Cytology

Doctor 2019 | Medicine | JU

◉ Sheet ○ Slides

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1.4: types of prokaryotic cells (0:00 → 9:00)

The distinction between prokaryotic and eukaryotic cells is based on structural complexity and not on phylogenetic relationship .

Prokaryotes are divided into two major taxonomic groups, or domains: the Archaea (or archaebacteria) and the Bacteria (or eubacteria)

1. Domain archaea: organisms that live under extremely inhospitable environment (extremophiles)

** Members of the Archaea are more closely related to eukaryotes than they are to the other group of prokaryotes (the Bacteria).

** They include several groups of organisms whose evolutionary ties to one another are revealed by similarities in the nucleotide sequences of their nucleic acids.

a. methanogens: convert CO_2 and H_2 into methane CH_4.

b. halophiles: live in extremely salty environments, like Dead Sea or deep sea brine pools with salinity about 5M $MgCl_2$.

c. acidophiles: acid-loving prokaryotes that thrive at a pH as low as 0.

d. thermophiles: live at very high temperature

e. hyperthermophiles: live in the hydrothermal vents of the ocean floor. "Strain 121" is able to grow and divide in 121°C, the temperature used to sterilize surgical instruments in an autoclave.

2. Domain bacteria: found in different habitats, even in rock layers kilometers beneath the earth's surface.

- **mycoplasma**(0.2 µm diameter): the only bacteria without cell wall and it contains a genome with less than 500 genes.

- **cyanobacteria** (The most complex prokaryotes) : They contain elaborate cytoplasmic membrane arrays, which are sites of photosynthesis; very similar to chloroplast photosynthetic membranes in plant cells.

& As in plants, cyanobacteria photosynthesis is done By splitting H_2O molecules; releasing molecular oxygen (O_2) .

& Many cyanobacteria also do **N_2 fixation** - convert N_2 gas into reduced nitrogen forms (e.g., NH_3) that are used to make nitrogen-containing organic compounds like amino acids and nucleotides.

& species capable of both photosynthesis & nitrogen fixation can survive on the barest of resources (light, N_2, CO_2, H_2O)

& cyanobacteria are the first to colonize bare rocks left lifeless by a scorching volcanic eruption

& They also live inside the hairs of polar bears; responsible for the unusual greenish color of their coat

Prokaryotic diversity:

^ Roughly 6000 species of prokaryotes have been identified, which is less than one-tenth of 1 percent of the millions of prokaryotic species thought to exist on Earth.

^ Even though all organisms may share some genes (like genes for rRNAs or the enzymes of certain metabolic pathway), the sequences of the nucleotides that make up the genes vary considerably from one species to another. This is the basis of biological evolution.

** microbiologists are familiar only with the microorganisms they can grow in a culture medium

- When patient suffers from respiratory or urinary tract infection & sees doctor, one of first steps taken is to culture the pathogen

- Once cultured, it can be identified & the proper treatment prescribed

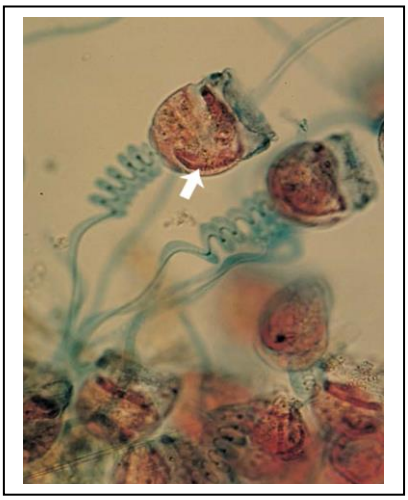
~ To study prokaryote diversity , cells are concentrated from ocean water, their DNA extracted & DNA sequences analyzed

Recent sequencing techniques have gotten so rapid and cost-efficient that virtually all of the genes present in the microbes of a given habitat can be sequenced, generating a collective genome from a specific habitat, or metagenome.
- This approach can provide information about the types of proteins these organisms manufacture & thus about many of the metabolic activities in which they engage

Microbiome: the collection of microbes that live on or within our bodies, in habitats such as the intestinal tract, mouth, and skin. This helps in identifying the organisms in people of different age, diet, geography and state of health. Among the functions of proteins encoded by these microbial genomes are the synthesis of vitamins, the breakdown of complex plant sugars, and the prevention of growth of pathogenic organisms.

1.5 Types of eukaryotic cells (9:00 → 18:00)

* Eukaryotes are either unicellular or multicellular organisms.



Vorticella, a complex of ciliated protist. Each cell has a macronucleus (arrow), which contains many copies of the genes.

Unicellular organisms: many protists are unicellular such as amiba, yeast… it is only one cell, which is capable of sensing the environment, engulfing organic food, movement…

Most unicellular organisms are diploid (2 sets of chromosomes)
(2n)

** alga is an autotrophic multicellular protist.

Cell differentiation:

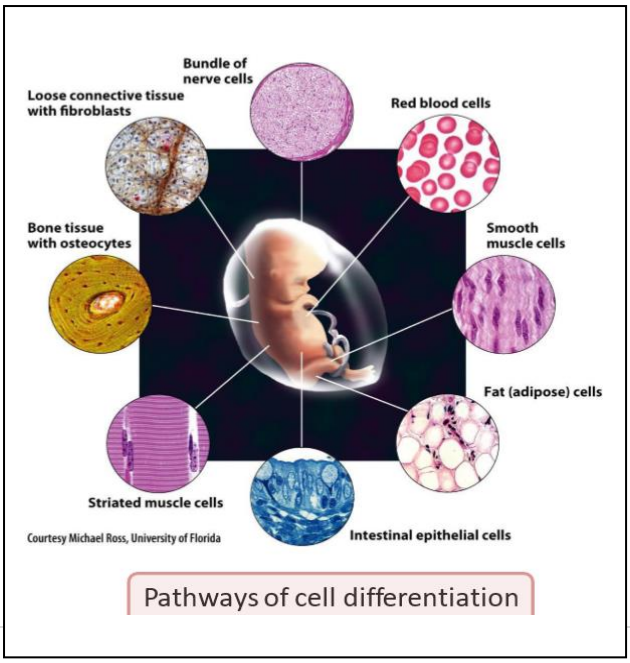
An embryo starts from a zygote, which divides into various cells, approximately 250 types of cells. This is because of the different activation of genes, so cells have different proteins and functions depending primarily on the signals it receives from the surrounding environment; these signals in turn depend on the position of that cell within the embryo.

** All cells have the same organelles; the difference is the number, appearance and location of organelles. E.g. the number of mitochondria is larger in muscle cells more than other cells.

** the structure of each cell suits its function:

a. Skeletal muscle cells contain a network of precisely aligned filaments composed of unique contractile proteins.

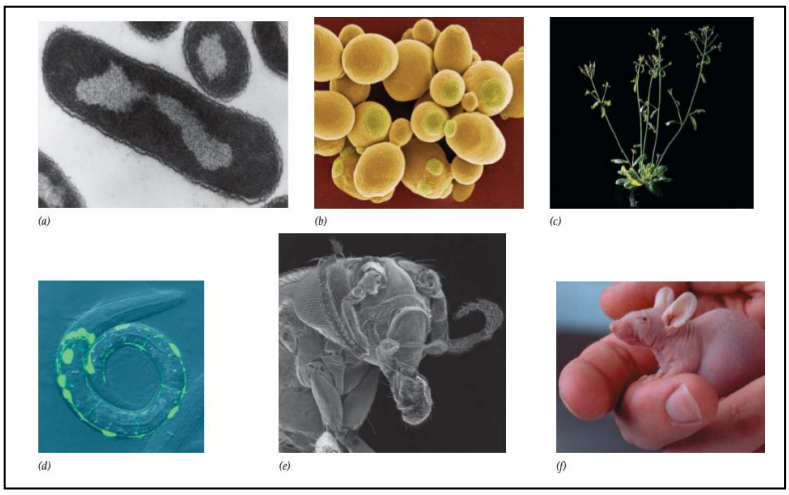
b. Cartilage cells become surrounded by a characteristic matrix containing polysaccharides and the protein collagen, which together provide mechanical support.



Pathways of cell differentiation

c. Red blood cells become disk-shaped sacks filled with a single protein, hemoglobin, which transports oxygen.

Model Organisms: (18:00 → 25:00)



Biologists focus on some representative model, called model organisms. Knowledge built on these studies will provide a framework to understand those basic processes that are shared by most organisms, especially humans. Each of these organisms has specific advantages that make it particularly useful. Here are six models, one prokaryote and six prokaryotes.

a) E. Coli : a prokaryote lives in the digestive tract of human and other mammals. It is simple, it has one circular DNA, and its lifetime about half an hour. The mechanisms of replication, transcription, and translation, were originally worked out on this one prokaryotic organism.

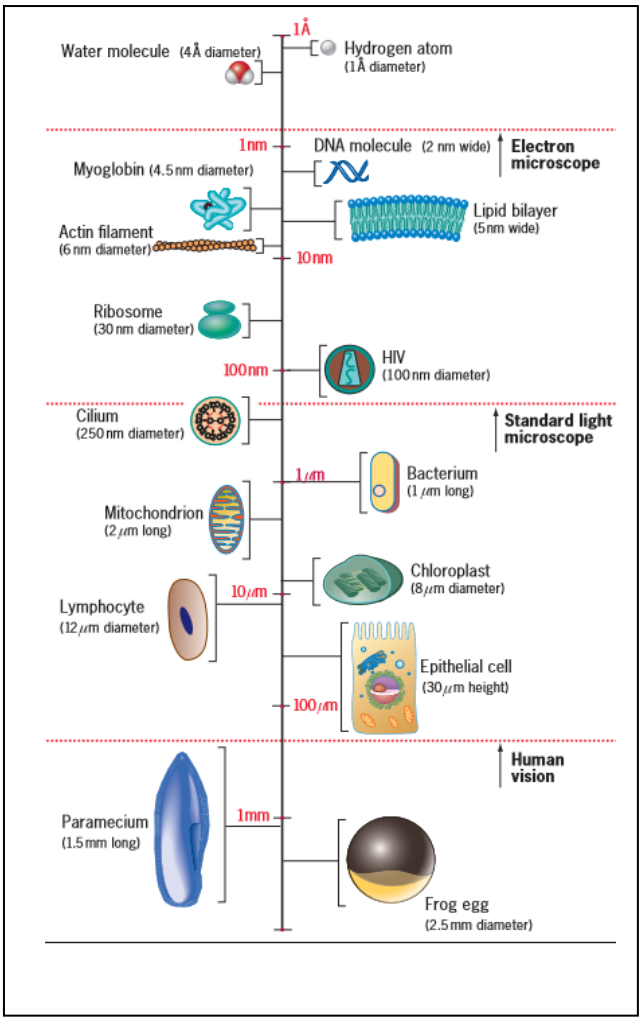
b) Saccharomyces cerevisiae: baking yeast(protist), the least complex of eukaryotes studied, it contains proteins that are homologous to human proteins, a small genome, easy to culture, it can live in aerobic or anaerobic condition. It is deal for identification of genes through the use of mutants.

c) Arabidopsis thaliana: weed related to the mustard and cabbage, small genome (120 million base pairs) for a flowering plant, a rapid generation time, large seed production, height of few inches.

d) Caenorhabditis elegan: microscope sized nematode, about 1000 cells, it has a transparent body wall, a short generation time, easily cultured, a facility for genetic analysis.

e) Drosophila melanogaster(fruit fly): small complex eukaryote, readily cultured in lab, short lifetime; few days, it is a favored animal for the study of genetics.

f) Mus musculus: the common house mouse, easily kept and bred in laboratory. The "nude mouse" pictured here develops without a thymus gland and, therefore, is able to accept human tissue grafts that are not rejected.



1.6 The size of cells and their components: (25:00 →34:00)

Micrometer (µm) = 10^{-6} meter, Nanometer (nm) = 10^{-9} meter, Angstrom (Å) = 10^{-10} meter

*one angstrom = the diameter of a hydrogen atom

Why are cells small?

a) Because DNA genes serve as a templates of RNAs, a cell can only produce a limited number of RNAs in a given amount of time. The greater the cytoplasmic volume, the longer it will take to synthesize the number of messages required by that cell.

b) As a cell increases in size, the surface area/volume ratio decreases. The ability of a cell to exchange substances with its environment is proportional to its surface area. Cells that are specialized for absorption of solutes, typically possess microvilli, which greatly increase the surface area available for exchange.

c) The time required for diffusion is proportional to the square of the distance to be traversed. As a cell becomes larger and the distance from the surface to the interior becomes greater, the time required for diffusion becomes longer.

فكلما عظمت الأهداف طال الطريق.

Plasma membrane(34:00 → 53:00)

(most of this topic was discussed in lecture 4, and in order to avoid overlapping and misunderstanding it will be in sheet 4, except the beginning which is about nerve gas)

NERVE GAS:

Sarin is a type of nerve gas—a chemical weapon. It works by poisoning an enzyme that degrades chemical signals used by nerves to activate muscle cells. – the doctor mentioned in the lecture☺

THE END