STUDY GUIDE - *Ch. 6.1 - Biologists use Microscopes & Biochemistry to Study Cells* **NAME:** _____

- **PHYSICALLY PRINT OUT this PDF and HANDWRITE (with a black or blue pen) your answers directly on this PDF.** *Typed or digitally-written work is **not** accepted. Do **not** answer questions on separate paper.*
- **Importantly, study guides are NOT GROUP PROJECTS!!!** *You, and you alone, are to answer the questions as you **read** your assigned textbook. You are **not** to share answers with other students. You are **not** to copy any answers from any other source, including the internet.*
- **Get in the habit of writing LEGIBLY, neatly, and in a medium-sized font.** *AP essay readers and I will skip grading anything that cannot be easily read so start perfecting your handwriting, and don't write so large you can't add all the relevant details and key elaborations in the space provided.*
- **SCAN physical documents in color and with good resolution. Then, upload your final work as PDFs to Archie.** *Avoid uploading dark, shaded, washed-out, sideways, or upside-down scans of homework. Keep completed physical study guides organized in your biology binder to use as future study and review tools.*
- **READ FOR UNDERSTANDING and not merely to complete an assignment.** ***First**, read a section quickly to get an overview of the topic covered. Then, read it a **second** time slowly, paraphrasing each paragraph **out loud** and analyzing every figure. Finally, read it a **third** time as you answer the study guide questions if assigned and start building your memory. Try to write answers out in your own words, when possible, and try to purposefully and accurately use all new terminology introduced.*

1. Today, the three tenets to **Modern Cell Theory** are as follows...

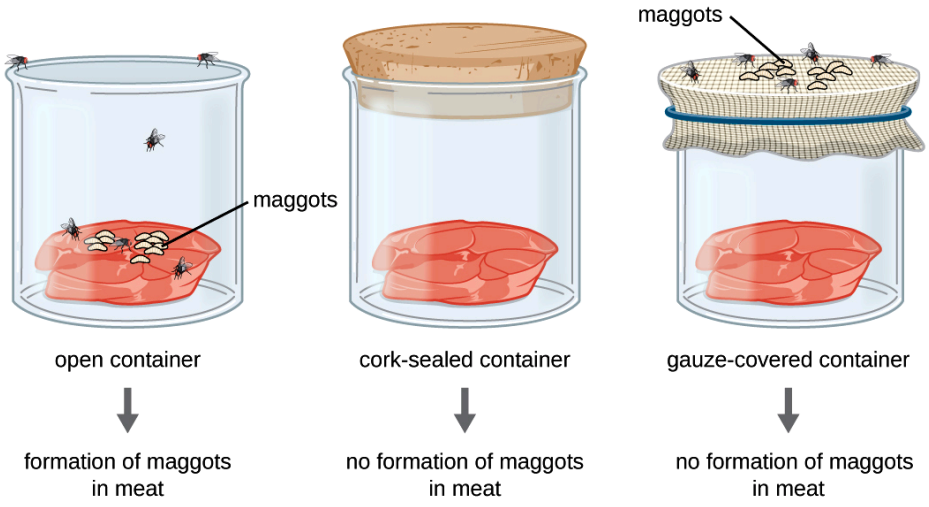
   I. All living organisms are composed of one or more cells.
   II. The cell is the basic unit of structure and organization in organisms.
   III. Cells arise from pre-existing cells.

   Cells are the fundamental to life. Before we go into the modern study of cells, let's take a look at some key related milestones in history. *(Source: Biology Libretext).*

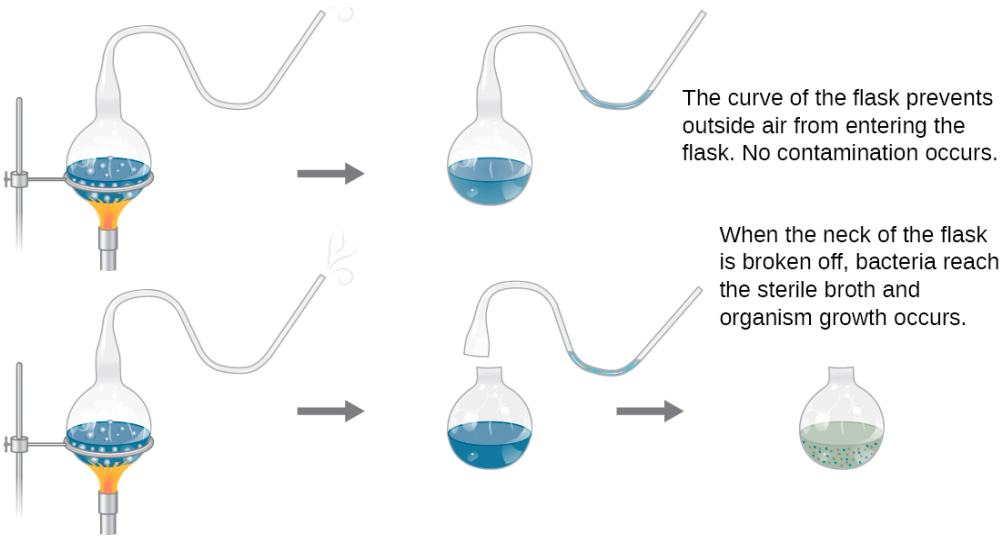
   - Prior to the discovery of microbes during the 17th century, other theories circulated about the origins of disease. **Ancient Greeks** proposed the **miasma theory**, which held that human disease (like the Black Death) originated from particles emanating from decomposing matter, such as that in sewage or cesspits. Greek philosopher **Aristotle** (384–322 BC) supported the theory of **spontaneous generation**, the notion that life can arise from nonliving matter.

   - In 1546, Italian physician **Girolamo Fracastoro** proposed that seed-like spores may transfer between individuals via direct contact, exposure to contaminated clothing, or the air. He was an early proponent of what would become the **germ theory of disease**, the idea that diseases may result from microbial infection (**Microbes** are organisms that are too small for humans to see without a microscope. They include organisms like bacteria, archaea, and single-celled eukaryotes such as certain amoeba or paramecia).

   - Italian physician **Francesco Redi** performed an experiment in 1668 that **refuted the idea of spontaneous generation**. He predicted that preventing flies from having direct contact with meat would prevent the appearance of maggots. Redi left meat in each of 6 containers, 2 exposed to open air, 2 covered in gauze, and 2 that were sealed. Maggots developed in the uncovered jars while no maggots appeared in either the gauze-covered or the tightly sealed jars. He concluded that maggots could only form when flies were allowed to lay eggs in the meat and that the maggots were the offspring of flies, **not** the product of spontaneous generation!



- In 1665, English scientist **Robert Hooke** first used the term "cells" to describe the small chambers within cork that he observed under a microscope. Their significance as the fundamental unit of life was not yet recognized.
- In 1674, Dutch businessman and scientist **Antonie P. van Leeuwenhoek,** the "Father of Microbiology," was the first to observe living unicellular organisms like bacteria, among others, which he termed "animalcules."
- In 1838, **Matthias Schleiden** (1804–1881), a German botanist, observing plant tissues, described them as being composed of cells. **Theodor Schwann** (1810–1882), a noted German physiologist, made similar microscopic observations of animal tissue.
- In 1852, **Robert Remak** (1815–1865), a prominent neurologist and embryologist, published convincing evidence that **cells are derived from other cells as a result of cell division.**
- In 1847, Hungarian obstetrician **Ignaz Semmelweis** observed that mothers who gave birth in hospital wards staffed by physicians and medical students were more likely to suffer and die from puerperal fever (10%–20% mortality rate) than mothers in wards staffed by midwives (1% mortality rate). He observed medical students performing autopsies and then subsequently carrying out vaginal examinations on living patients without washing their hands in between. He suspected that the students carried the causative agent of disease from the autopsies to the patients. He suggested physicians and medical students wash their hands with chlorinated lime water before and after examining every patient. The maternal mortality rate in mothers cared for by physicians who did so dropped to a 1% mortality rate. This demonstrated that **hand washing was a very effective method for preventing disease transmission.**
- In 1848, British physician **John Snow** conducted studies to track the source of cholera outbreaks in London, tracing the outbreaks to two specific water sources, both of which were contaminated by sewage. He demonstrated that cholera bacteria were transmitted via the contaminated drinking water to people.
- In 1856, **Louis Pasteur**, a prominent French chemist, discovered properties of fermentation by microorganisms. He demonstrated with his swan-neck flask experiments that airborne microbes, **not** spontaneous generation, were the cause of food spoilage, and he suggested that if microbes were responsible for food spoilage and fermentation, they could also be responsible for causing infection. This was the **foundation for the modern germ theory of disease**. He made a series of flasks with long, twisted necks (**"swan-neck" flasks**), in which he boiled broth to sterilize it (to kill any microorganisms). Some had argued that life originated from a **"life force"** that was destroyed by extended boiling. Pasteur's design allowed air inside the flasks to be exchanged with air from the outside, but prevented the introduction of any airborne microorganisms, which would get caught in the twists and bends of the flasks' necks. If a life force, besides the airborne microorganisms, were responsible for microbial growth within the sterilized flasks, it would have access to the broth, whereas the microorganisms would not. He correctly predicted that sterilized broth in his swan-neck flasks would remain sterile as long as the swan necks remained intact. However, should the necks be broken, microorganisms would be introduced, contaminating the flasks and growing in the broth. Pasteur's set of experiments irrefutably **disproved the theory of spontaneous generation.** In 1864, Pasteur articulated ***"Omne vivum ex vivo"*** **("Life only comes from life").**



- Subsequently, **Robert Koch** proposed a series of postulates (**Koch's postulates**) based on the idea that the cause of a specific disease could be attributed to a specific microbe. Koch and his colleagues were able to definitively identify the causative pathogens of specific diseases, including anthrax, tuberculosis, and cholera. Koch's **"one microbe, one disease"** concept was the culmination of the 19th century's **paradigm shift away from miasma theory and toward the germ theory of disease.**

- **Rudolf Virchow** (1821–1902), a well-respected pathologist, was the first to determine the causes of various diseases by examining their effects on tissues and organs. His published essay, "Cellular Pathology," popularized the concept of cell theory using the Latin phrase **omnis cellula a cellula ("all cells arise from cells").**

- In 1905, based upon the plant cell chloroplasts' ability to reproduce independently, Russian botanist **Konstantin Mereschkowski,** suggested that chloroplasts may have originated from ancestral photosynthetic bacteria living symbiotically inside a eukaryotic cell. He proposed a similar origin for the nucleus of plant cells. This was the first articulation of the **endosymbiotic hypothesis,** and would **explain how eukaryotic cells evolved from ancestral bacteria.** *(Endosymbiosis will be discussed in Ch.6 & again in Ch.25)*

- American anatomist **Ivan Wallin** (1883–1969) began to experimentally examine the similarities between mitochondria, chloroplasts, and bacteria, putting the endosymbiotic hypothesis to the test.

- In the 1967s, following the discovery of mitochondrial and chloroplast DNA, **Lynn Margulis**, an American geneticist, published her ideas in **support of the endosymbiotic hypothesis** of the origins of mitochondria and chloroplasts, which are now widely accepted.

2. Based on the work of many, today we know that **cells are an organism's most basic unit of structure and function** and, though modified over time by evolution, **all cells alive today are derived from earlier cells and so share similarities in structure and function**. Microscopes, invented in 1590, have aided our study of cells.

   a. How does a **light microscope** work?

   b. Three concepts are important in microscopy: *Magnification* refers to how much you can zoom into the object. *Resolution* refers to how clear the magnified image is. *Contrast* refers to the difference in brightness of light and dark areas in the image. To increase contrast, science can use stains (dyes) or can label cell components visually as seen in Figure 6.3. How much can a **light microscope magnify an object**?

   c. How does an **electron microscope** work?

   d. What is the difference between a **scanning and transmission electron microscope**?

   Scanning Electron Microscope (SEM) =

   Transmission Electron Microscope (TEM) =

e. How much an an **electron microscope magnify an object** *(FYI: 100x is not the answer)*?

f. What is a big **advantage of using a light microscope over an electron microscope**?

g. The development of electron microscopes has further opened our window on the cell and its organelles. What is considered a major **disadvantage of the electron microscope**?

3. a. Explain the purpose of **cell fractionation**.

b. What is a **centrifuge?**

c. How does a centrifuge **help separate cellular component by size (weight)**?

d. Refer to Figure 6.4. Describe the step-by-step **technique of cell fractionation**, being sure to underline and describe what we mean by the terms **homogenate**, **supernatant**, and **pellet** in your answer.

e. Based on the example in Figure 6.4, when engaging in differential centrifugation, which **cellular component(s) accumulated in the first pellet, second pellet, third pellet, fourth pellet, and on?**