

1. **Pick up** Name Folder

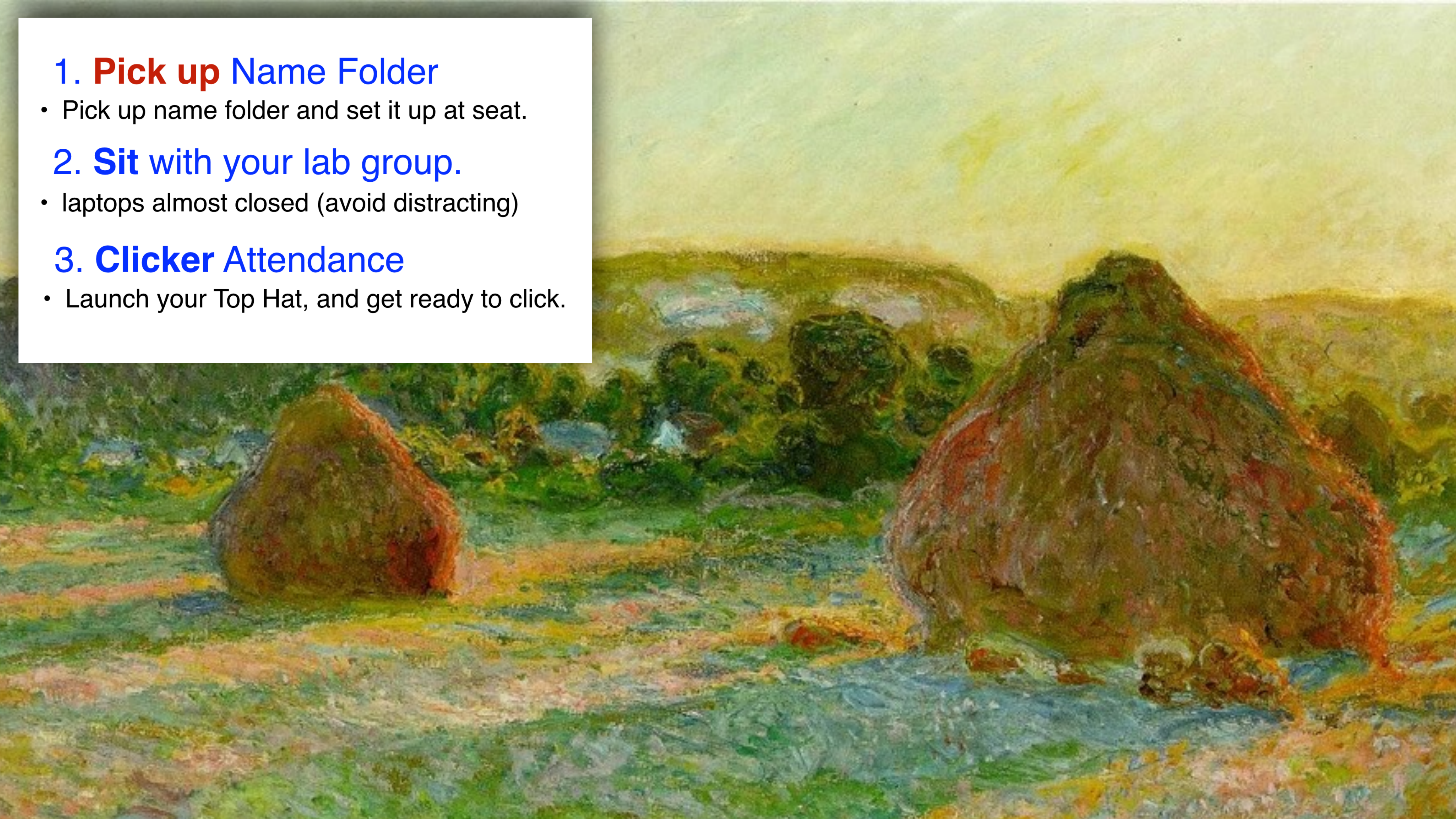
- Pick up name folder and set it up at seat.

2. **Sit** with your lab group.

- laptops almost closed (avoid distracting)

3. **Clicker** Attendance

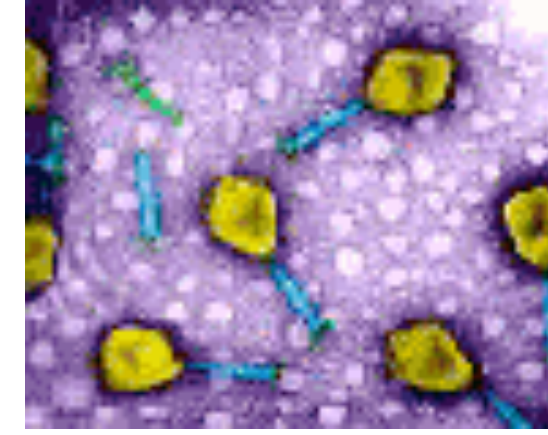
- Launch your Top Hat, and get ready to click.



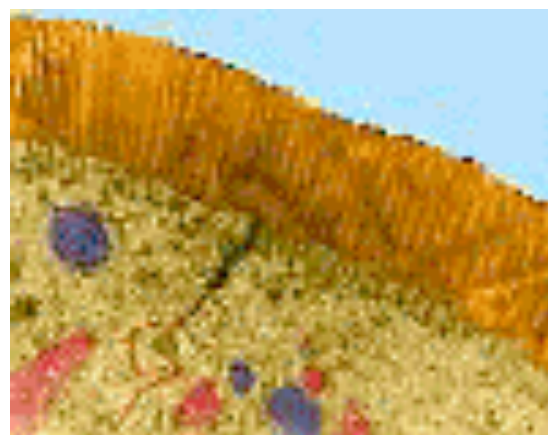
An impressionist landscape painting with a textured, visible brushstroke style. The scene depicts a valley or a path leading through a field of purple and blue flowers towards a distant horizon. The sky is a mix of yellow, orange, and green, suggesting a bright, hazy day. The overall mood is vibrant and atmospheric.

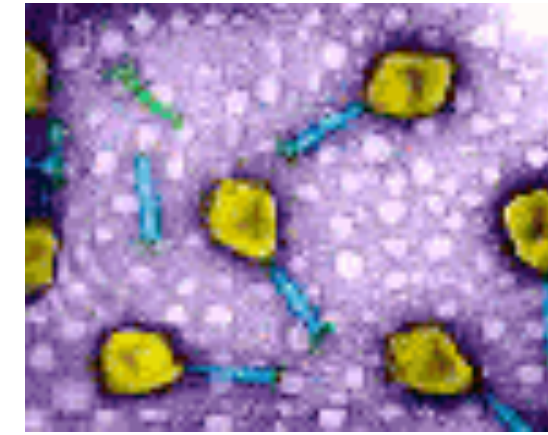
. Laptops closed (unless TopHat)

(open if need 4 TopHat, don't distract others)

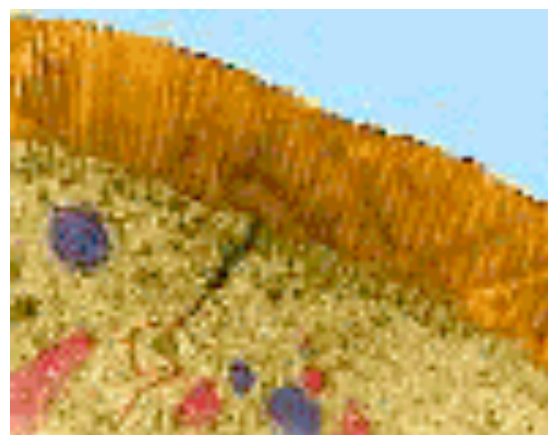


See different



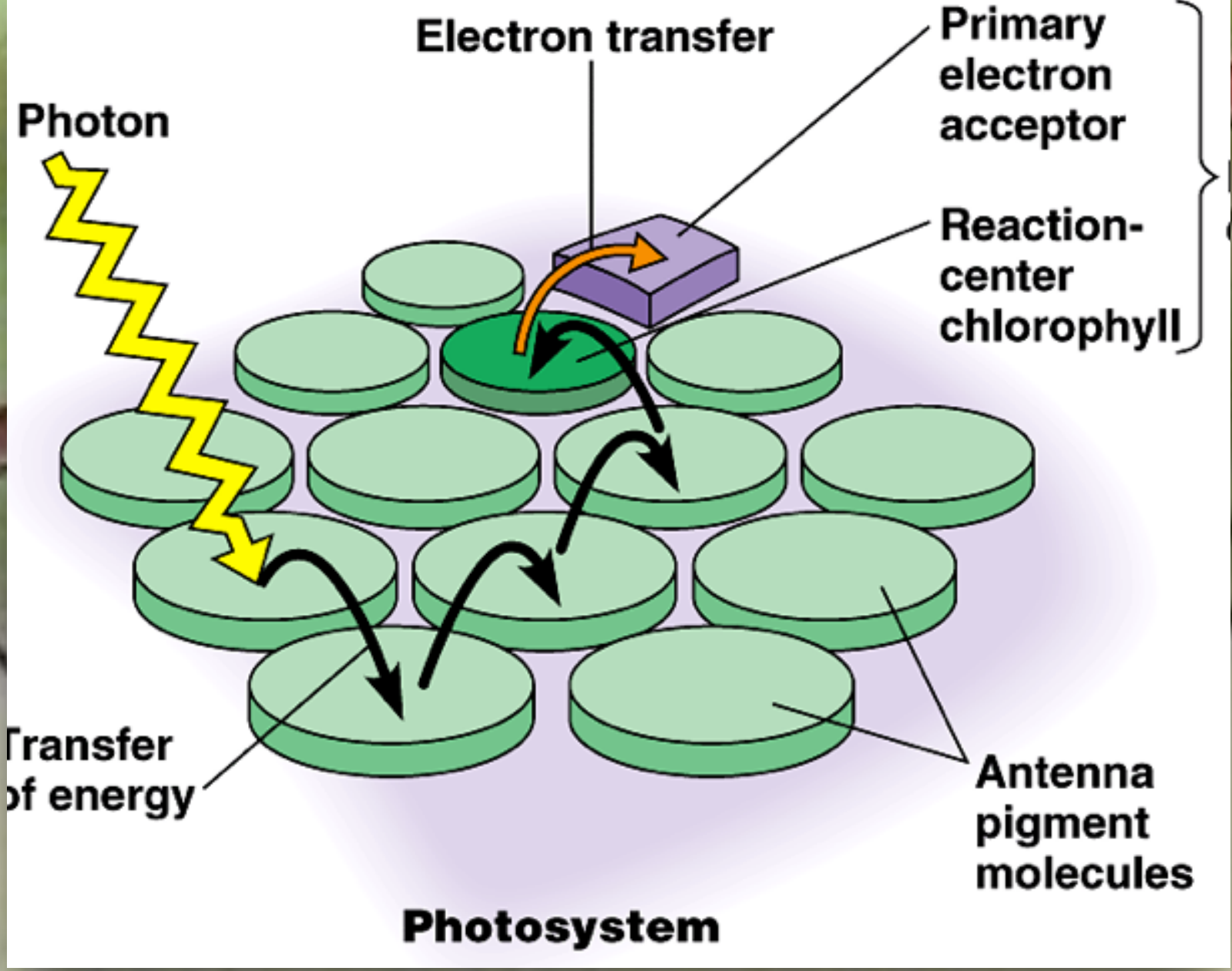
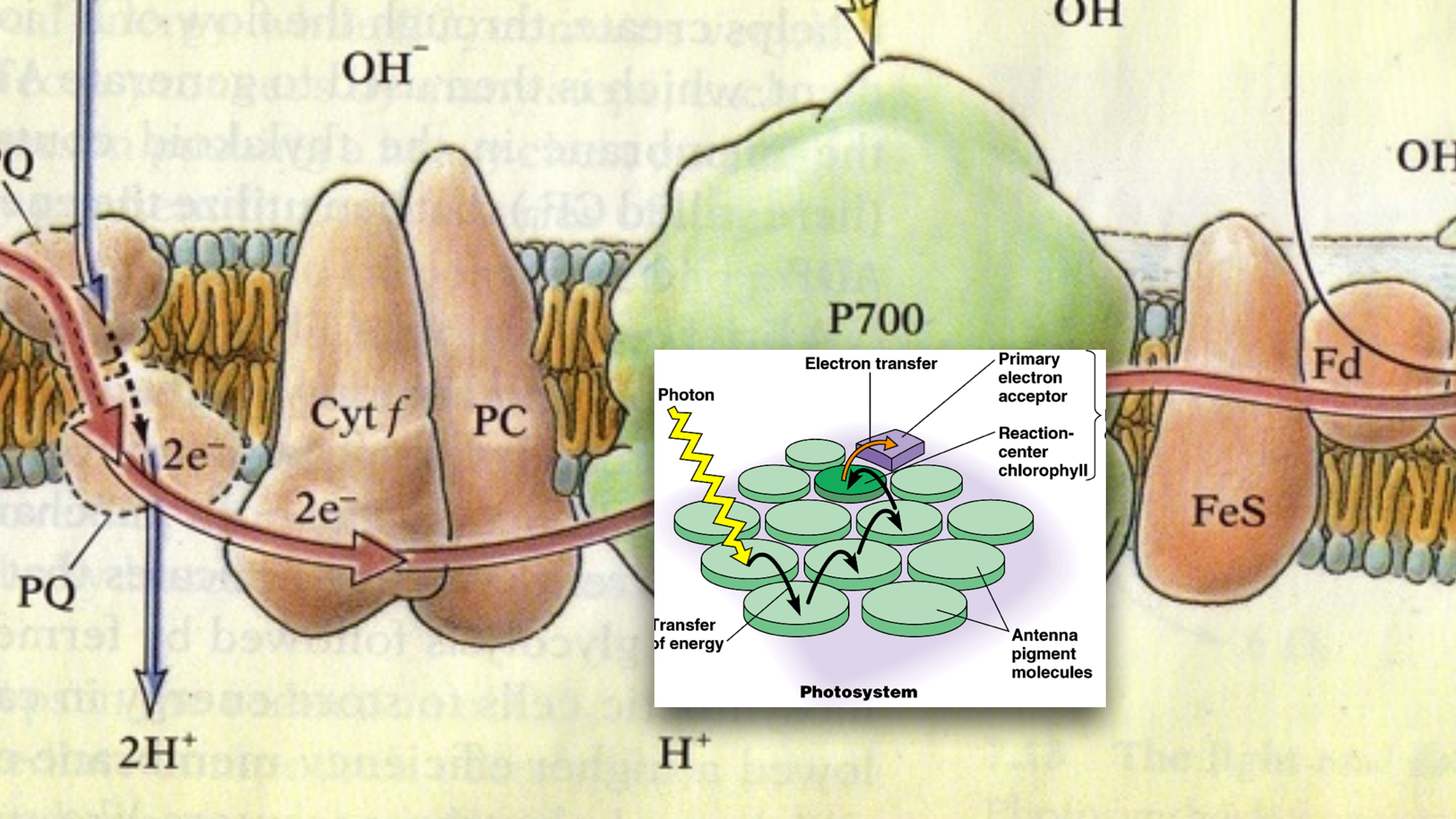


(the “verbal” final)



The image is a painting of a landscape. In the foreground, there are two large, rounded, reddish-brown mounds, possibly haystacks or rock formations, positioned on either side of a central path. The ground is textured with various shades of green, blue, and yellow, suggesting grass and earth. In the background, there is a hazy, greenish landscape with rolling hills or mountains under a pale, yellowish sky. The overall style is impressionistic, with visible brushstrokes and a focus on color and light.

The verbal final



An impressionist landscape painting featuring a prominent mountain peak on the right side. The sky is a mix of warm yellow, orange, and pink tones, suggesting a sunrise or sunset. The foreground and middle ground are composed of textured brushstrokes in shades of blue, purple, and red, creating a sense of depth and atmosphere. The overall style is characteristic of the Impressionist movement, with visible, expressive brushwork and a focus on light and color.

The verbal final

4.4 Can non-living objects harvest and store energy?



- Context: Life consumes energy, and the first cells would need an abiotic way to harvest and store energy.
- Major theme: The origin of living systems occurred by natural processes, and life continues to evolve within a changing environment; organisms can be linked by lines of descent from common ancestry.
- Bottom line: Nonliving vesicles can accumulate energy in the form of a pH gradient.

Biology Learning Objectives

- Use evidence to support the scientific understanding that life evolved from abiotic forces and phenomenon.
- Discuss how vesicles can grow, compete, *and store energy*.
- Illustrate how abiotic structures exhibit dynamic and competitive behaviors.

In Section 4.2, you saw RNA molecules function as RNA polymerases. In Section 4.3, you saw RNA molecules become entrapped inside abiotic vesicles and produce osmotic pressure to out-compete relaxed vesicles for lipids. Life also requires energy, and so far you have not seen any data indicating that these primitive cells could harvest or store energy. Is it possible for primitive, abiotic cells to store energy in an abiotic world? Could growing vesicles sequester energy that could be used to do work at a later time? You will analyze published data that will help you determine if energy storage is possible in an abiotic world.

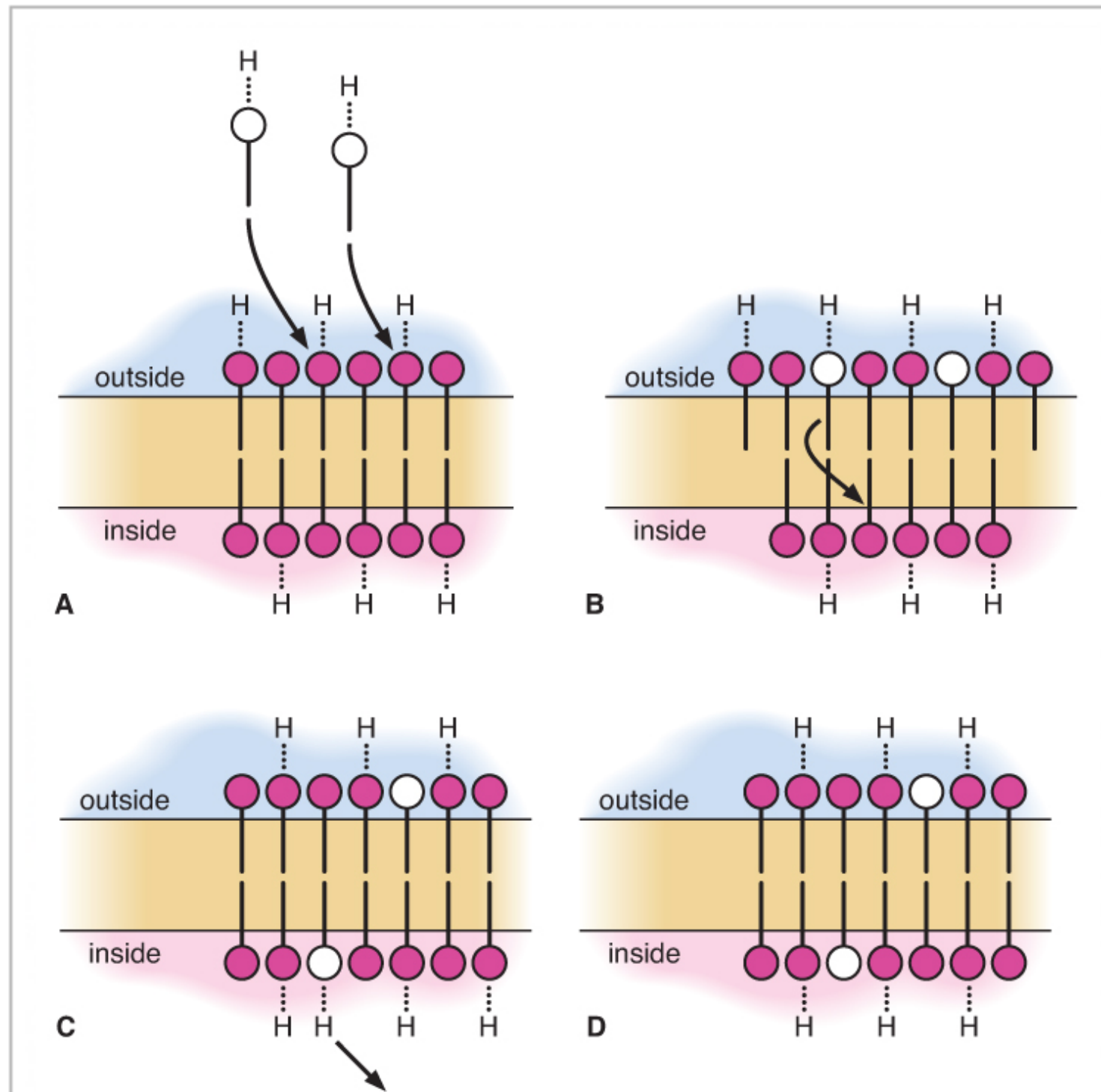


Figure 4.16 Proposed mechanism for accumulation of a pH gradient inside the vesicle lumen. The process proceeds from (A) through (D) over time to gradually accumulate H^+ ions inside vesicles, which lowers internal pH. Lipids can flip from one side of the bilayer to the other. From Chen and Jack W. Szostak. 2004a. Figure 2. Irene A. Chen and Jack W. Szostak. 2004a. Membrane growth can generate a transmembrane pH gradient in fatty acid vesicles. PNAS. 101 (21): 7965 – 7970. Copyright (2004) National Academy of Sciences, U.S.A.

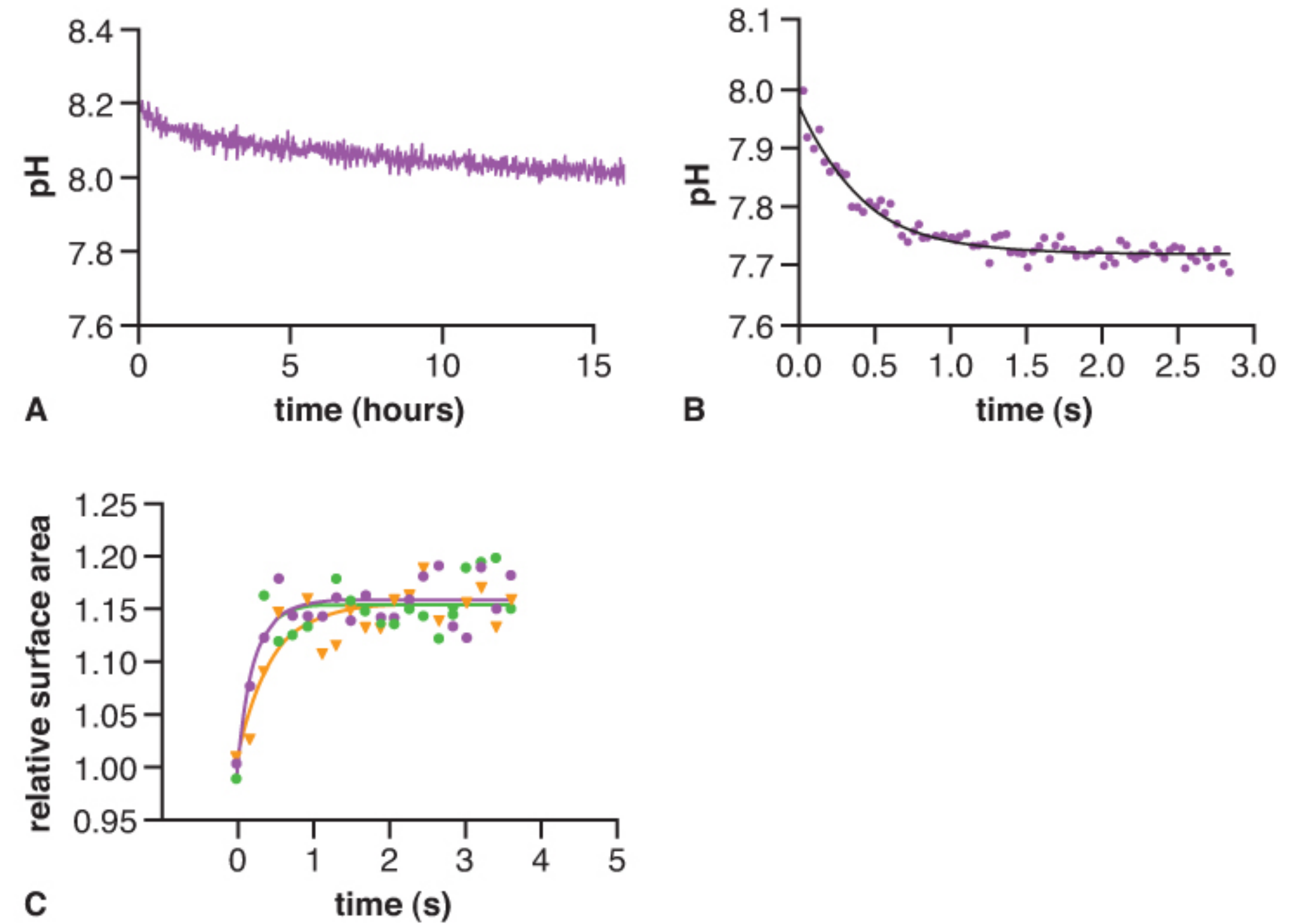
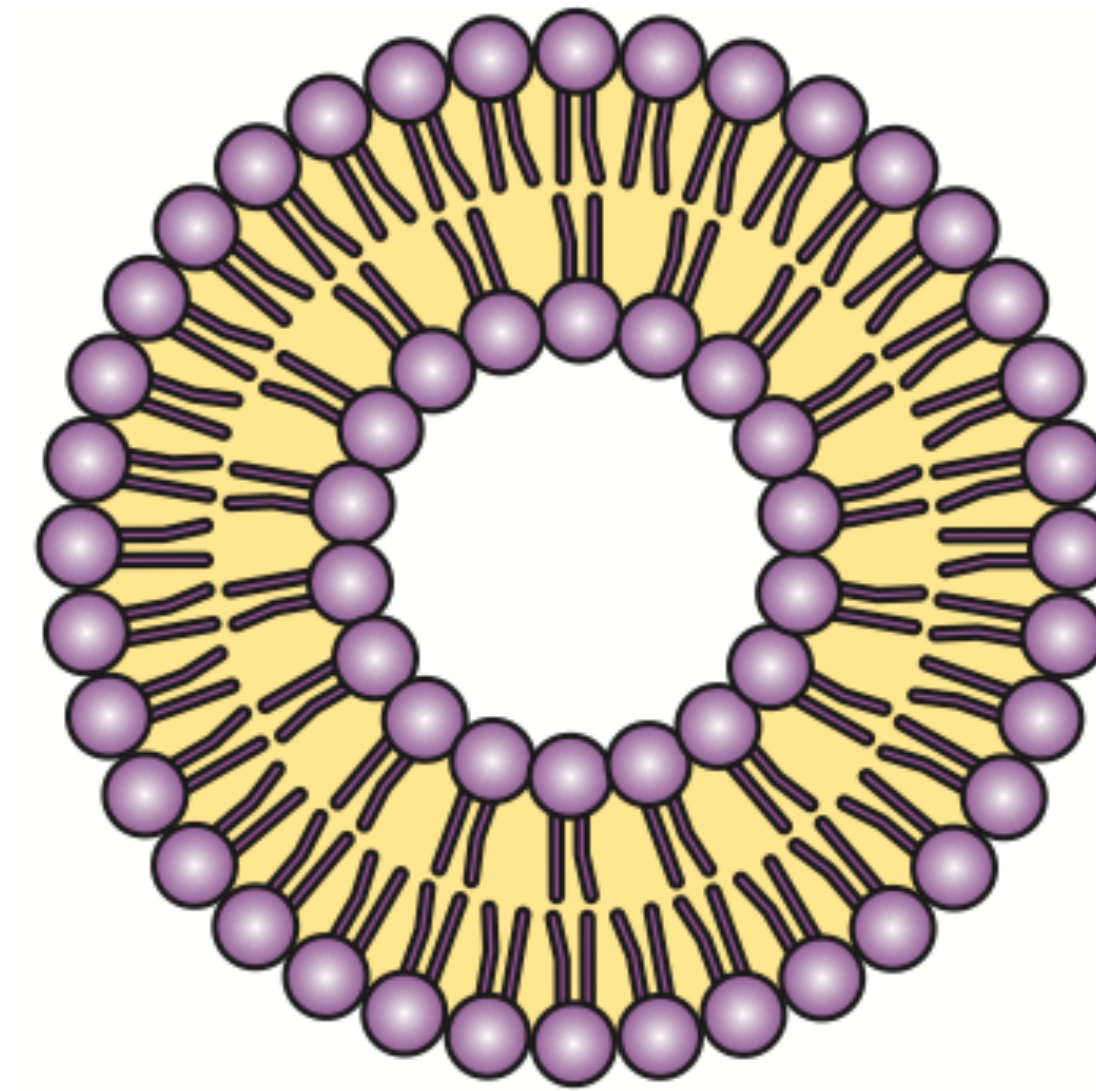
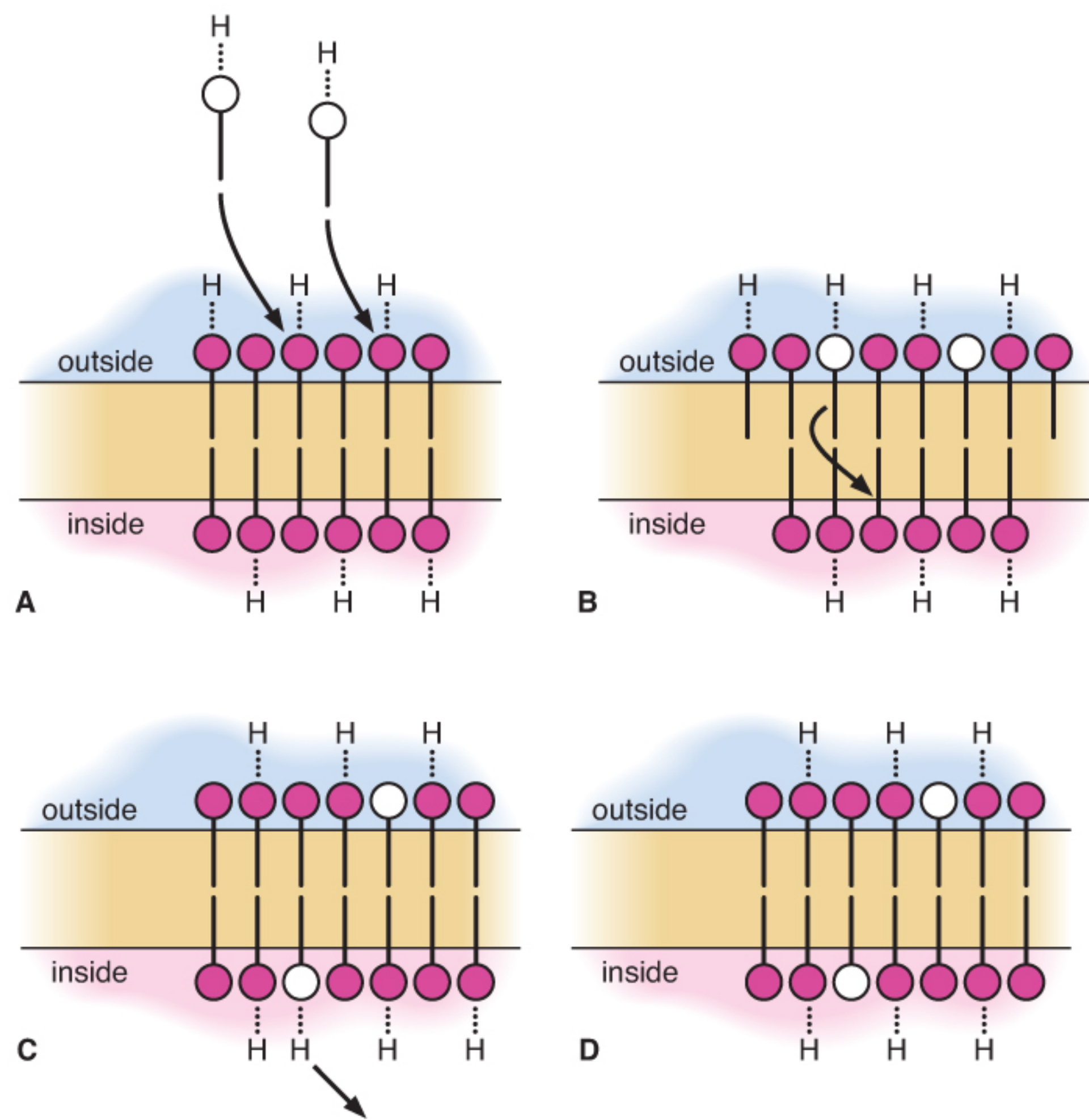


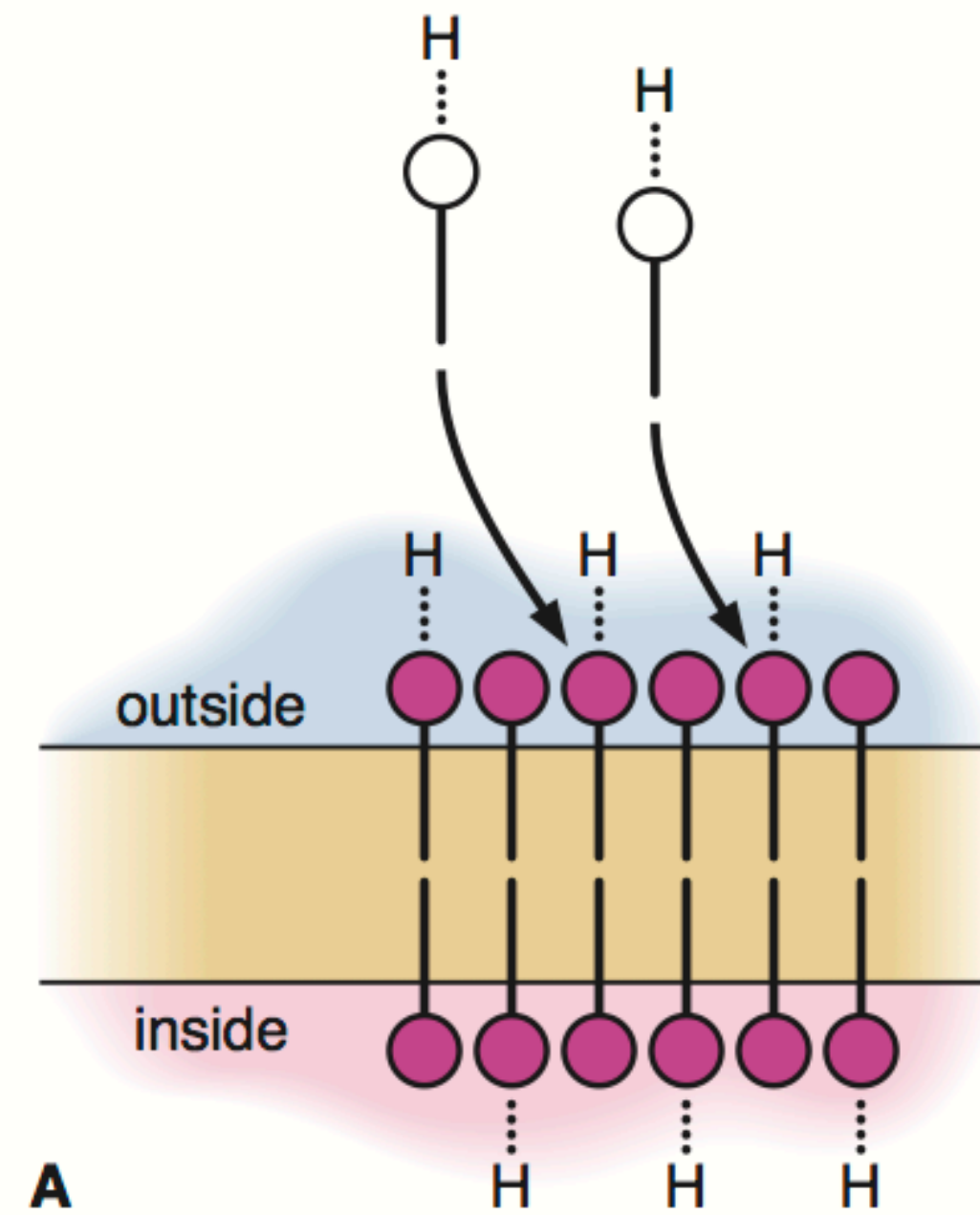
Figure 4.17 Vesicle pH after adding micelles. **A**, pH drops quickly at first, and then slowly. **B**, Reduced pH immediately after adding micelles. **C**, Change of surface area for vesicles in **B**. Three trials are shown with each line representing an exponential curve fit. From Chen and Jack W. Szostak. 2004a. Figure 3. Irene A. Chen and Jack W. Szostak. 2004a. Membrane growth can generate a transmembrane pH gradient in fatty acid vesicles. PNAS. 101 (21): 7965 – 7970. Copyright (2004) National Academy of Sciences, U.S.A.



vesicle

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Model of pH Gradient Production



new lipids fuse
with outer layer

Fig. 4.16

Model of pH Gradient Production

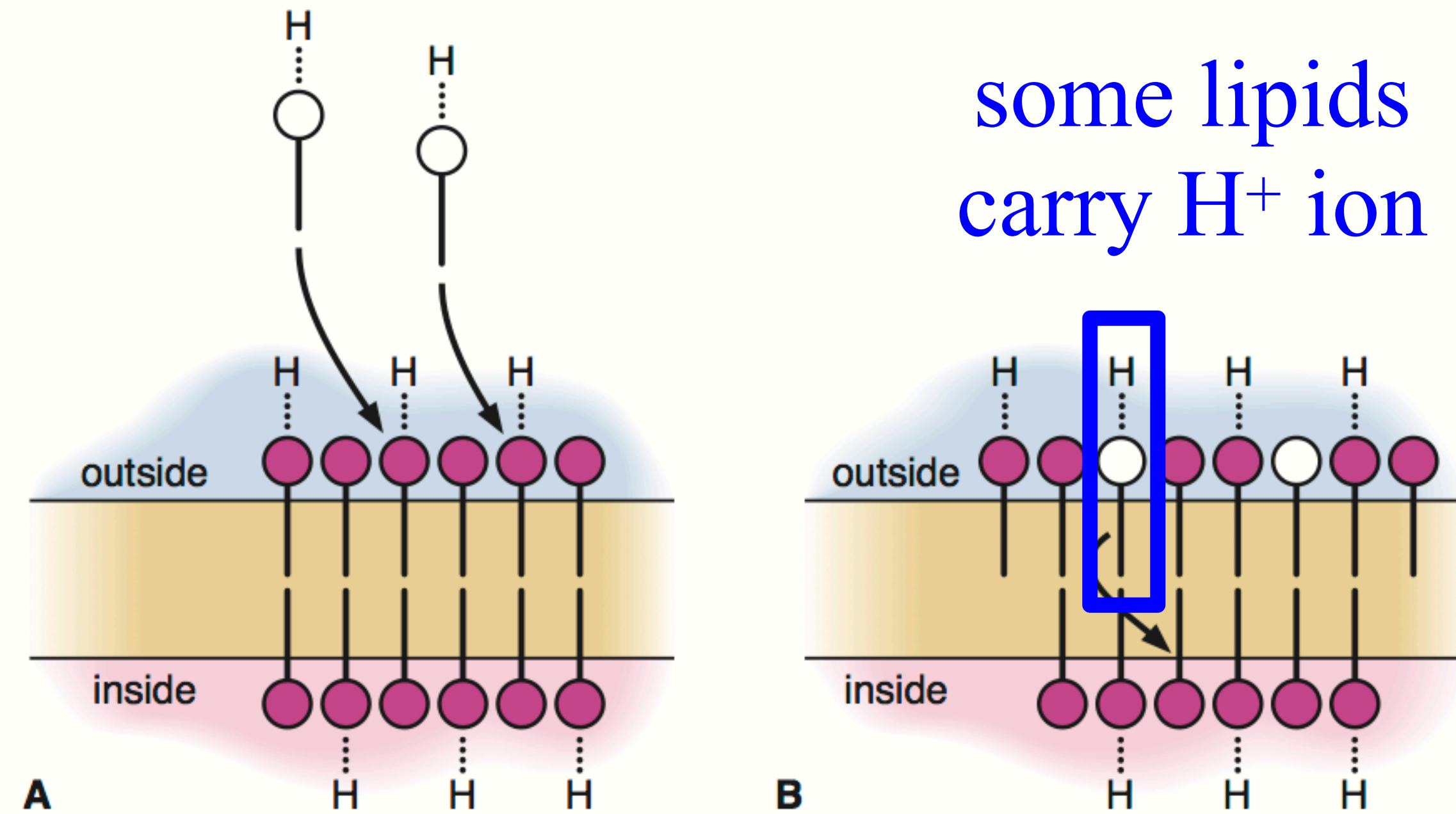
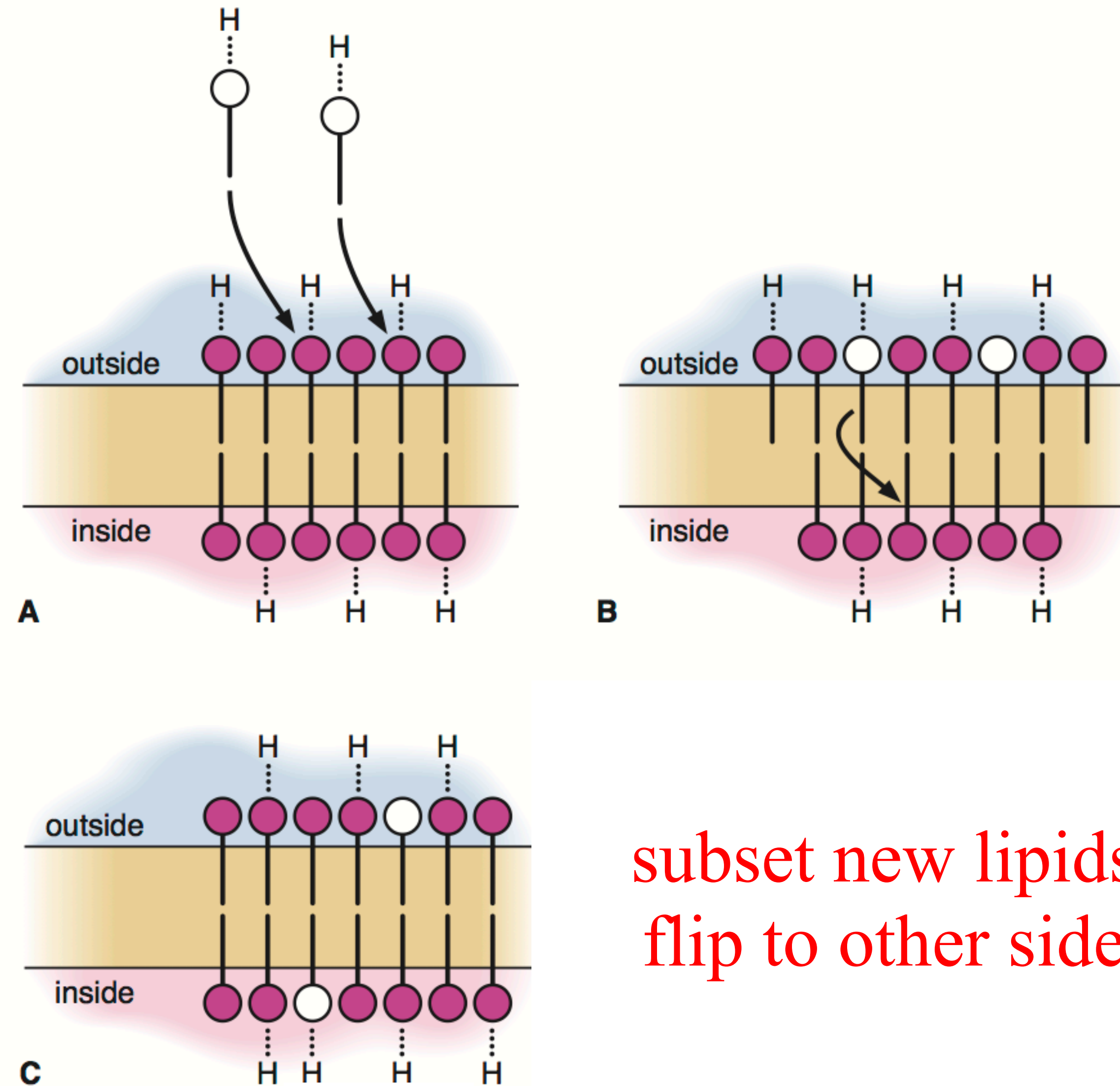


Fig. 4.16

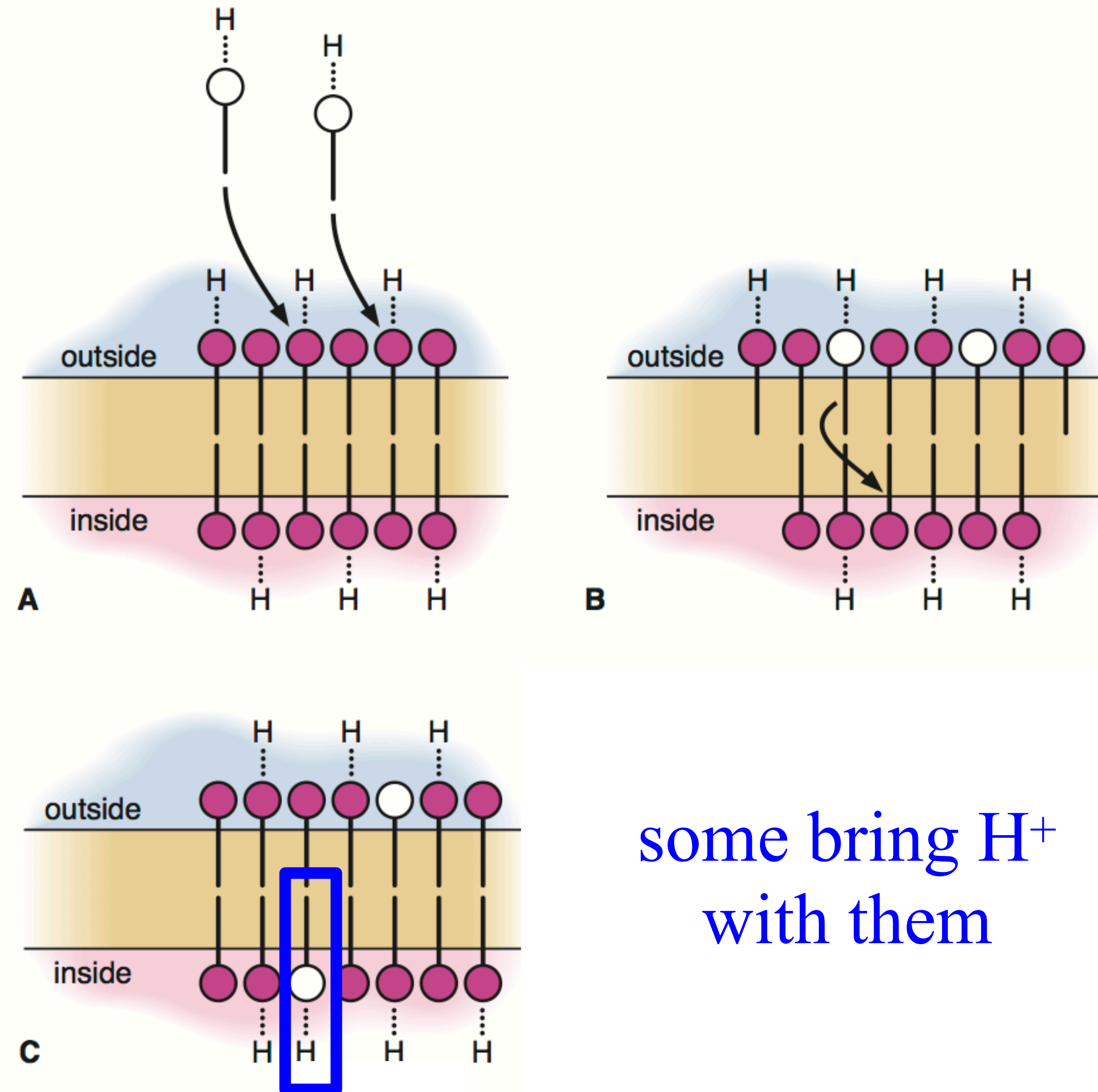
Model of pH Gradient Production



subset new lipids
flip to other side

Fig. 4.16

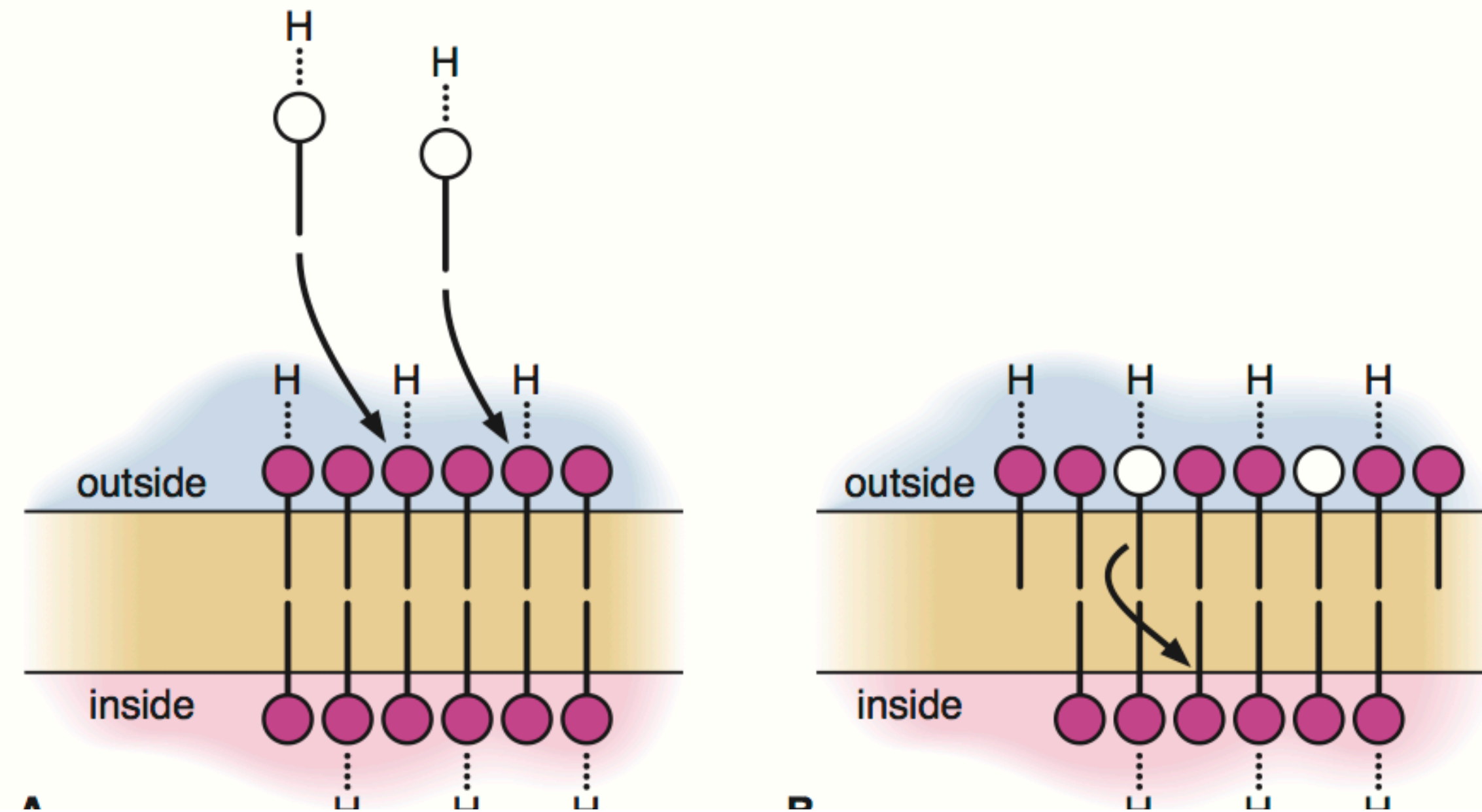
Model of pH Gradient Production



some bring H^+
with them

Fig. 4.16

Model of pH Gradient Production



subset of new charges diffuse inside vesicle

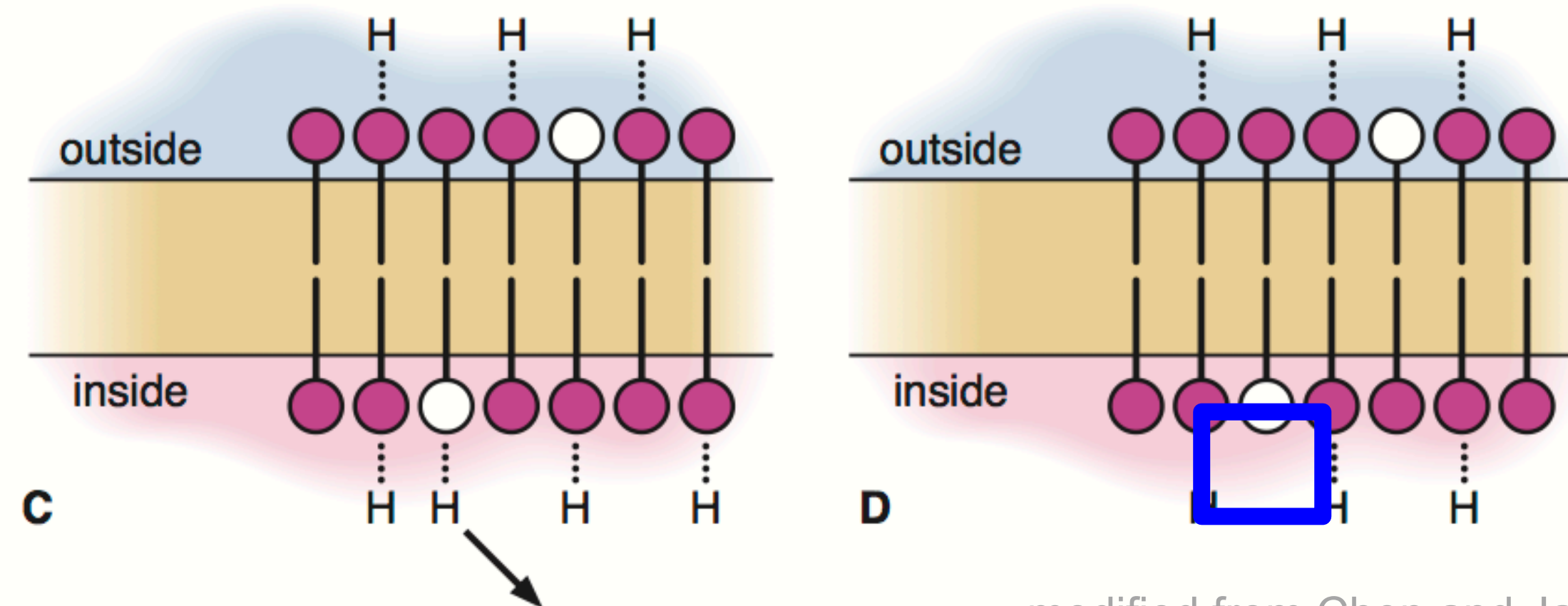
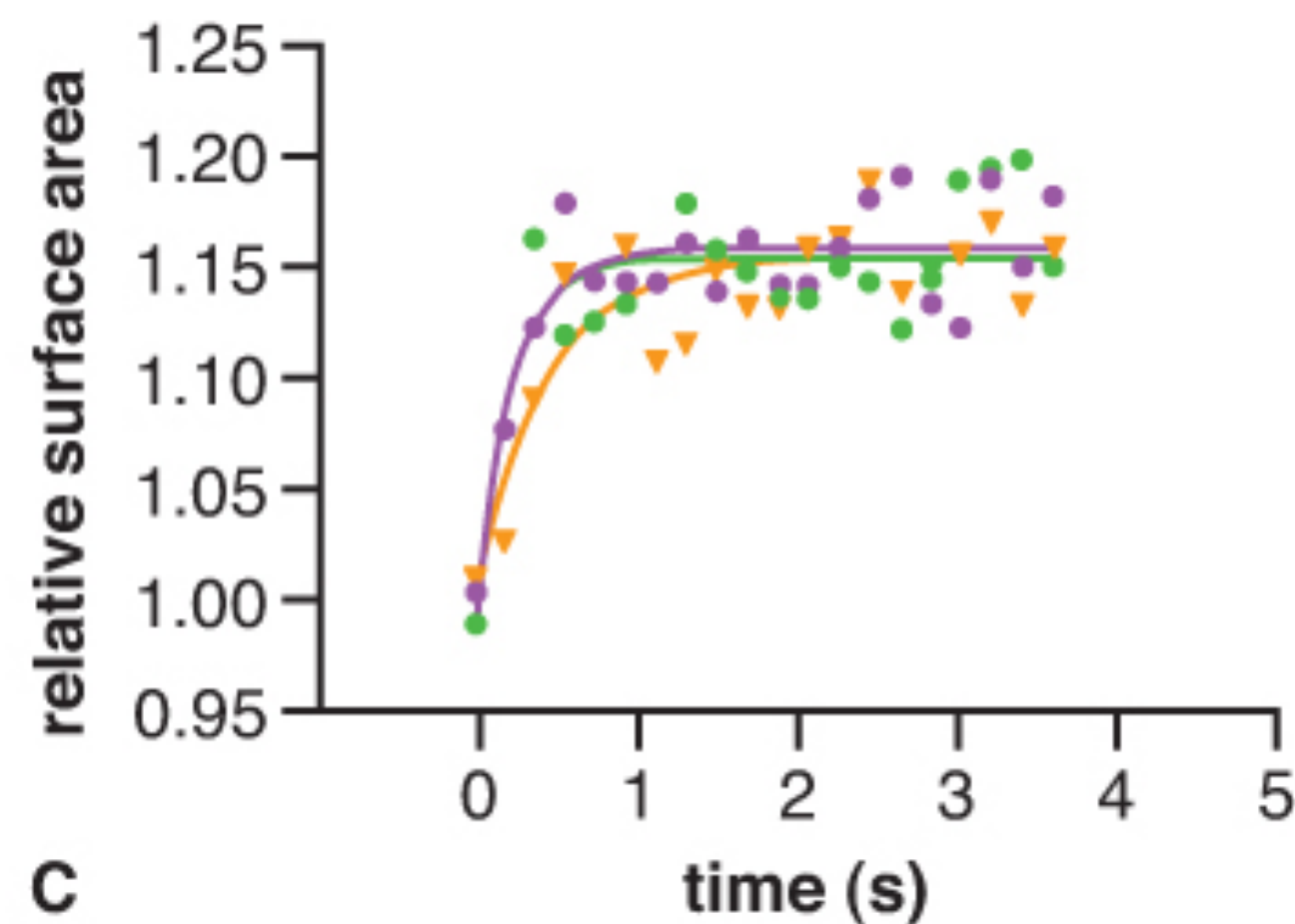
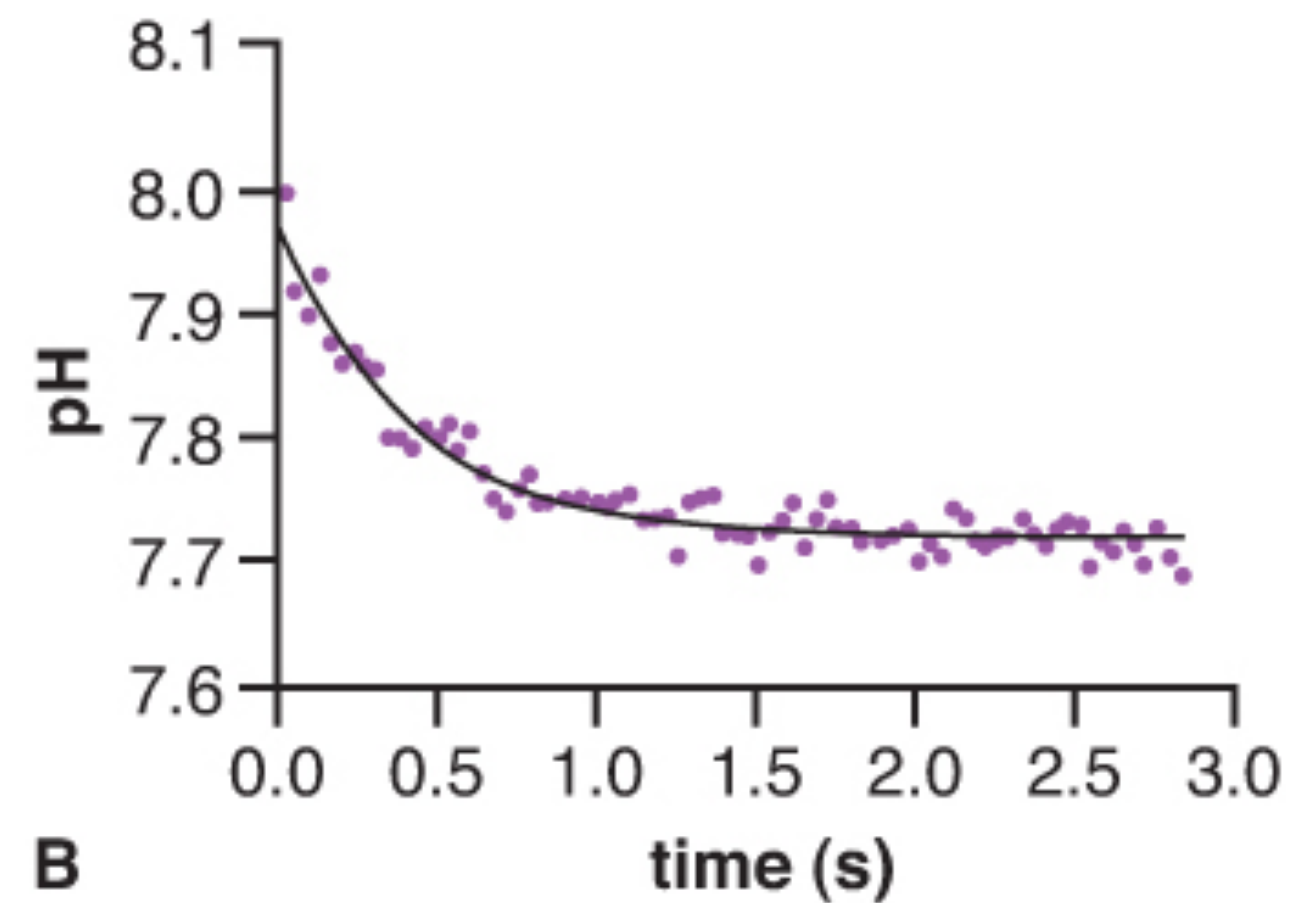
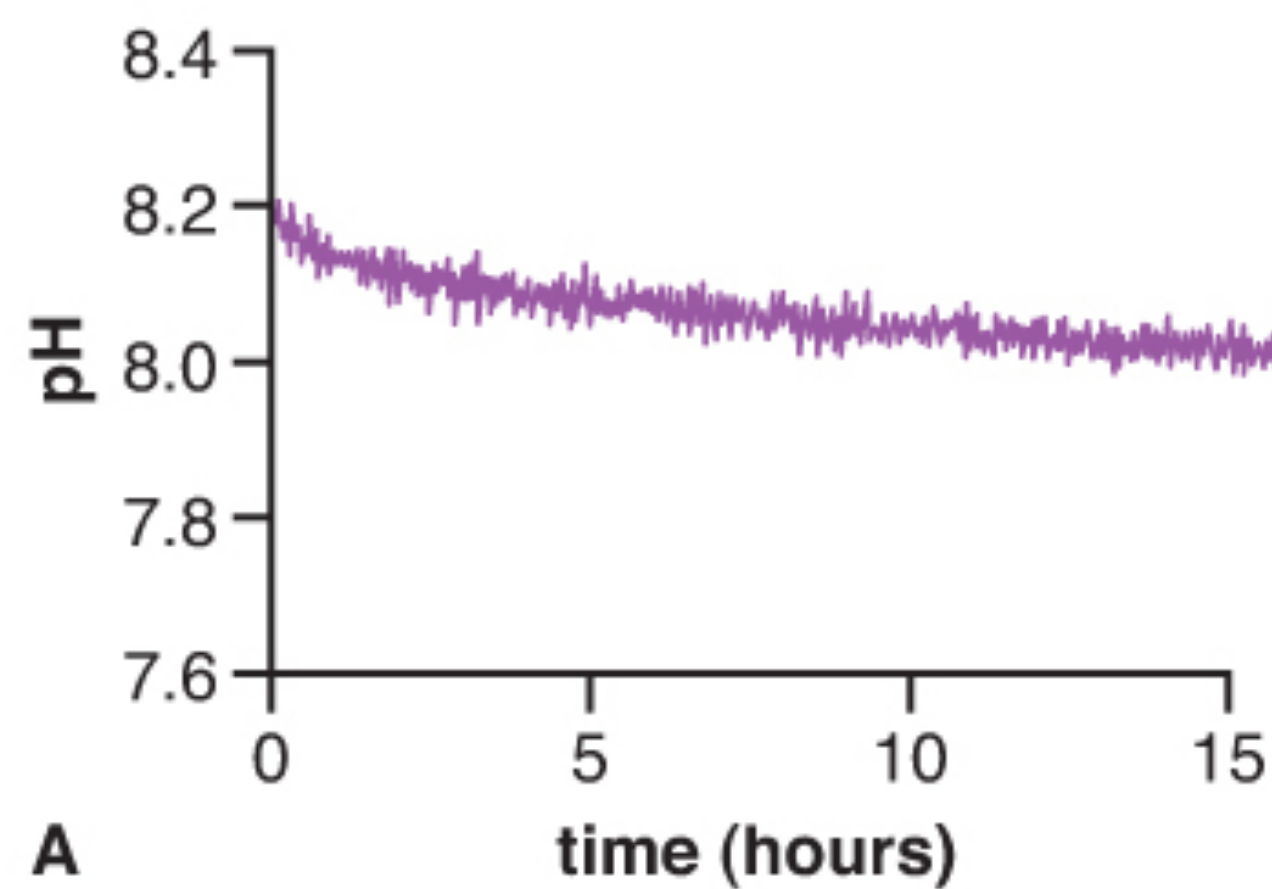


Fig. 4.16

modified from Chen and Jack W. Szostak. 2004a

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(Trifecta)

Figure 4.17 Vesicle pH after adding micelles. **A**, pH drops quickly at first, and then slowly. **B**, Reduced pH immediately after adding micelles. **C**, Change of surface area for vesicles in **B**. Three trials are shown with each line representing an exponential curve fit. From Chen and Jack W. Szostak. 2004a. Figure 3. Irene A. Chen and Jack W. Szostak. 2004a. Membrane growth can generate a transmembrane pH gradient in fatty acid vesicles. PNAS. 101 (21): 7965 – 7970. Copyright (2004) National Academy of Sciences, U.S.A.

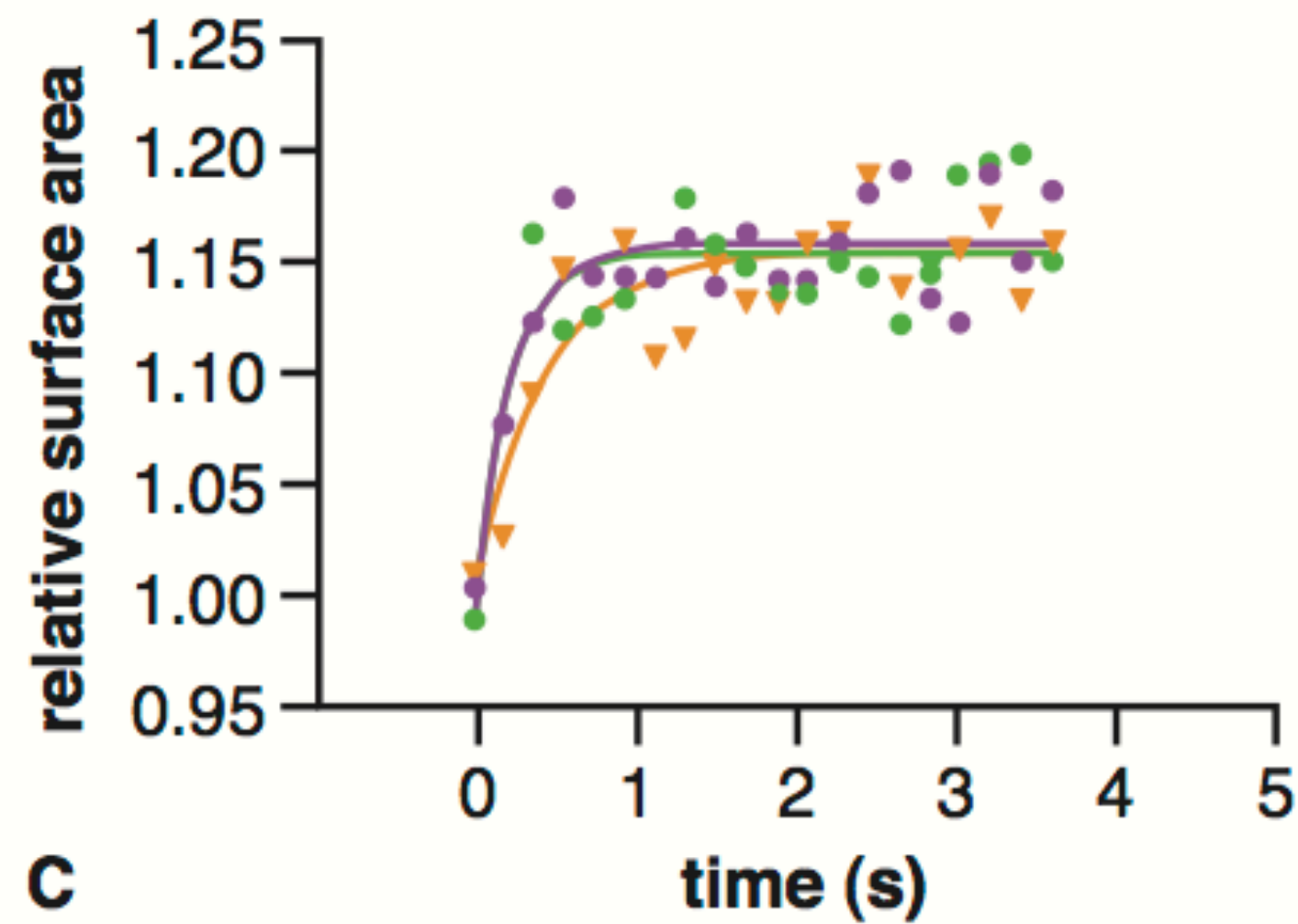
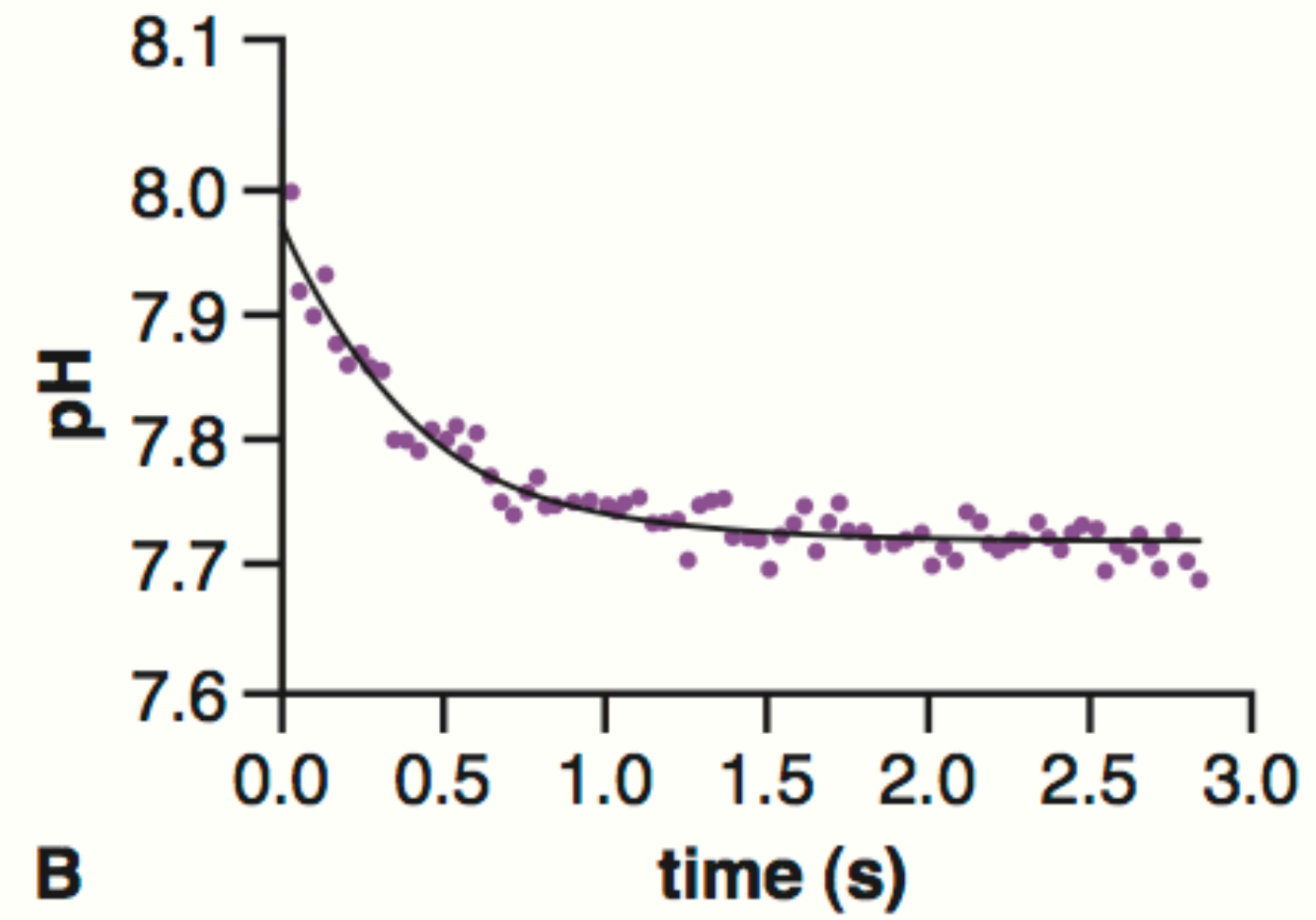
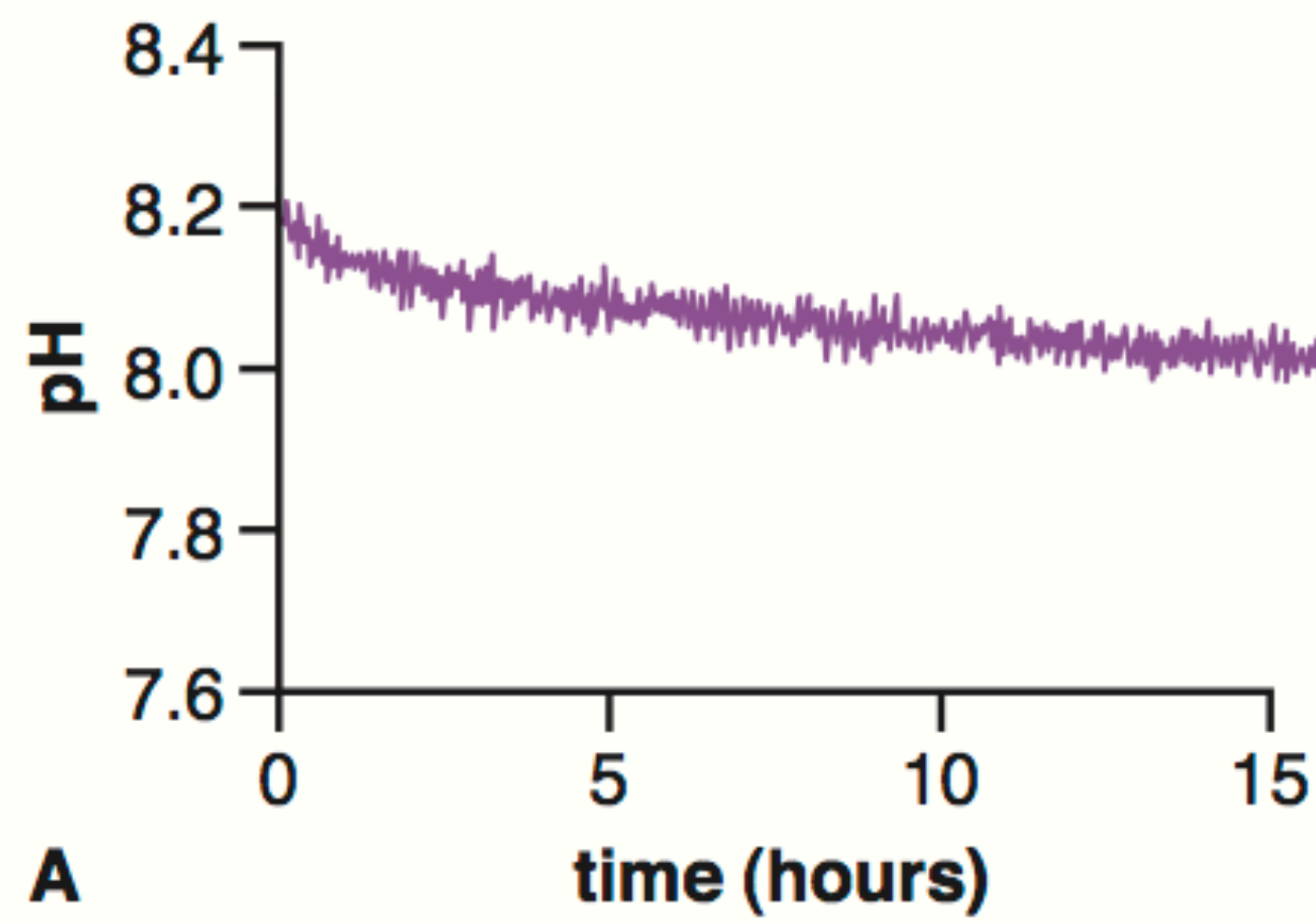


Fig. 4.17

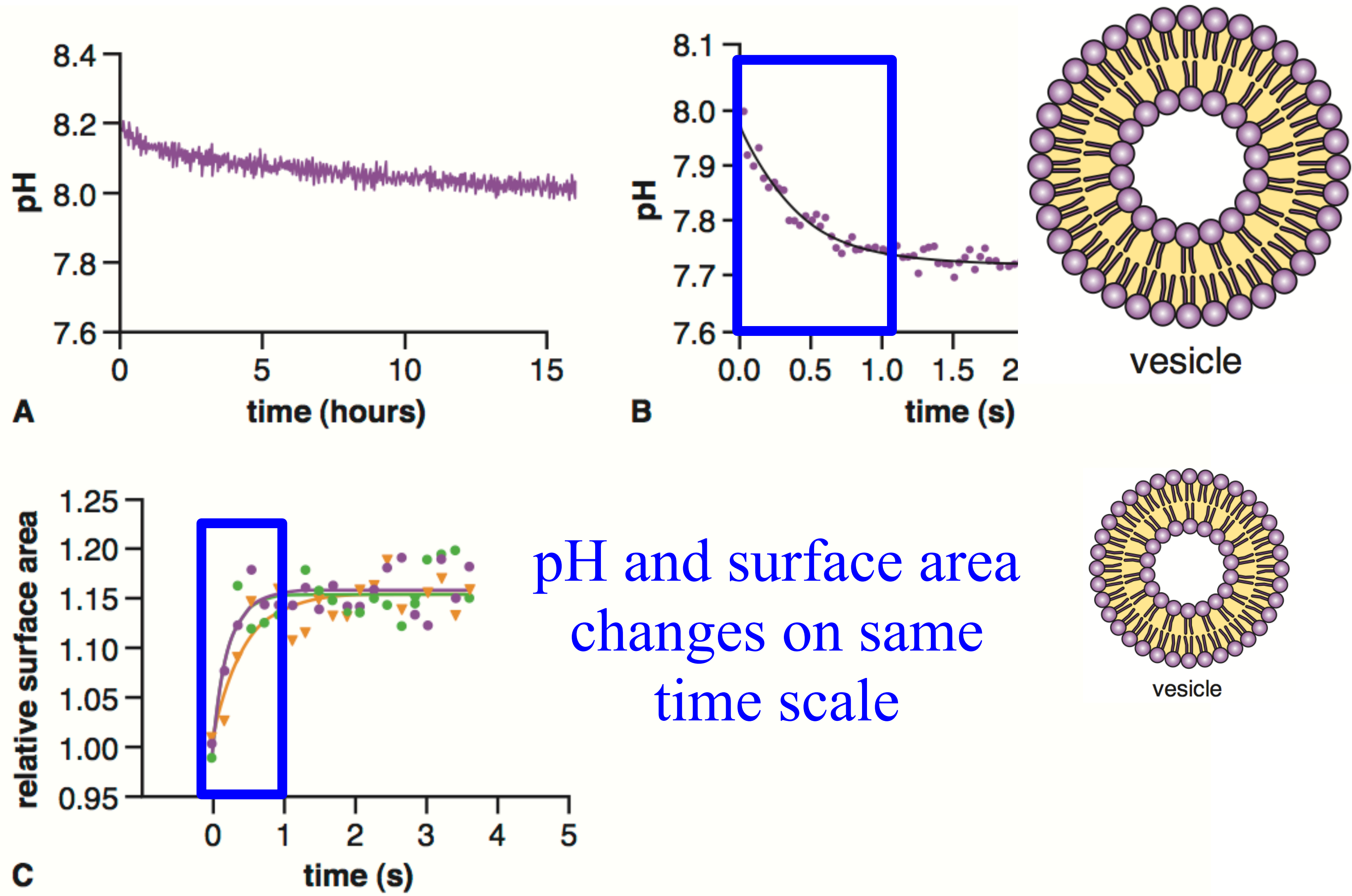
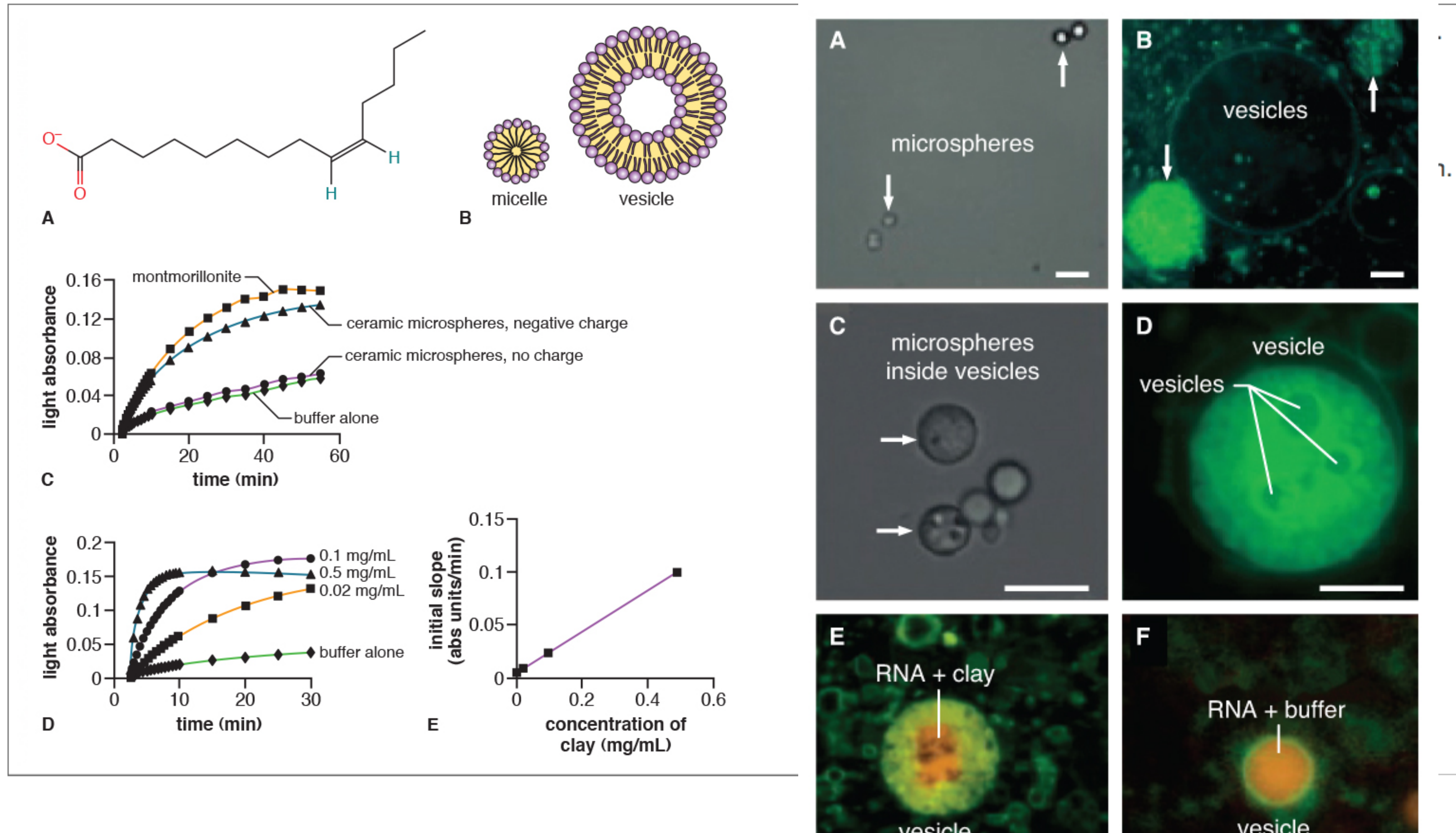


Fig. 4.17

Clay: lipids can gather together and form abiotic “cells” with RNA inside



Growth, Reproduction, Storage of energy (H⁺s)

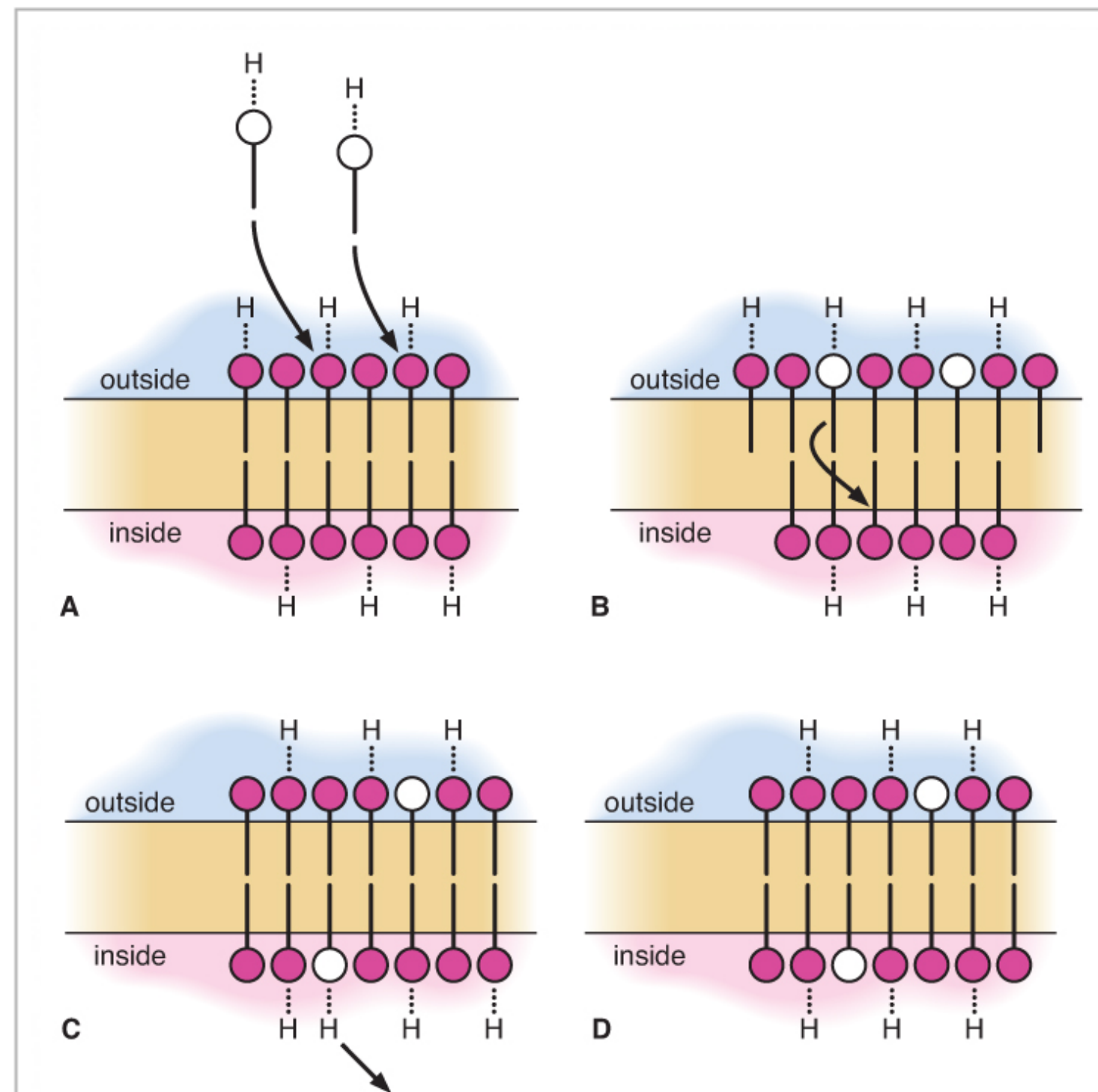
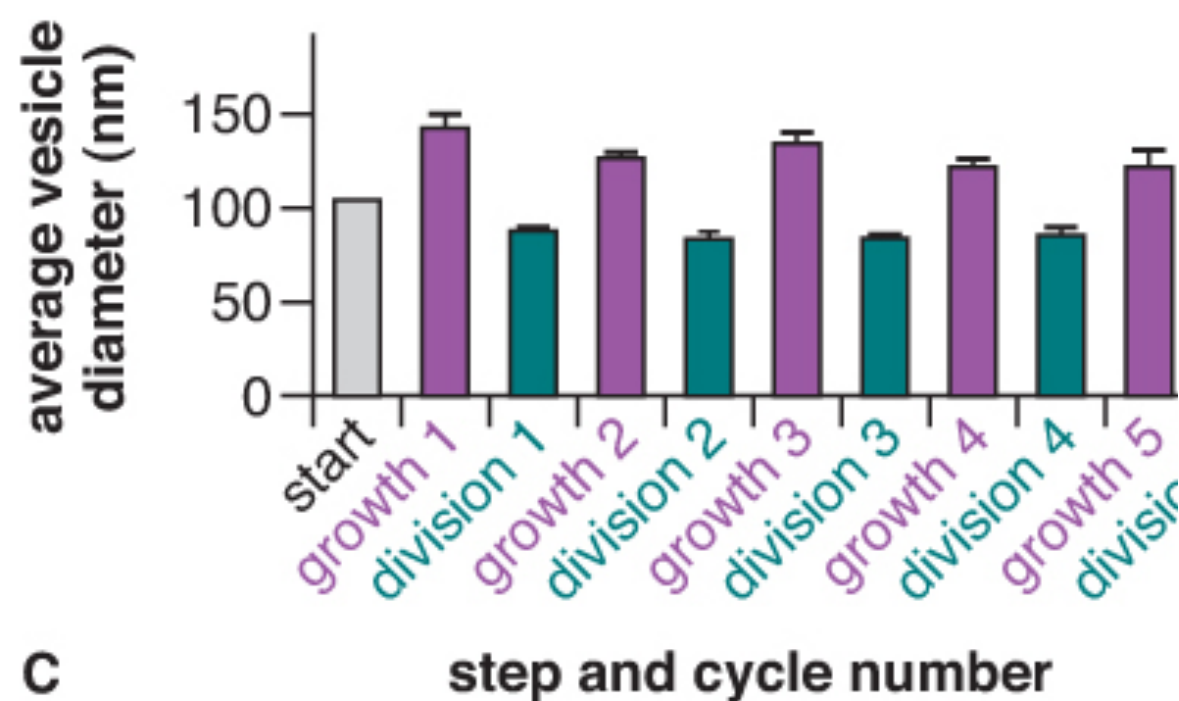
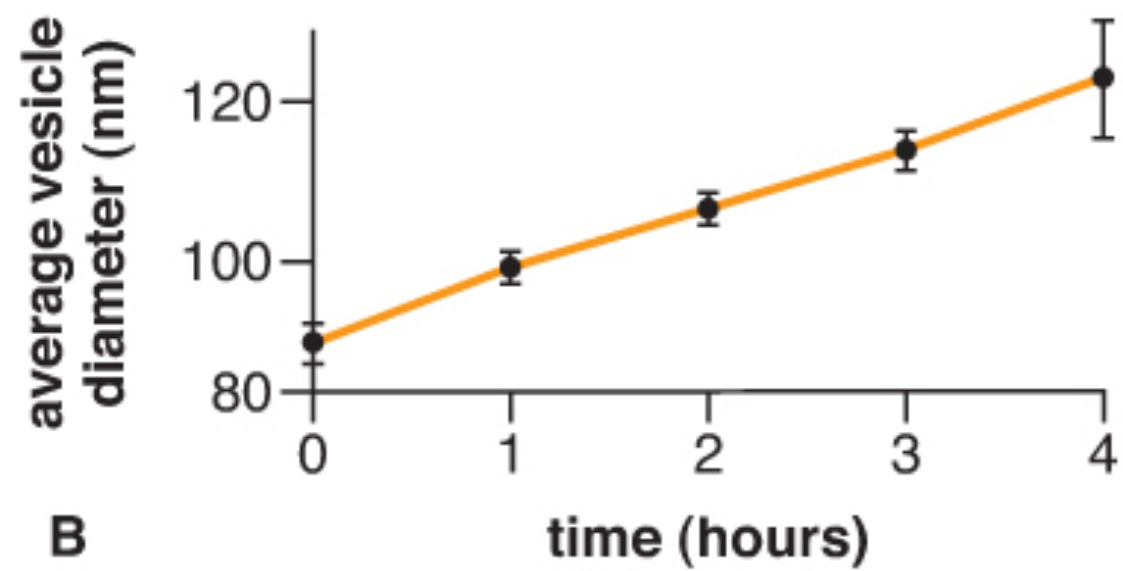
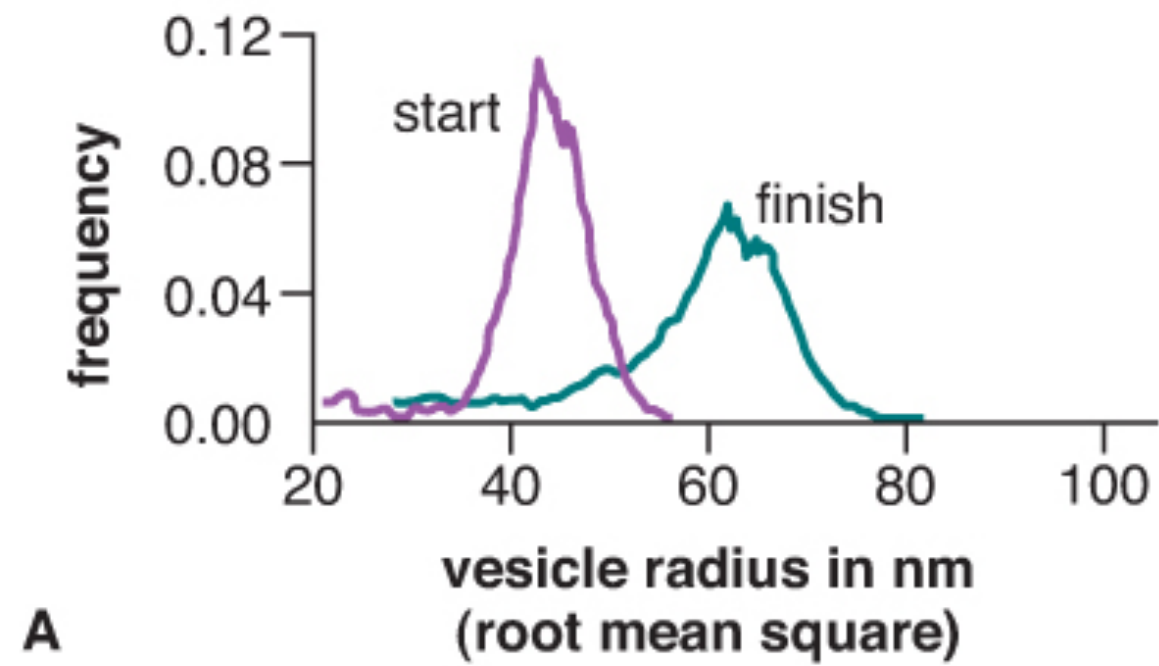


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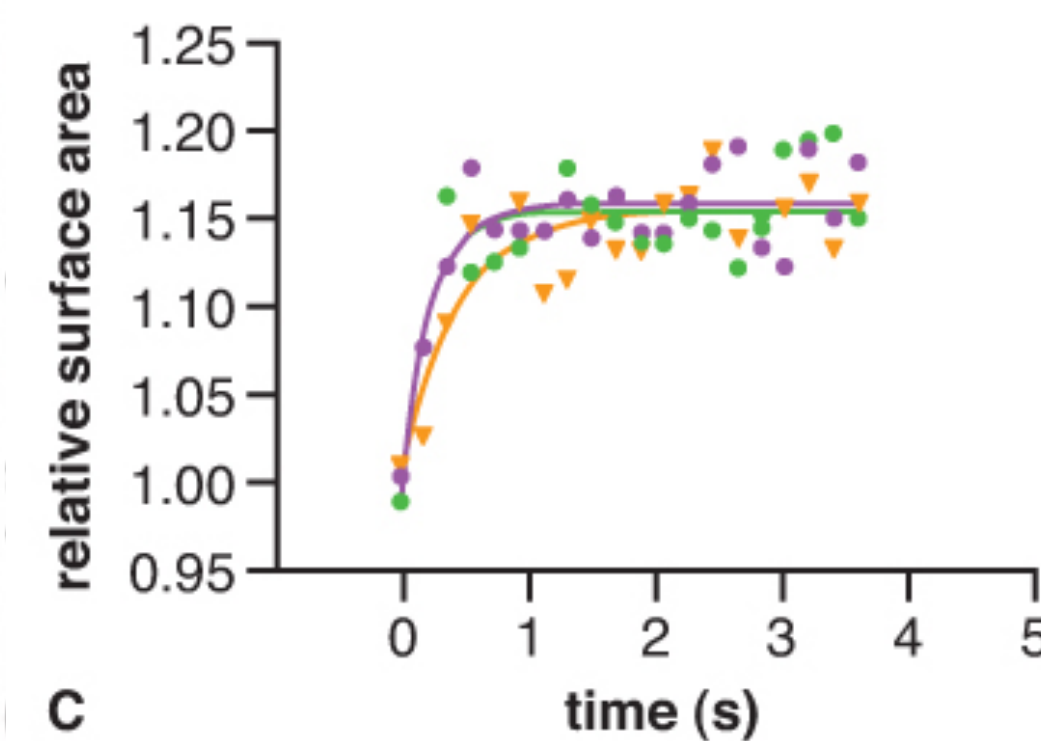
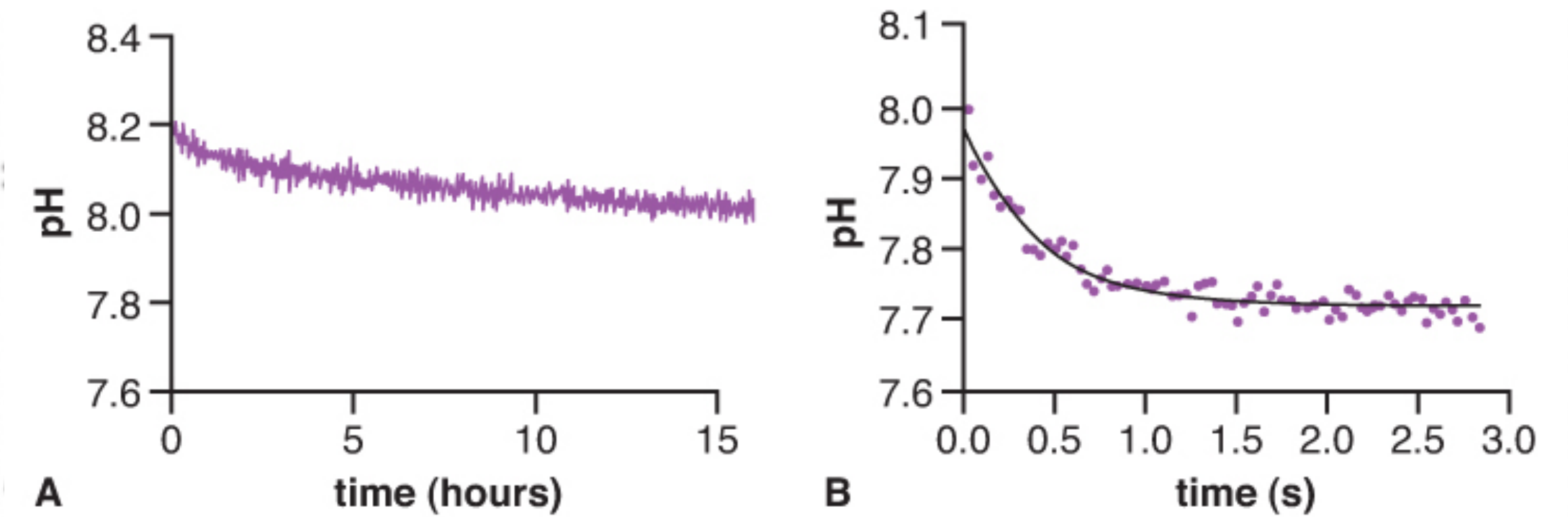


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If it looks like a cell, and acts like a cell...?

- Lipids can form through abiotic mechanisms.
- Abiotic vesicles can form spontaneously.
- Abiotic vesicles can trap RNA inside them.
- RNA ribozymes can polymerize RNA molecules.
- Abiotic vesicles can grow by consuming additional lipids.
- Abiotic vesicles can compete against each other for lipids.
- Abiotic vesicles can divide and leak their RNA cargo with each division.
- Abiotic vesicles with RNA inside can outcompete vesicles lacking RNA inside.



The momentous transition to multicellular life may not have been so hard after all

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<https://youtu.be/hjTdbWblhxw>

3min

What is our next question of EvoLife?

How did mitochondria and chloroplasts originate?

Biology Learning Objective

- Assemble evidence that demonstrates the evolutionary origin of mitochondria and chloroplasts.

(Preparing for) **Wednesday's lecture:**

Budgeting homework time (60 min): In the Chapter **Photosynthesis (OSB)** has quite a few figures. This should take 8 minutes if you just read it. But w pause to review figures and take good notes, this assignment should take y Give yourself at least 10 more minutes to google and read about Lynn Marg

1. _____ **For Wednesday's lecture, first google "Lynn Margulis" to find notes on, the endosymbiotic hypothesis. Then in the chapter Photosynthesis 8.1 "Overview of Photosynthesis" and take handwritten notes.**
2. _____ (Tip): Prepare to explain (aloud) the anatomy of a chloroplast.
3. _____ **Advanced:** Take a peek at section 8.2, in particular study Fig process in class.

What is OSB? Q? 1-25-23 (Wed class) OSB Photosynthesis

Summary Section 8.1 - Overview of Photosynthesis - (OSB)

- Explain relevance of PHS to other living things
- Describe main structures involved
- ID substrates + products
- Summarize the process

Talk about VF (What do bunnies eat? Cows? Plants?)

PHS is essential to all. $\text{O}=\text{C}=\text{O}$ scores food/bricks (stored in covalent bonds) (oil / coal / salads)

Photoautotrophs: self feed light
Plants, algae + cyanobacteria can do the PHS dance magic. the rest of us sad sacks are heterotrophs that parasite off of them... they die → we die exception → at bottom of ocean - chemoautotrophs do chemistry → food like bacteria thermophiles

Figure 1: photographs organisms that can self-feed we make ATP from stolen C10s via Respiration (electrons gained)

Photosynthesis - can convert light to scores AND store that E longterm (light rxns) (synthesis rxns)

eg. Wolf (predator) → eats deer (prey) → eats grass → eats light beams + air (CO₂) (Star beams/sun)

Figure 2: deer running

Main structures + Summary of Photosynthesis ($6\text{CO}_2 + 6\text{H}_2\text{O} \Rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$) (G3P) glucose (6C's) = 2 G3P's (3C's each)

Sunlight + CO₂ + water ⇒ O₂ + sugar/wood (waste product)

where? → leaves of plants mostly → inside leaf in mesophyll cells → inside chloroplast

holes = stomata/stomata - let CO₂ inside leaf can open/close (chloroplast)

holes found underside / bottom of leaf = stomata (mouth)

H₂O from ground → H₂O exits escapes → CO₂ (gas) enters inside thylakoid lumen → thylakoid memb. → stack called "granum" → outer memb. (in between) inner memb. space → region call "stroma" aqueous/watery fluids = "bed"

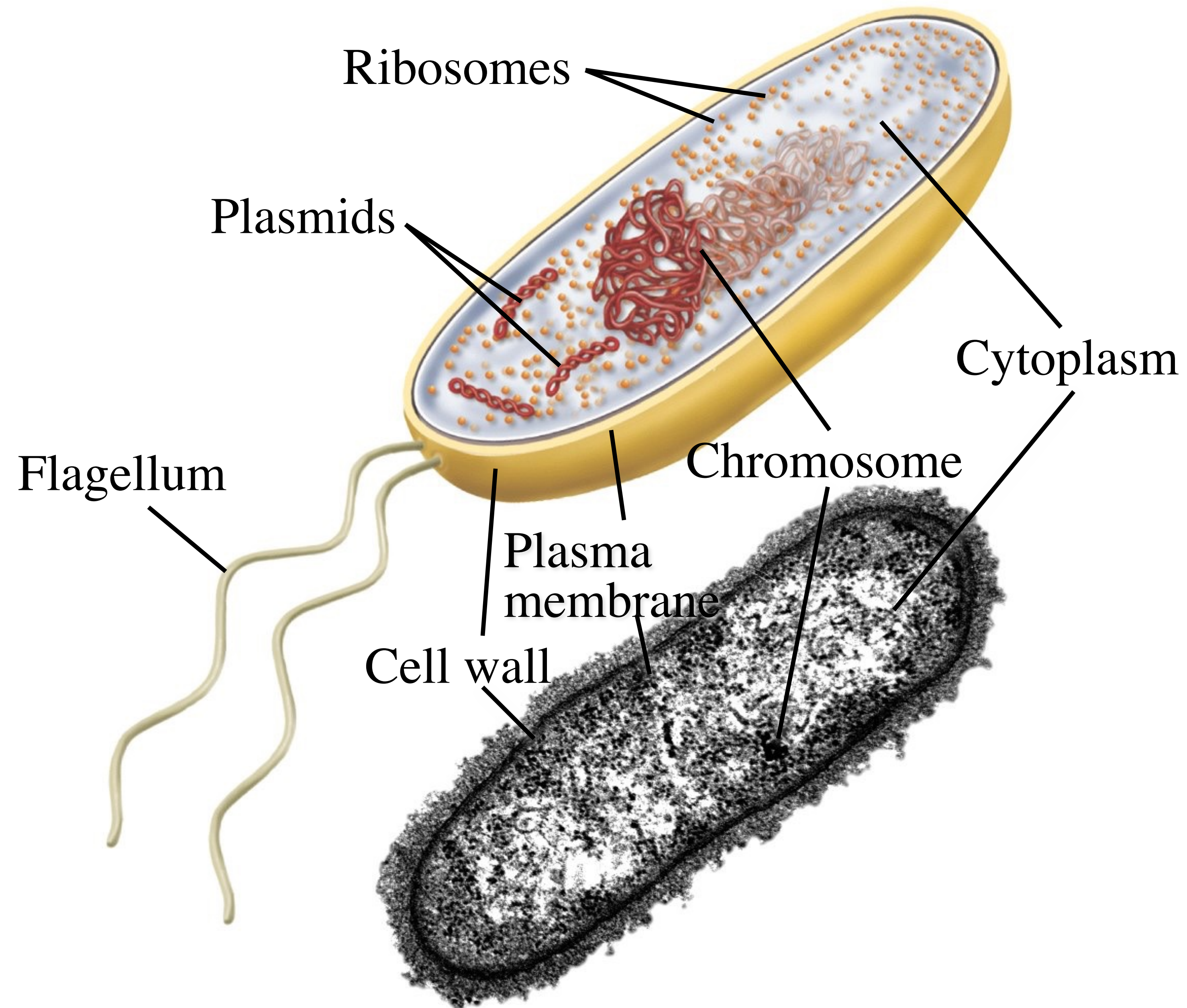
green color = (paint) because lot of green pigments = chlorophyll

Two Parts to Photosynthesis

photo (light reactions) + synthesis (light-independent reactions) → sugar/wood

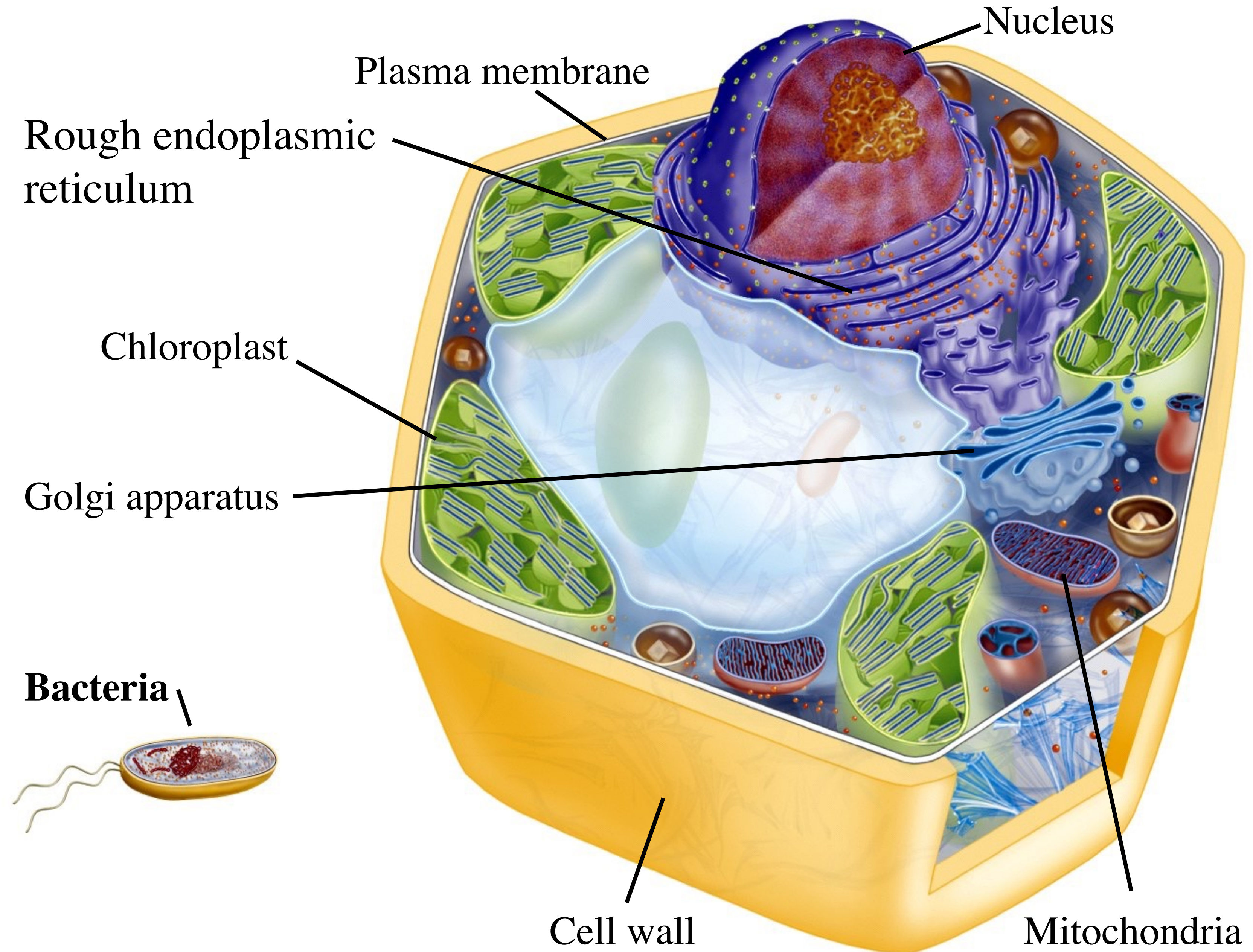
CO₂ → dependent → O₂ (waste) → Calvin Cycle

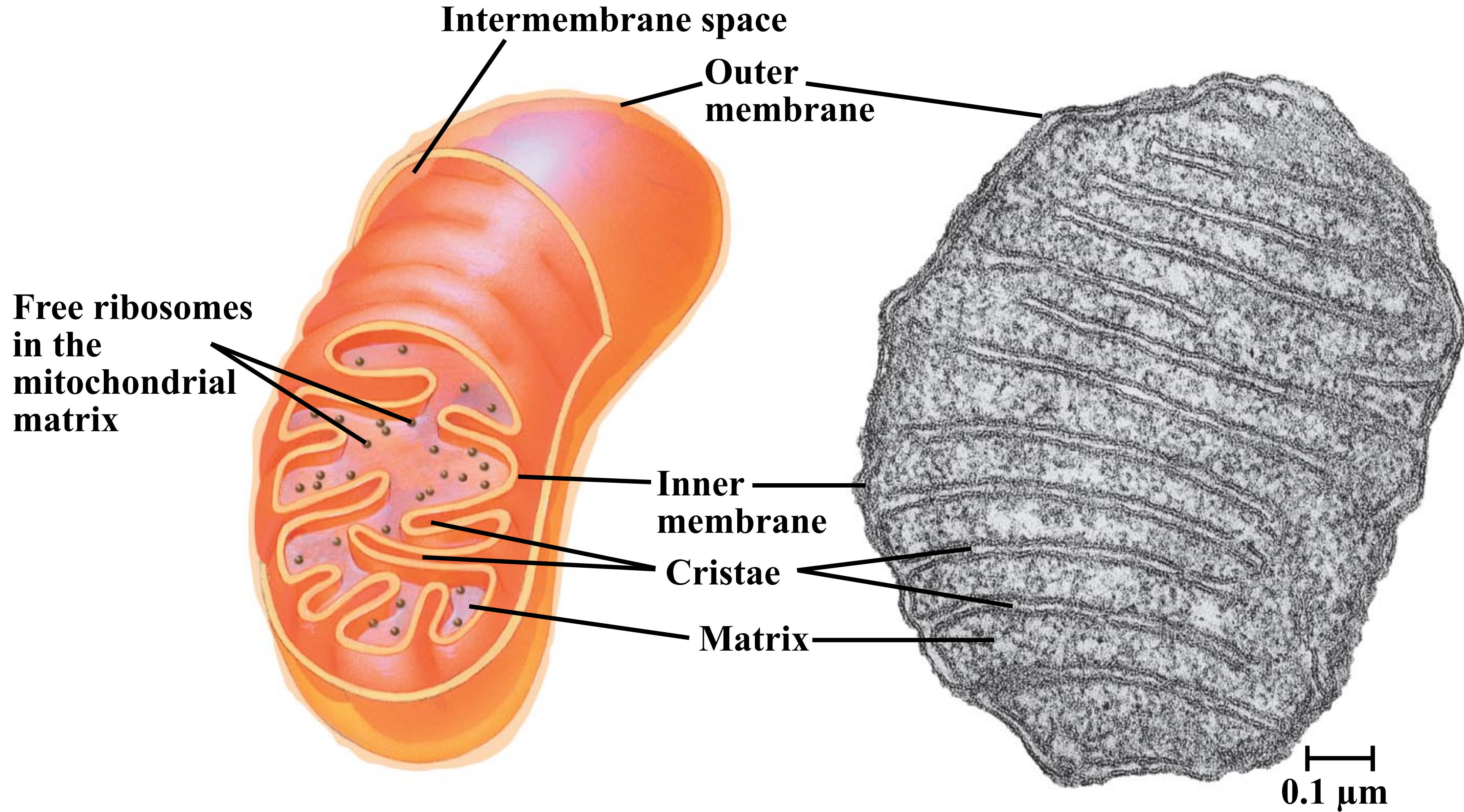
sunlight → NADPH → ATP



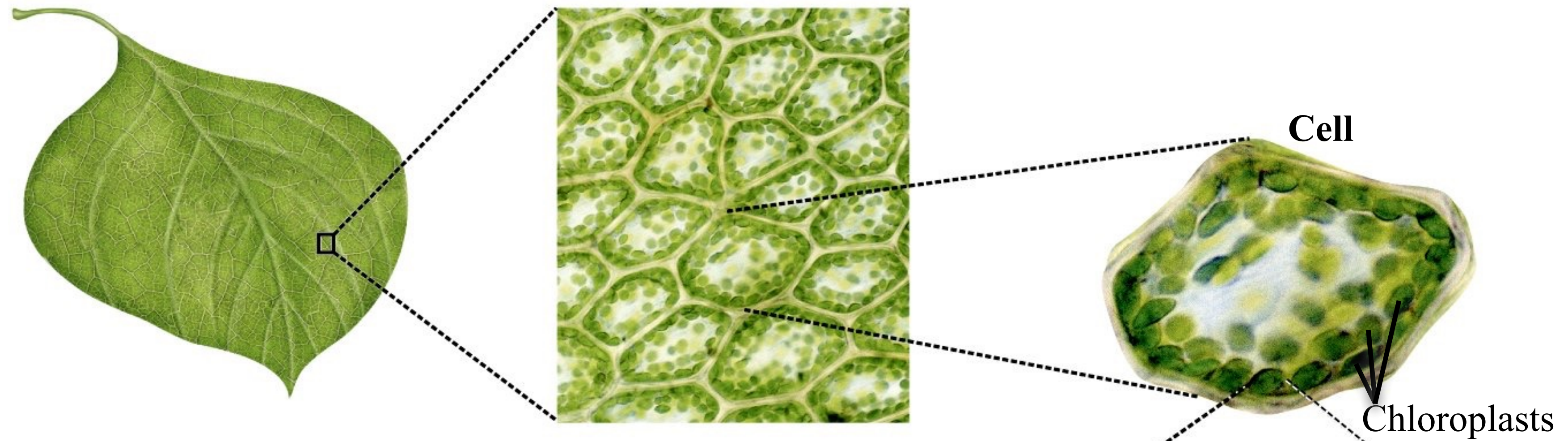
So what does a bacteria cell have?

What eukaryotic cell has that prok. doesn't?

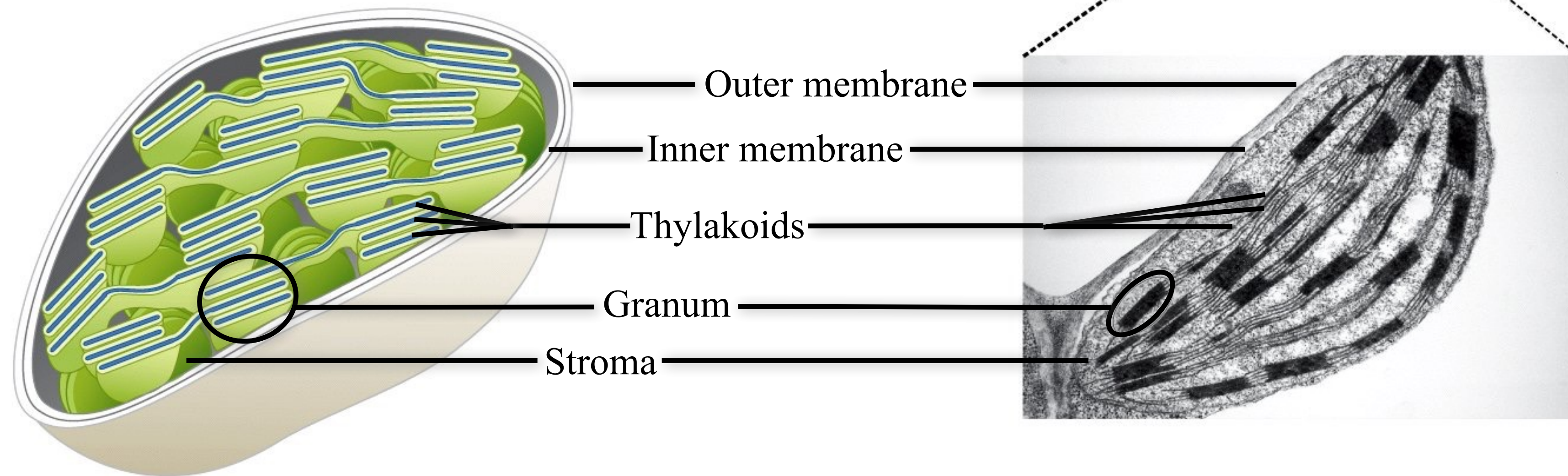


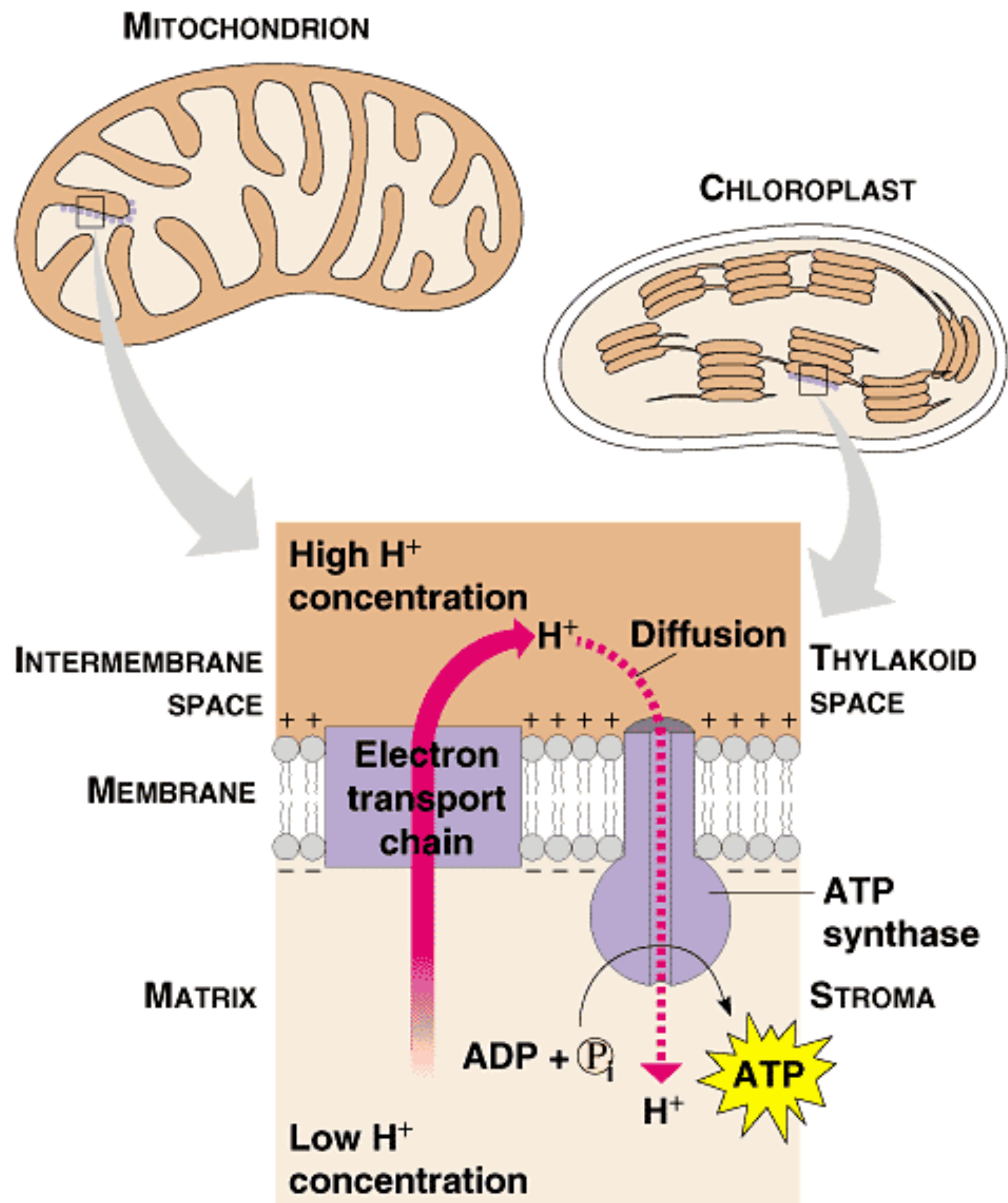


Leaves contain millions of chloroplasts.



Chloroplasts are highly structured, membrane-rich organelles.





So where did my organelles come from?



What does *endosymbiosis* suggest is the evolutionary origin of the chloroplast?



Lynn Margulis as a young woman.
Source:
<http://www.bu.edu/cas/bio100/bio-history/faculty/>; accessed May 15, 2006.

- a. nuclear envelope
- b. invagination of membrane
- c. golgi apparatus
- d. endocytosis of bacterium
- e. infection of virus

Plasma membrane

Cytoplasm

**Ancestral
prokaryote**

DNA

Invagination

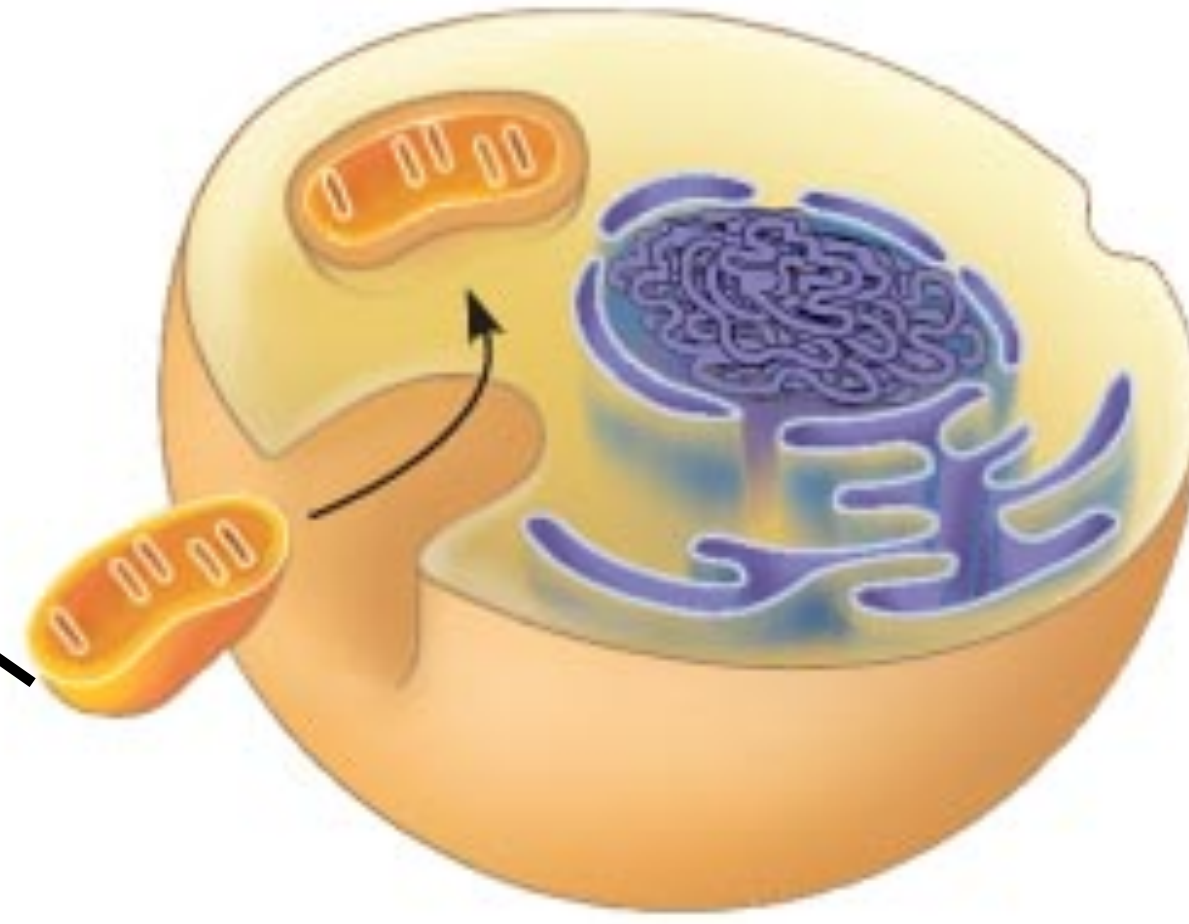
Endoplasmic reticulum

Nucleus

Nuclear envelope

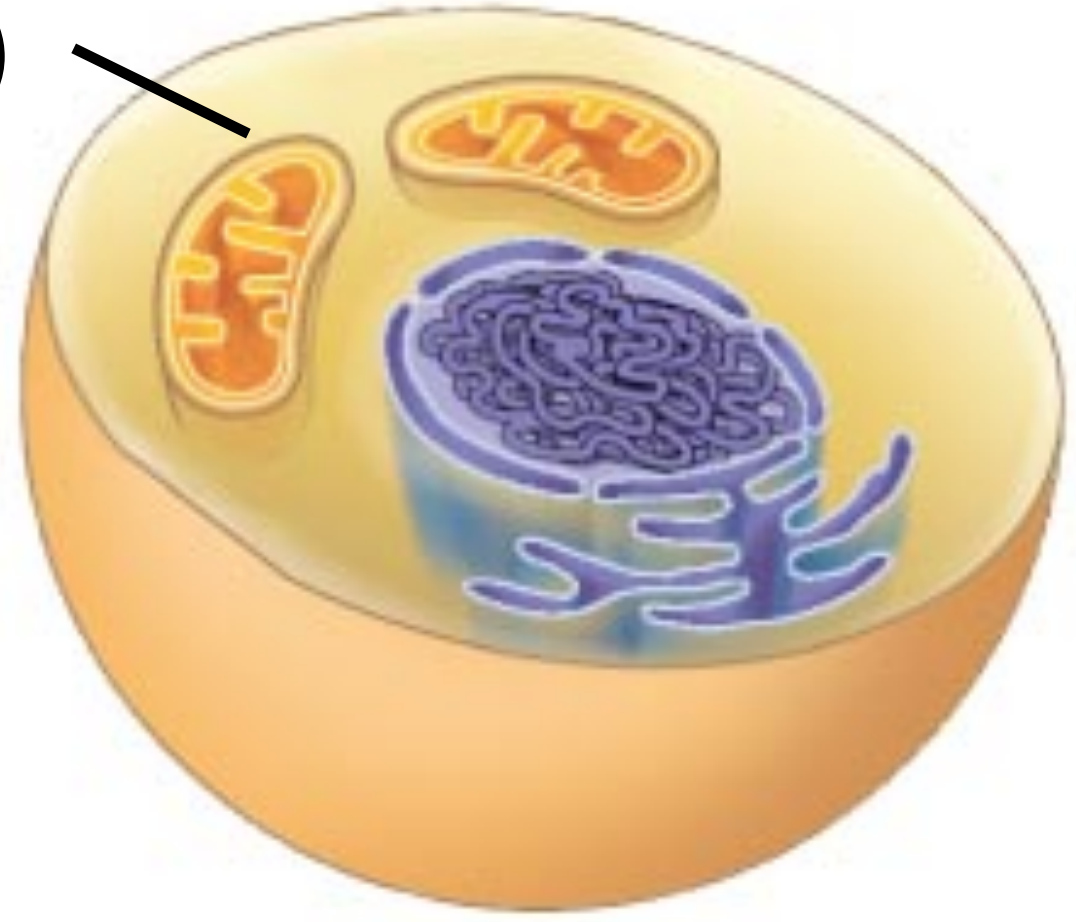


**Aerobic
heterotrophic
prokaryote**



Endocytosis

**Mitochondrion
(with extra mem)**



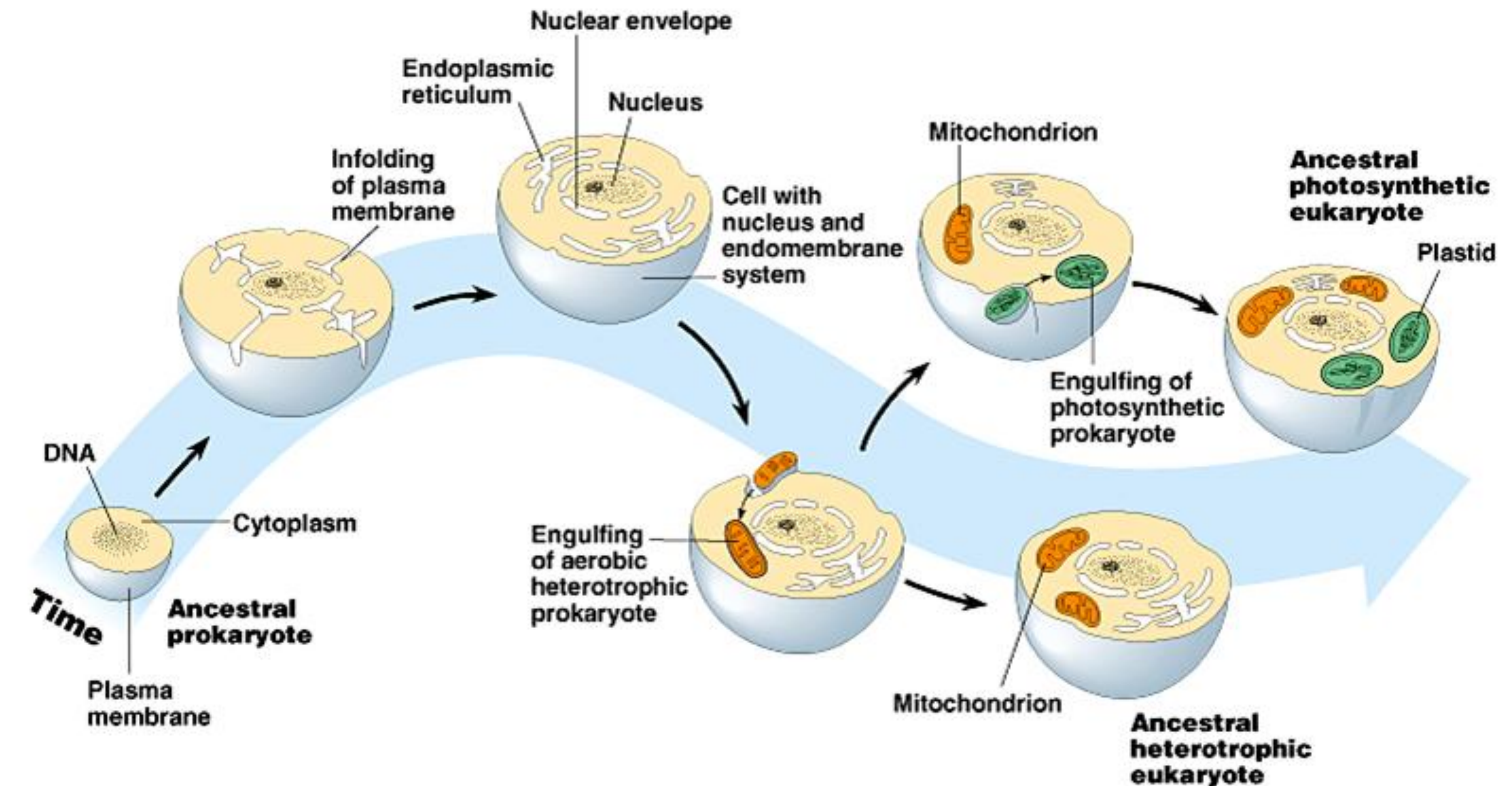
How to test the *endosymbiosis* hypothesis...

What evidence could you look for?

(that might support or refute the hypothesis)



Lynn Margulis as a young woman.



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Design an experiment

to test the *endosymbiosis* hypothesis...

- Maybe using PCR
- Maybe using Microscopy
- Perhaps using streptomycin, erythromycin, or tetracycline
- What's the Trifecta of your experiment: purpose, methods and predicted results?

Evidence for Endosymbiosis

Mitochondria/Chloroplasts ↔ Bacteria

Morphology/Behavior: They swim around in your cells, divide, look like cyanobacteria etc

Anatomy: Have 2 membranes, inner like bacteria & outer like plasma membrane.

Molecular: Their own genes & ribosomes, that function-sequences of genes, ribosomes, same as bacteria, antibiotic, circular no histones

Pathogens: Undigested prey or parasites *via endo*

How do chloroplasts function? (a deep dive into one organelle)

Biology Learning Objective

- Build knowledge of the processes used by chloroplasts when functioning (photosynthesis).
- How do photons that depart the sun and strike the earth get converted to chemical energy (ATP, CHO) that is the source of all life.

5. Photosynthesis

The Light-Dependent Reactions of Photosynthesis



Summary: By the end of this section, you will be able to:

- Explain how plants absorb energy from sunlight
- Describe short and long wavelengths of light
- Describe how and where photosynthesis takes place within a plant

How can light be used to make food? When a person turns on a lamp, electrical energy becomes light energy. Like all other forms of kinetic energy, light can travel, change form, and be harnessed to do work. In the case of photosynthesis, light energy is converted into chemical energy, which photoautotrophs use to build carbohydrate molecules (**Figure 1**). However, autotrophs only use a few specific components of sunlight.

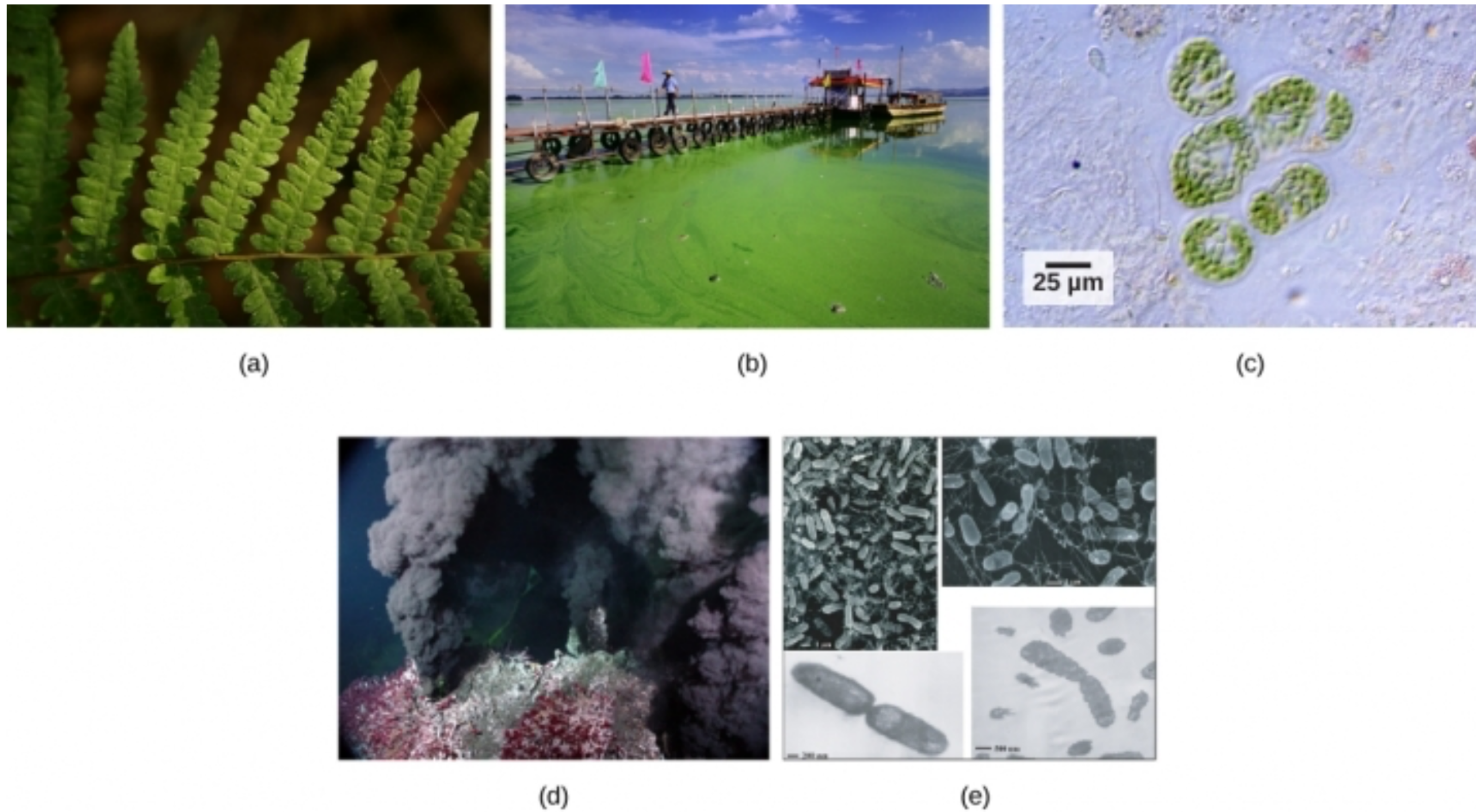
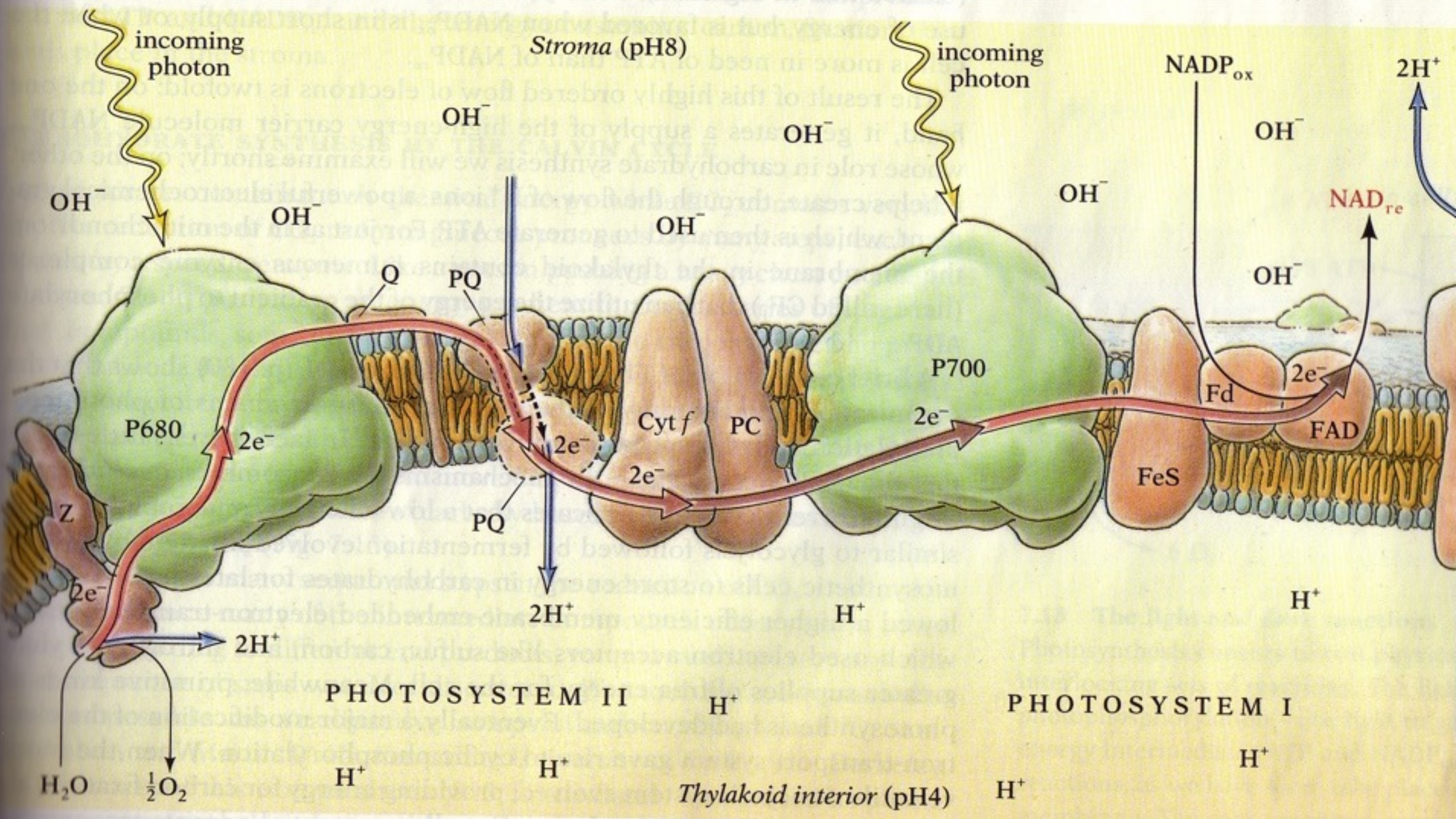
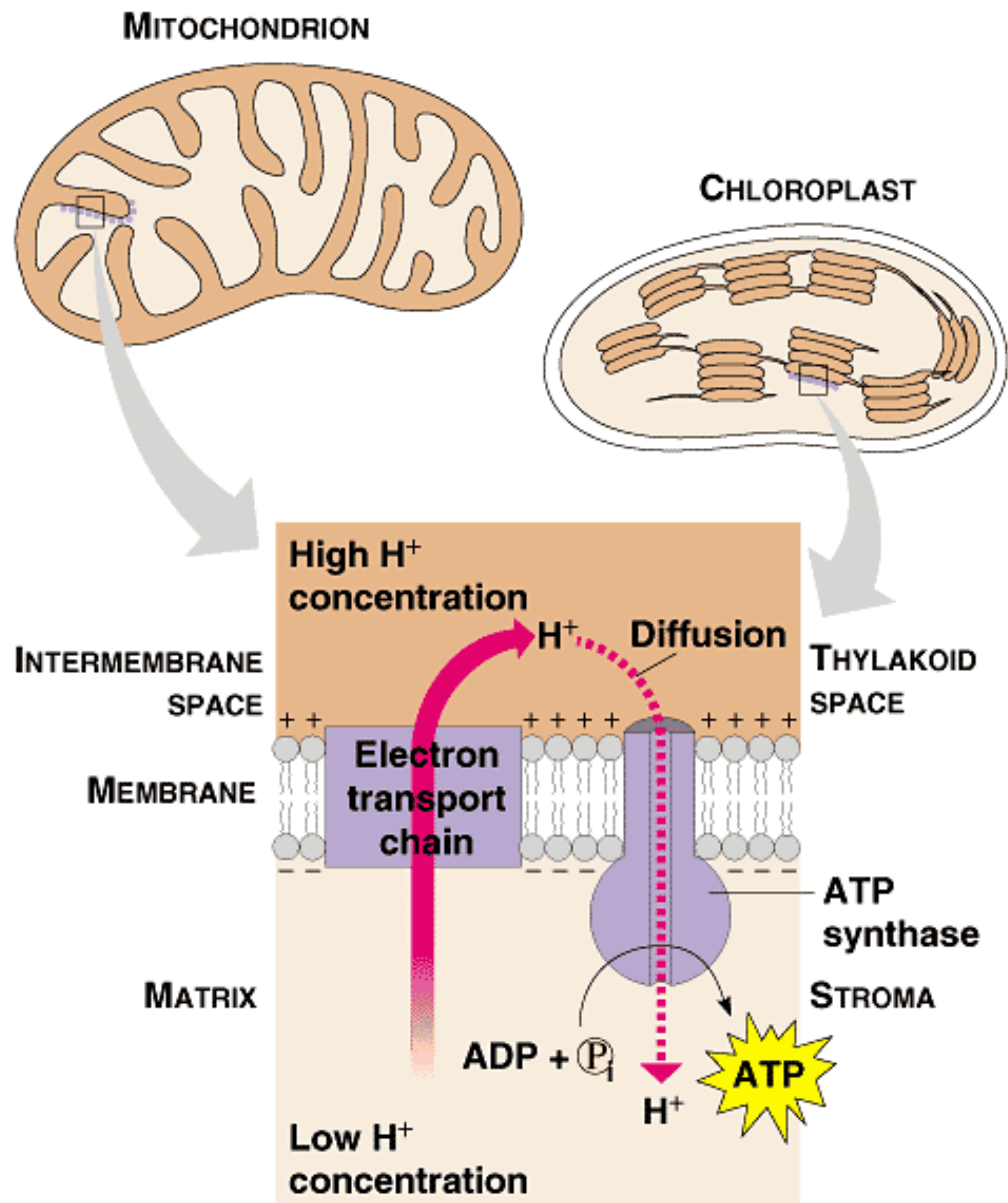
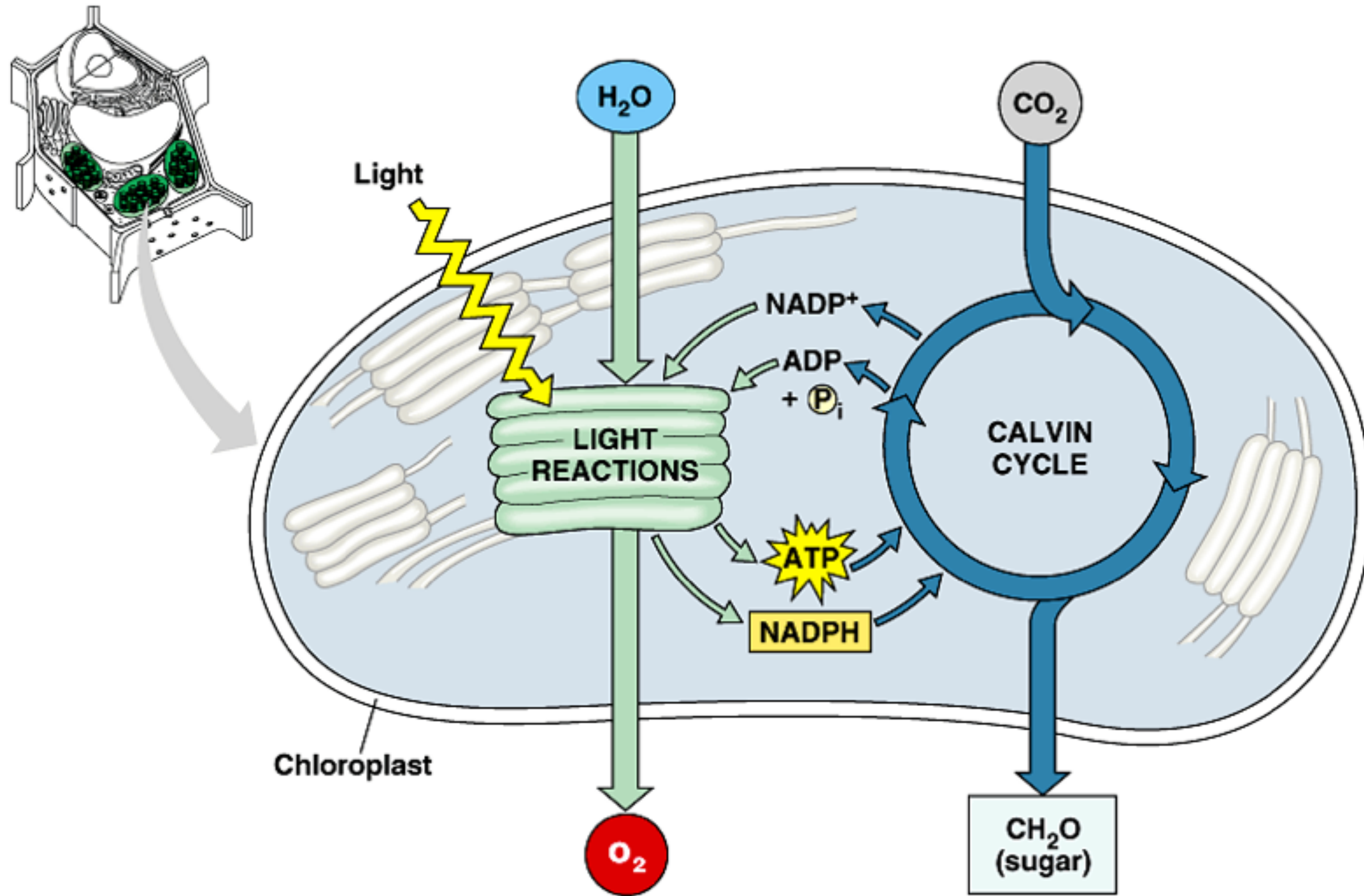


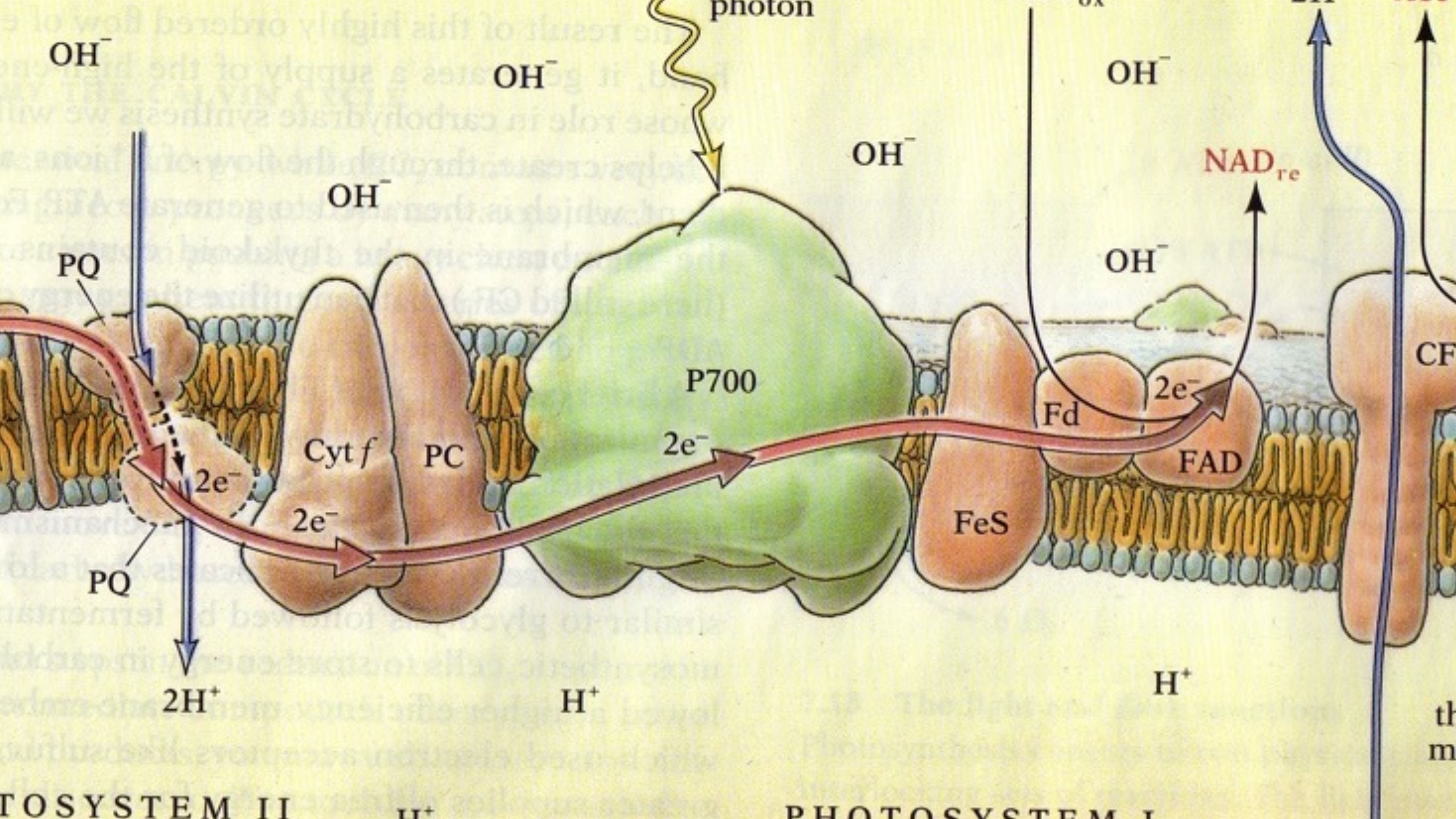
Figure 1: Photoautotrophs including (a) plants, (b) algae, and (c) cyanobacteria synthesize their organic compounds via photosynthesis using sunlight as an energy source. Cyanobacteria and planktonic algae can grow over enormous areas in water, at times completely covering the surface. In a (d) deep sea vent, chemoautotrophs, such as these (e) thermophilic bacteria, capture energy from inorganic compounds to produce organic compounds. The ecosystem surrounding the vents has a diverse array of animals, such as tubeworms, crustaceans, and octopi that derive energy from the bacteria. (credit a: modification of work by Steve Hillebrand, U.S. Fish and Wildlife

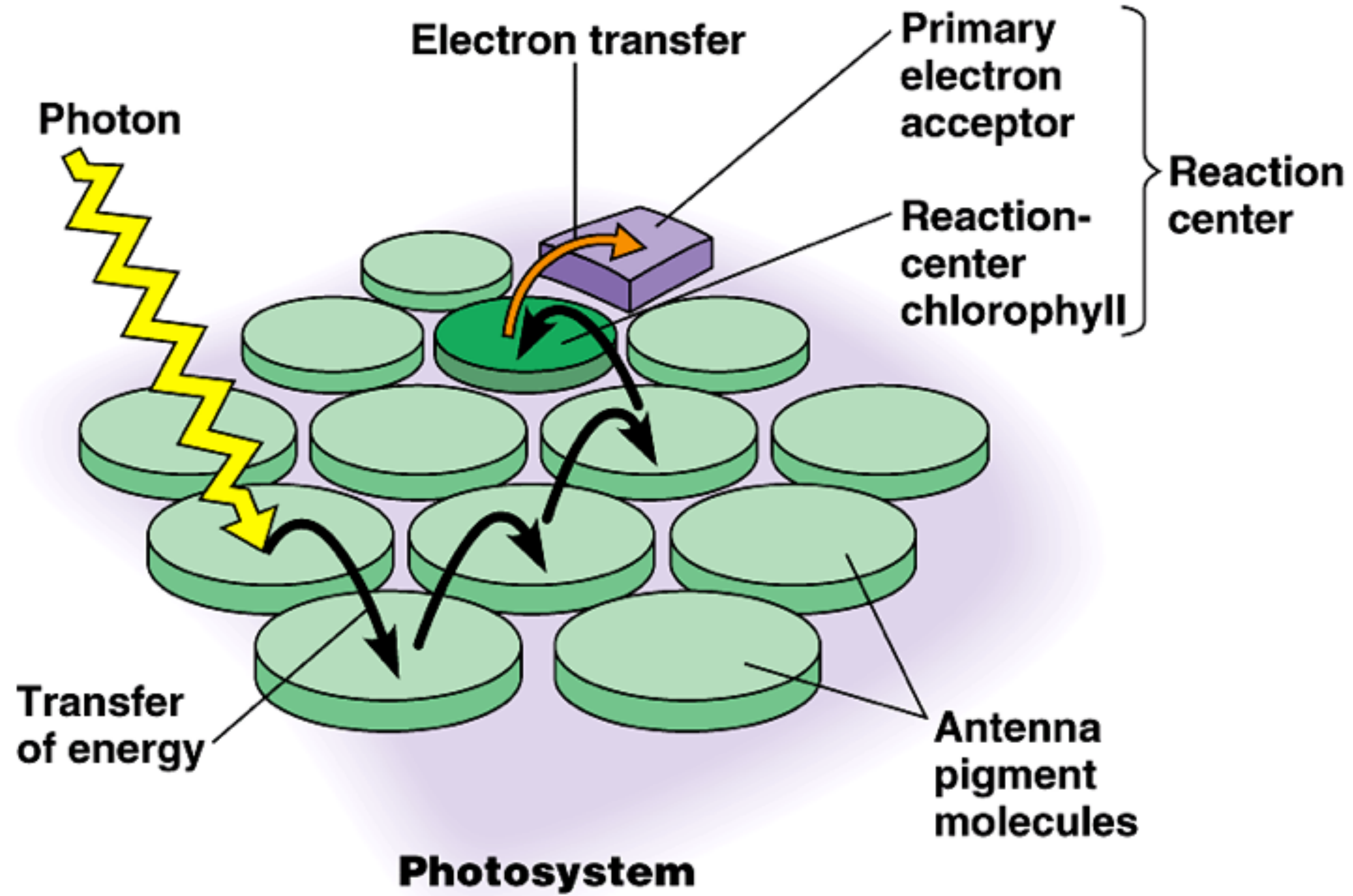




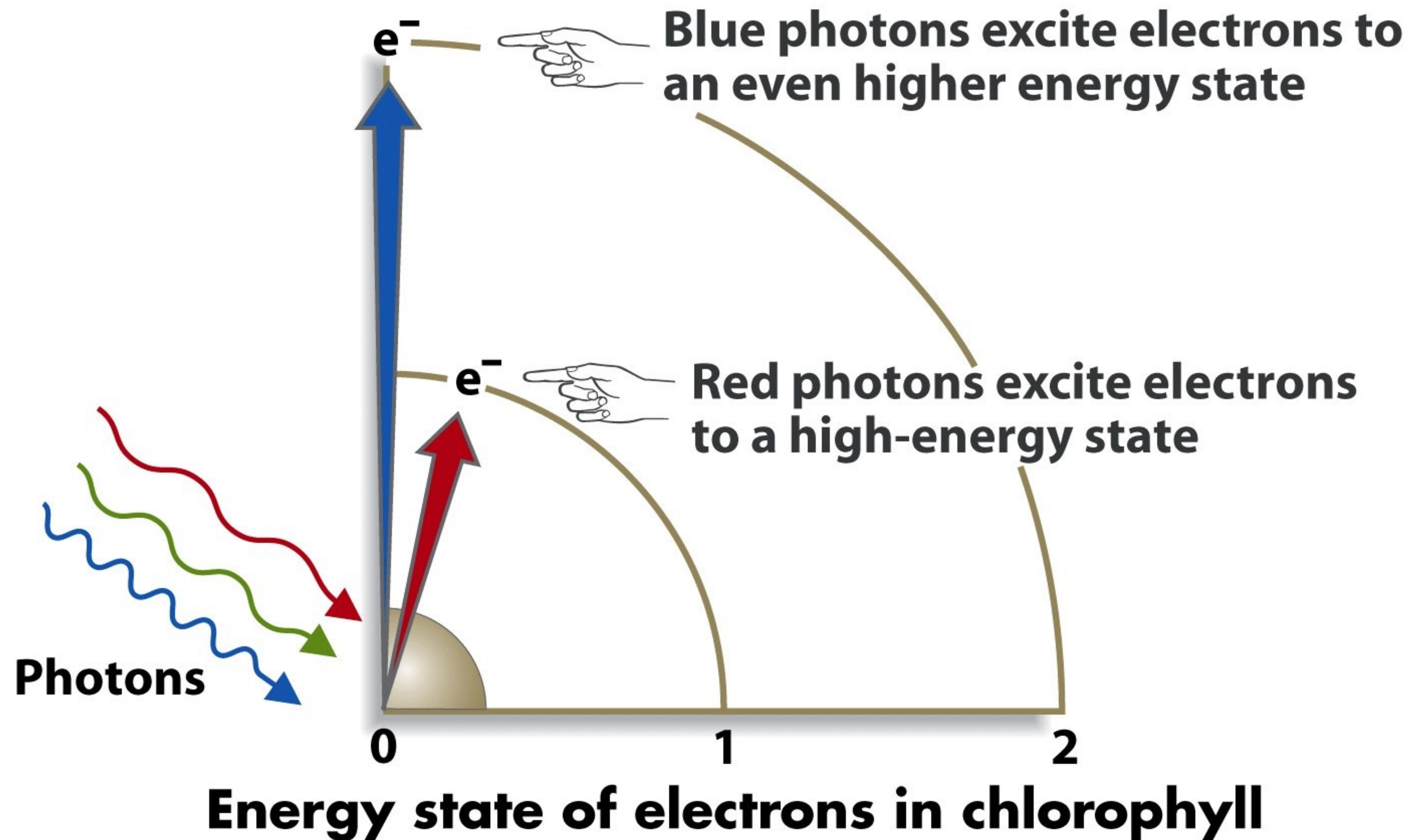








When Light Is Absorbed, Electrons Enter an Excited State



Time to capture photons (photosystem football)

