CHAPTER 5: CELL STRUCTURE AND FUNCTION
RECAP: LEVELS OF ORGANIZATION

• Used to categorize living things
• Cell is the smallest “living” classification
  • Lesser categorizations: biomolecules, atoms, organelles, etc…cannot live independently → not alive
• Categories not black/white
  • E.g. amoeba is both a cell and an organism
RECAP: LEVELS OF ORGANIZATION

• Biotic factor: living things
  • E.g. deer, bacteria, algae
• Abiotic factor: non-living things
  • E.g. rocks, air, water
  • E.g. measurable characteristics (temperature, salinity, tide, currents)
• Community: biotic only
• Ecosystem: biotic & abiotic
DISCUSSION:

WHY CLASSIFY USING LEVELS OF ORGANIZATION?
1) Classify Biologists, Research

<table>
<thead>
<tr>
<th>Biologist/Field of Study</th>
<th>Level(s) of Organization</th>
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<tbody>
<tr>
<td>Cell Biology</td>
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<td>Marine Biologist</td>
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<tr>
<td>Histology (the study of tissues)</td>
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<tr>
<td>Biomechanics (the study of mechanics of living things)</td>
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<tr>
<td>Evolutionary Biology</td>
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<tr>
<td>Genetics</td>
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https://www.nature.com/
2) **EMERGENT PROPERTIES**

Google “biology wise emergent properties)

https://biologywise.com/emergent-properties-explained-in-context-to-biology

Answer the following questions:

- What is an emergent property?
- What is a non-biological example of an emergent property?
- Summarize emergence at the cellular, organ, and population/community levels.
2) Emergent Properties

What is an emergent property?

• Properties emerging in a complex system that are different from those of the components that make up the system
• “The whole is greater than the sum of its parts.”

What is a non-biological example of an emergent property?

• A chemical compound (NaCl) is solid at room temperature, but Cl is gaseous.

https://biologywise.com/emergent-properties-explained-in-context-to-biology
2) EMERGENT PROPERTIES

Summarize emergence at the cellular, organ, and population/community levels.

- Cell is composed of biomolecules and organelles that work together.
- Organs are made of many cells which work together to achieve the function of the whole organ (e.g. pumping blood or making decisions), which is unachievable with single cells.
- Populations (e.g. of bees, humans) can divide labour to increase societal efficiency. Think of factories where each machine is specialized to do exactly one thing.

https://biologywise.com/emergent-properties-explained-in-context-to-biology
2) Emergent Properties

Example: cells in the retina working together to transmit complex information to the brain

https://biologywise.com/emergent-properties-explained-in-context-to-biology
5.1: CELL THEORY
Before Cell Theory (1600s)

“Spontaneous generation”: all life arose abruptly from inanimate matter

- Based on observations:
  - Maggots on rotting food
  - Mold on bread
  - Mushrooms from dead trees

Pioneers in Microscopy

Anton van Leeuwenhoek

- Invented the microscope
- Discovered microorganisms, which he called “animalcules” in pond water
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- Invented the microscope
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Robert Hooke
- Discovered cells in plant cork
Cell Theory

Three main components:
• All living things are composed of cells
• Cells are the basic units of structure and function in living things
• All cells come from pre-existing cells

Modern cell theory (not testable):
• https://sciencing.com/modern-cell-theory-5492537.html
Modern Cell Theory (not testable)

- The cell represents the elementary unit of construction and function in living organisms.
- All cells come from the division of pre-existing cells.
- Energy flow – metabolism and biochemistry – happens within cells.
- Cells contain genetic information in the form of DNA passed on from cell to cell during division.
- In the organisms of similar species, all cells are fundamentally the same.
- All living organisms consist of one or more cells.
- Some cells – unicellular organisms – consist of only one cell.
- Other living entities are multicellular, containing multiple cells.
- The living organism's activities depend upon the combined actions of individual, independent cells.

5.2: CELL STRUCTURE
• Cells vary in size, shape, structure, function

• Some characteristics common to all cells:
  • Cell membrane
  • Genetic Material
  • Nucleus
    • Eukaryotes only
  • Cytoplasm
Every cell has a cell membrane that separates it from its surroundings:
- Tightly controls what enters and leaves the cell (food, wastes, signals)
- Provides protection, support

Composed of several kinds of molecules (don’t memorize):
- Lipids (bilayer)
- Proteins
- Carbohydrates
**Cell Wall**

- Only found in plants, algae, some bacteria
- Surrounds cell membrane
  - Provides protection, support
  - Porous: allows water, oxygen, carbon dioxide, etc. to pass through
- Made of **cellulose** (stringy stuff in celery)
Nucleus

• A large dark structure found in many cells
• Contains DNA ‘instructions’ for protein synthesis
• Information center of the cell
• Found in eukaryotes only (stay tuned!)
PARTS OF A NUCLEUS

Nuclear envelope
- Surrounds nucleus
- Has many nuclear pores that allow substances to flow in and out of the nucleus

Nucleolus
- Made of RNA and proteins
- Is where ribosomes are made
- Helps in protein production
Parts of a Nucleus

Chromosomes (testable)

- DNA in the nucleus of eukaryotic cells is found in large structures called chromosomes
- Contains genetic information that must be copied to make:
  - Next generation of cells
  - Proteins
- Does not leave the nucleus
Chromosomes (not testable)

- Humans have 23 pairs (46) chromosomes
- Some birth defects (e.g. Down syndrome) involve changes in the number or structure of chromosomes

https://www.frontiersin.org/articles/10.3389/fgene.2015.00022/full
Parts of a Nucleus

Trimastix pyriformis
(Klebs) Bernard et al.

nucleus

nucleolus

endoplasmic reticulum

0.5 micrometres
cytoplasm

• The cytoplasm is the area between the nucleus and the cell membrane
• Helps cell maintain its shape (70% of cell volume)
• Made of water, dissolved molecules, and organelles
5.3: CYTOPLASMIC ORGANELLES
• **Organelles** are the structures inside the cytoplasm.
• Each organelle performs a specialized function in the cell
  • Can be thought of as the cell’s “organs”
Vacuoles store materials such as water, salts, proteins, carbohydrates.

Plastids are plant organelles of various forms and functions:

- Store food and pigments
- Examples:
  - Chloroplast: photosynthesis
  - Leukoplasts: store starch
  - Chromoplasts: store pigments
Mitochondria and Chloroplasts

- Power houses of the cell
- Generate energy for cell to use, by converting it from one form to another
- **Mitochondria** (sing. mitochondrion)
  - Present in all eukaryotes
- **Chloroplasts:**
  - Present in plants/algae only

Stay tuned!
me: what are taxes and how do I pay them?
school system: worry not
school system: mitochondria is the powerhouse of the cell
MITOCHONDRIA AND CHLOROPLASTS

Q: Which of these two cells uses more energy? Speculate about the function of each cell.
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Ribosomes are the ‘factories’ where proteins are made

- Made of RNA and protein
- Among the tiniest organelles!
- Some attached to membranes, others free-floating
RIBOSOMES PERFORM PROTEIN SYNTHESIS

bound ribosomes
composed of rRNA and proteins

free-ribosomes
ENDOPLASMIC RETICULUM (ER)

• Complex network of sacs
• Transports materials through the inside of the cell
• Two types:
  • Smooth:
    • No ribosomes attached
    • Manufactures & transports fats
  • Rough:
    • Has ribosomes attached
    • Manufactures & transports proteins
Q: One of the two types (smooth, rough) of ER is usually found right next to the nucleus. Which type is that? Justify your answer.
Golgi Apparatus (Golgi Body)

- Modifies and repackages proteins for transport elsewhere (inside or outside cell)
- Flattened stack of membranes
GOLGI APPARATUS (GOLGI BODY)
LYSOSOME: CLEANUP CREWS

- Contains chemicals and enzymes necessary for digestion
- Digests/breaks down foreign materials
- Recycles used/dying organelles
- Absent in plants
CYTOSKELETON: FRAMEWORK

• Framework of filaments and fibers
• Supports cell structure, drives cell movement
• Examples:
  • Cilia, flagella
  • Cilia video
HOW TO EXPLAIN YOUR ANSWERS
# How to Explain Your Answers

**Steps**

**Step 1: Answer the question**

**Step 2: Explain the connection between:**
- Answer
- Course Content
- Question

**Step 3: Concluding statement**
- Links answer to question if not already clear
5. The mouth is the first site of chemical digestion in a human. Your saliva starts the process of breaking down the food you eat. Keeping this in mind, what organelle do you think would be numerous inside the cells of your mouth?
<table>
<thead>
<tr>
<th>Steps</th>
<th>Cheek Cell #1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1: Answer the question</td>
<td>The lysosome.</td>
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<tr>
<td>Step 2: Explain the connection between:</td>
<td></td>
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<tr>
<td>- Answer</td>
<td></td>
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<tr>
<td>- Course Content</td>
<td></td>
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<tr>
<td>- Question</td>
<td></td>
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<tr>
<td>Step 3: Concluding statement</td>
<td></td>
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<tr>
<td>Steps</td>
<td>Cheek Cell #2</td>
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<tr>
<td>--------------------------------------------</td>
<td>--------------------------------------</td>
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<tr>
<td>Step 1: Answer the question</td>
<td>The mitochondria.</td>
</tr>
<tr>
<td>Step 2: Explain the connection between:</td>
<td></td>
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<tr>
<td>- Answer</td>
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<td>Step 3: Concluding statement</td>
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MITOCHONDRIA AND CHLOROPLASTS

Q: Which of these two cells uses more energy?
1. Suppose you were to compare skin cells of an individual with oily skin and one with dry skin. Which organelle(s) might be more numerous in one sample than the other? Be specific and explain.

2. Cells of the pancreas are involved in synthesizing and releasing large quantities of digestive enzymes. Which two organelles would pancreatic cells have a large quantity of? (Hint: NOT lysosome)

3. Heart muscle cells can have up to 5000 mitochondria each. Explain why this is necessary.
ORGANELLE DISORDERS

Not directly testable
• Disorder in calcium and chlorine ion channels in the cell membrane

• Balance of salts disrupted → abnormal amounts of salts and fluid in affected organs

Cystic Fibrosis

- salty-tasting skin
- chronic respiratory problems
- lung infections
- poor growth/weight loss
- meconium ileus

https://ed.fnal.gov/arise/guides/bio/3-Cells/3a-CellsOrganelleAssignmentII.pdf
Pompe Disease

- Lysosomes unable to break down glycogen into simple sugars (e.g. glucose)
- Build-up of glycogen in lysosomes
- Cell cannot get energy from glucose efficiently
- Progressive muscle weakness
Leigh Syndrome

• An enzyme used in mitochondria is defective
• Mitochondria cannot produce ATP energy effectively
• Symptoms in the central nervous system
  • Loss of mental and movement abilities
Mitochondrial Diseases

- Skeletal muscle
  - Weakness
  - Fatigue
  - Myopathy
  - Neuropathy

- Brain
  - Seizures
  - Myoclonus
  - Ataxia
  - Stroke
  - Dementia
  - Migraine

- Heart
  - Conduction disorder
  - Wolff–Parkinson–White syndrome
  - Cardiomyopathy

- Eye
  - Optic neuropathy
  - Ophthalmoplegia
  - Retinopathy

- Liver
  - Hepatopathy

- Kidney
  - Fanconi's syndrome
  - Glomerulopathy

- Pancreas
  - Diabetes mellitus

- Blood
  - Pearson's syndrome

- Colon
  - Pseudo-obstruction

- Inner ear
  - Sensorineural hearing loss

- ATP

- Nuclear DNA

- Mitochondrial DNA

- Oxidative phosphorylation
For the following: identify the organelle or structure involved that is malfunctioning. Indicate whether the organelle/structure is underactive or overactive. Explain your reasoning.

4. A girl accidentally consumes cyanide and dies almost immediately because the conversion of glucose energy to ATP in her cells stops.
5. Charles is diagnosed with neonatal adrenoleukodystrophy (NALD), which is characterized by an inability of his body to break down long-chain fatty acids.
6. A smoker develops lung cancer and is told that the cause of the problem is a population of cells in her lungs that are undergoing mitosis (cell division) at a much greater rate than is normal for lung cells.
7. A couple learns that they will be unable to conceive a child naturally because the man’s sperm are nonmotile.
8. A young child is placed on a milk-free diet because the mucosal cells that line his small intestine do not secrete the enzyme necessary to break down lactose, the disaccharide present in milk.
HODGEPodge Day

Eukaryotes vs Prokaryotes, Cell Specialization
Chapter Test: November 5
(Levels of organization, cell theory, cell structure and function,
LEARNING OBJECTIVES

Prokaryotes vs Eukaryotes
• Compare and contrast prokaryotes and eukaryotes.
• Give examples of prokaryotes and eukaryotes.
• Describe endosymbiotic theory, and link it to the differences in membrane-bound organelles between prokaryotes and eukaryotes.

Cell Specialization
• Give two examples of specialized cells. Explain how their structure/anatomy allows for their functions.
Looking Ahead (Approximate Timeline)

Oct 30/31: Eukaryote v prokaryote, cell specialization
Nov 1/5: Review period
Nov 6/7: Chapter 5 Test (Levels of organization, cell theory, cell structure and function, eukaryote v prokaryote, cell specialization)
Nov 8-20: Mitosis/Meiosis, Reproduction
Nov 26-Dec 5: Photosynthesis/Cellular Respiration
Dec. 6-21: Viruses
PROKARYOTES

• Simple
• Unicellular organisms
• Cells are small (0.1 - 5.0 µm)
**Prokaryotes**

- Simple
- Unicellular organisms
- Cells are small (0.1 - 5.0 \(\mu\)m)

**Examples:**
  - Bacteria
    - *Escherichia coli*
    - *Streptococcus* sp.
  - Archaea
PREVIEW (NOT TESTABLE... YET)
EUKARYOTES

• Complex
• Mostly **multicellular** organisms
• Cells are larger (10 – 100 µm)
• Examples:
  • Potato
  • Yeast
  • *Paramecium spp.*
PROKARYOTES VS EUKARYOTES

All cells have:
• Cell membrane
• Cytoplasm
• Ribosomes
• DNA

*slight revision from previous slides
Only eukaryotes have **membrane-bound organelles:**

- Nucleus*
- ER
- Golgi body
- Lysosome
- Mitochondria, (Chloroplasts)
**EUKARYOTE**

- Etymology (Greek):
  - “Eu-” = well, good
  - “Karyon” = kernel (nucleus)
- Has a nucleus
  - More than one chromosome (linear DNA)

**PROKARYOTE**

- Etymology (Greek)
  - “Pro-” = before
  - “Karyon” = kernel (nucleus)
- No nucleus
  - Has nucleoid instead
  - One “chromosome” (circular DNA)
PROKARYOTES

• Additional protection/support:
  • All have cell wall
  • Many have capsules
Paramecium Parlor

And here’s where I’d put my nucleus!

IF I HAD ONE!

The simple lifestyle of the prokaryote did not suit Melvin.
Prokaryote vs. Eukaryote

Prokaryote

Eukaryote

Amoeba Sisters

#AmoebaGIFs
FURTHER READING

• https://courses.lumenlearning.com/biology1/chapter/comparing-prokaryotic-and-eukaryotic-cells/


• https://www.diffen.com/difference/Eukaryotic_Cell_vs_Prokaryotic_Cell