DNA viruses
- double or single stranded

Viron
- contains the genetic material, DNA or RNA
- within a protective protein coat (capsid)

Bacteriophage
- A virus that infects bacteria

Molecular Cell Biology
- 6.3. Viruses: Structure, Function, and Uses
- Figure 6-22. Retroviral life cycle

NPR - Virus Infection

Prion
- not alive
- an infectious prion protein
- misfolded normal protein (three-dimensional structure)
- can form aggregates
Types
- Creutzfeldt-Jacob disease (CJD) and Kuru a human neural prion disease
- Bovine spongiform encephalopathy (BSE) in cattle, "mad cow disease"
- Scrapie in sheep

Molecular Biology of the Cell
- Figure 6-89. Protein aggregates that cause human disease
- Prions Are Infectious Proteins
- Gene Reviews Prions
- Neuroscience Prion Disease

Biological Levels
- Whole cell
- Organelles (nucleus, mitochondria, ER, Golgi)
- Components
- Biological polymers (chains of molecules, consisting of monomer subunits)
  - DNA, RNA, Protein, sugars, cellulose
- Organic molecules (monomer subunits)
  - nucleotides, amino acids, carbohydrate

**Eukaryotic Cell Organelles**

- Fundamental concept - all cells
- Specialized exceptions
- Organelle
  - specialized part of a cell that has its own particular function
- Membrane bound (enclosed)
  - forms "compartments" within the cell

**Next Lecture**

- Cell Compartments and Membranes
  - Metabolic and biochemical “specialization”
  - Localization of function
  - Import and export
  - Regulation of transport
  - Detection of signals
  - Cell-cell communication
  - Cell Identity
  - Cell membrane - plasma membrane, plasmalemma
  - Organelle membranes - basic structure similar

**References**

**Textbooks**

- Molecular Biology of the Cell
  - Some Important Discoveries in the History of Light Microscopy
db=Books&rid=cell.table.576)
  - The evolution of higher animals and plants (Figure 1-38)
db=Books&rid=cell.figgrp.83)
  - From Prokaryotes to Eucaryotes
db=Books&rid=cell.section.25#60)
  - From Single Cells to Multicellular Organisms
db=Books&rid=cell.section.61#82)
  - Some of the different types of cells present in the vertebrate body

- Molecular Cell Biology
  - The Dynamic Cell
  - The Architecture of Cells
  - Microscopy and Cell Architecture

- The Cell - A Molecular Approach
  - An Overview of Cells and Cell Research
  - Tools of Cell Biology

**Search Online Textbooks**

- "prokaryote" Molecular Biology of the Cell
db=Books&cmd=search&doptcmdl=DocSum&term=prokaryote+AND+mboc4%5Bbook%5D) | Molecular Cell Biology
**Books**

- Plant Cell Vacuoles (http://books.google.com/books?id=KIbyPQIHG50C) By Deepesh Narayan De, CSIRO (Australia)

**External Links**

- American Society Cell Biology (http://www.ascb.org/)
- Berkeley History
  - Robert Hooke (1635-1703) (http://www.ucmp.berkeley.edu/history/hooke.html)
  - Antony van Leeuwenhoek (http://www.ucmp.berkeley.edu/history/leeuwenhoek.html)
- Theodor Schwann (http://home.tiscali.net/ch/biografien/biografien/schwann.htm)
- Museum of Microscopy (http://microscopy.fsu.edu/primer/museum/)

**2017 Course Content**


**2017 Laboratories:** Introduction to Lab

2017 Project Topics - TBD.

Dr Mark Hill 2015, UNSW Cell Biology - UNSW CRICOS Provider Code No. 00098G


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