Cell Biology 101

- 3 midterm exams : 30% each
- Attendance 10%
- Pass the course: 65%
- 65% - C
- 75% - B
- 85% - A
- 95% - A+

Introduction to Cell

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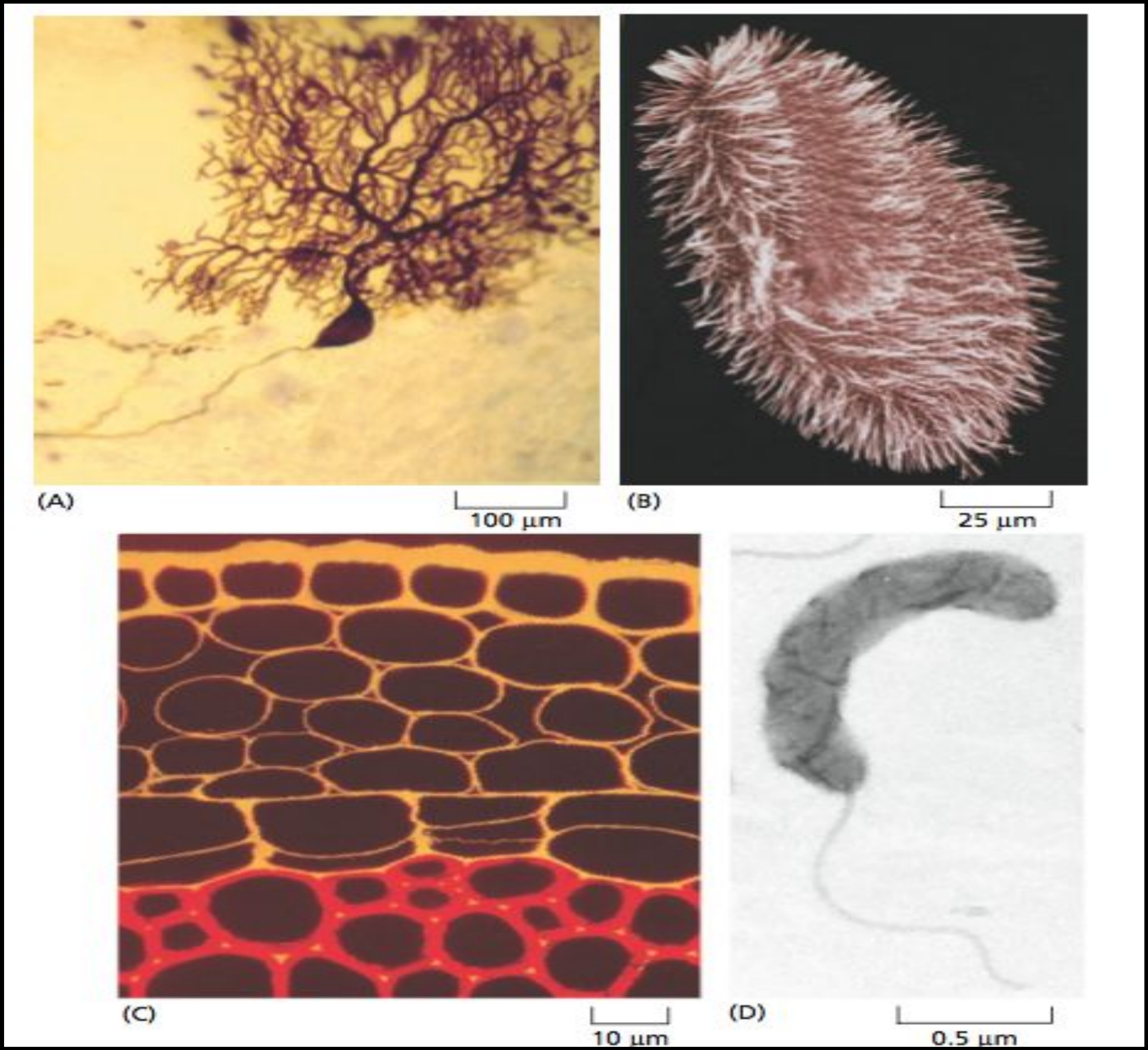
1.0 Unity and diversity of cells

What defines “Life”?

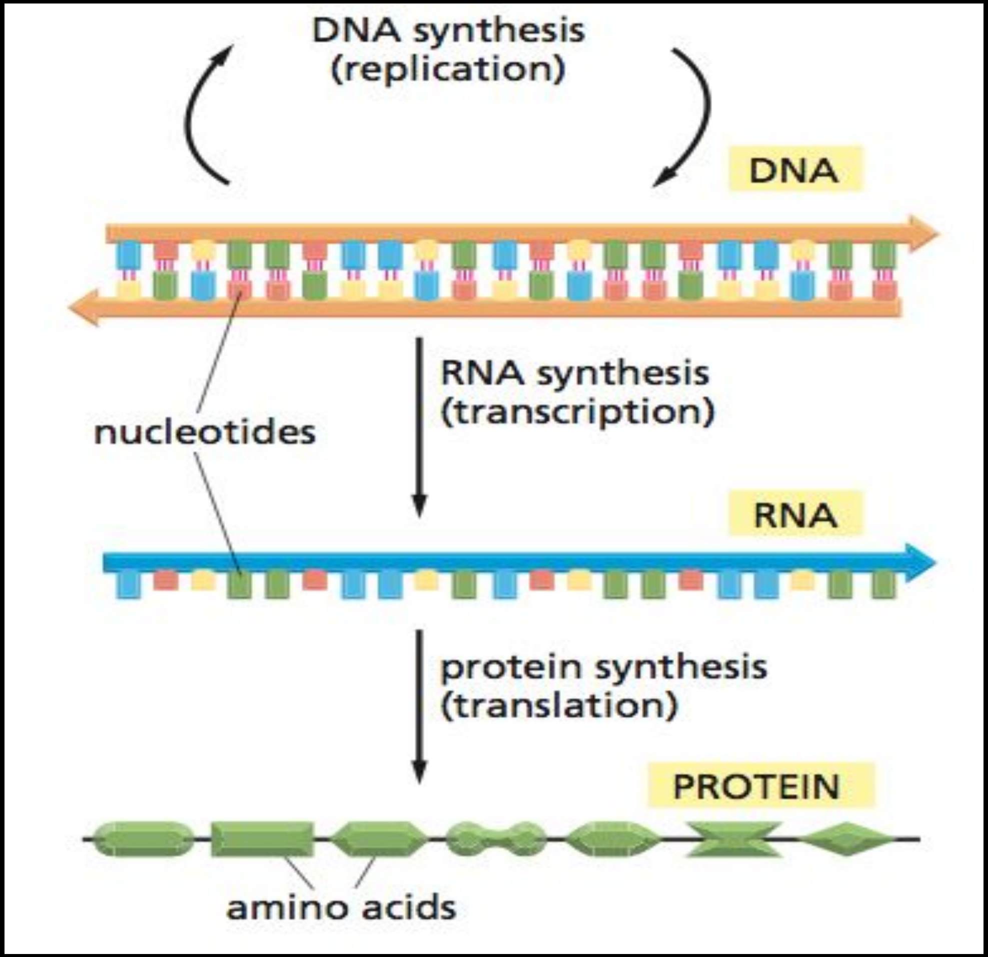
1. Are highly organized
2. Homeostasis
3. Reproduce themselves
4. Grow and develop
5. Use the energy from environment and transform it
6. Respond to stimuli
7. Adaptation to environment

Cells come in a variety of shapes and sizes



A. Nerve cell
B. Paramecium
C. Plant tissue
D. Bacterial cell

Living cells all have a similar basic chemistry

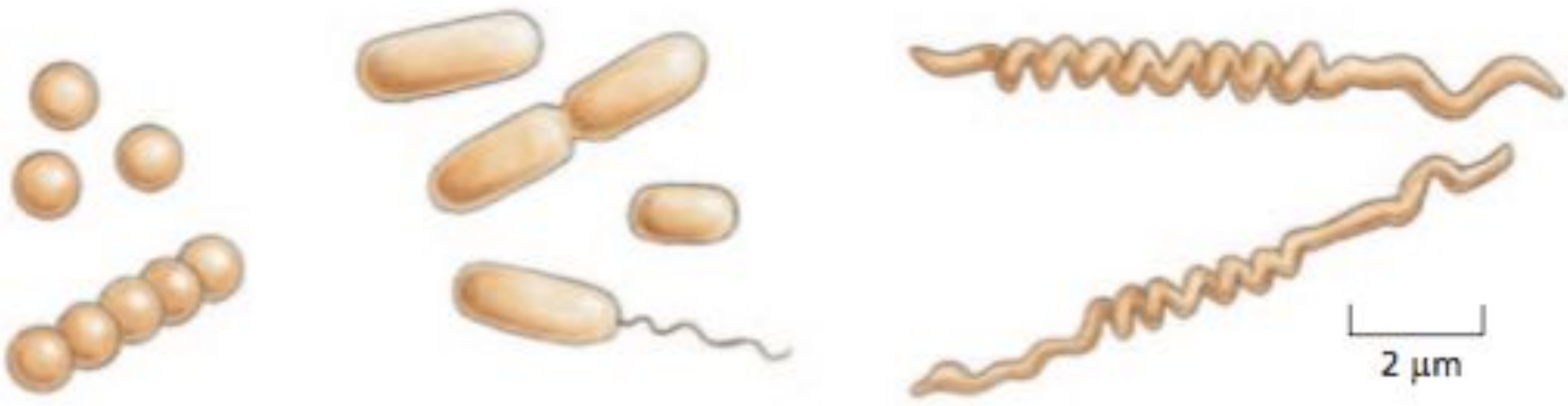


1. Same biological molecules
2. Evolved from common ancestor
3. Homolog genes
4. Almost the same genetic code
5. Genes defines cell characteristics

Prokaryotic cell

- Have simplest structure
- No organelles
- No nucleus, just naked DNA
- “Pro”- before, “karyo”-nucleus
- Different sizes and shapes
- Ex: domain bacteria and archea

Different size and shapes of bacteria



spherical cells,
e.g., *Streptococcus*

rod-shaped cells,
e.g., *Escherichia coli*,
Salmonella

spiral cells,
e.g., *Treponema pallidum*

Some other features of bacteria

- Have cell wall- may differ upon peptidoglycan content: gram positive and negative
- E. coli can divide every 20 minutes
- 8 billion in 11 hours: WOW!!!!
- $N=N_0 \times 2^{t/G}$: number of cells at time "t"

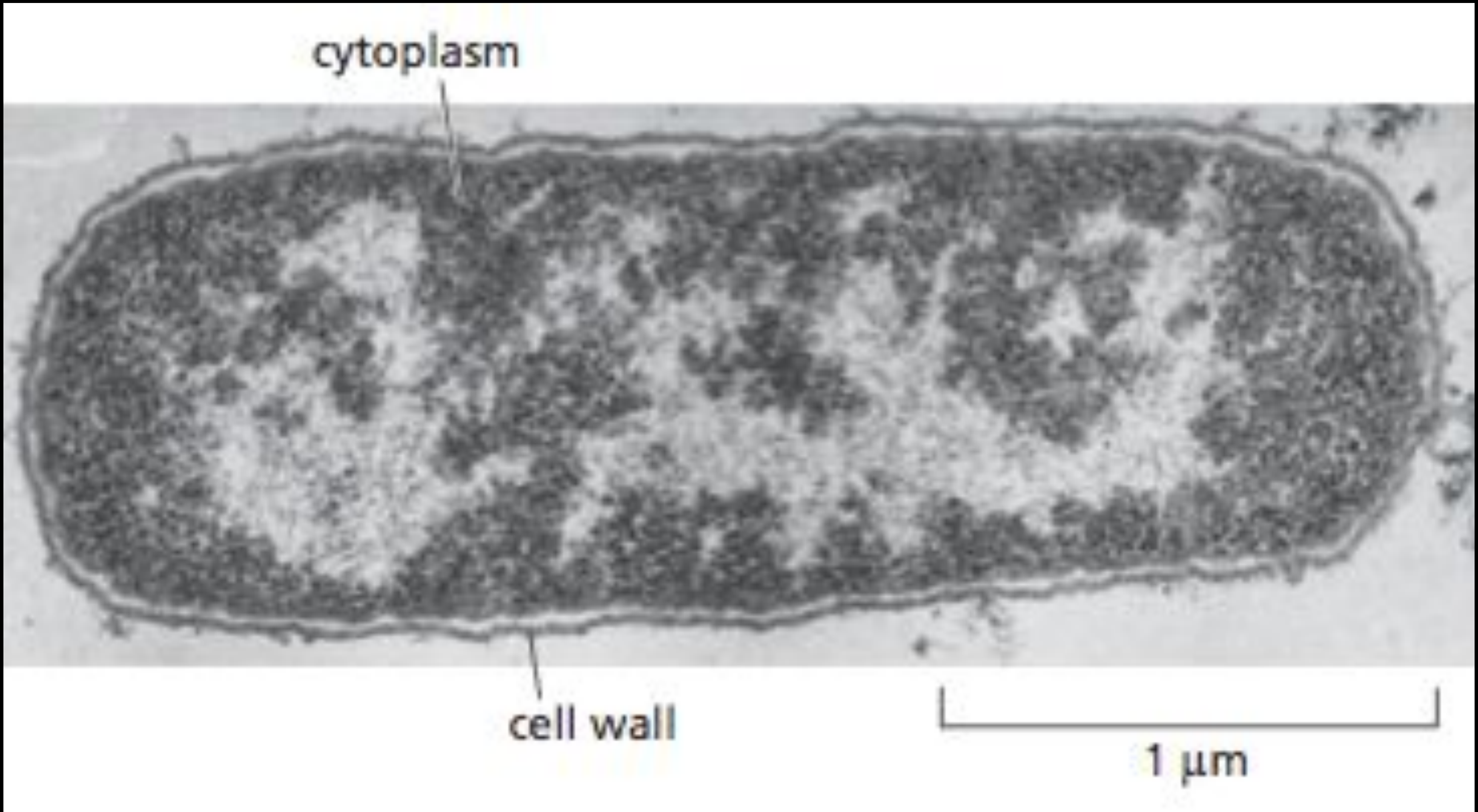
  N_0: # of cells at time 0

  G: population doubling time

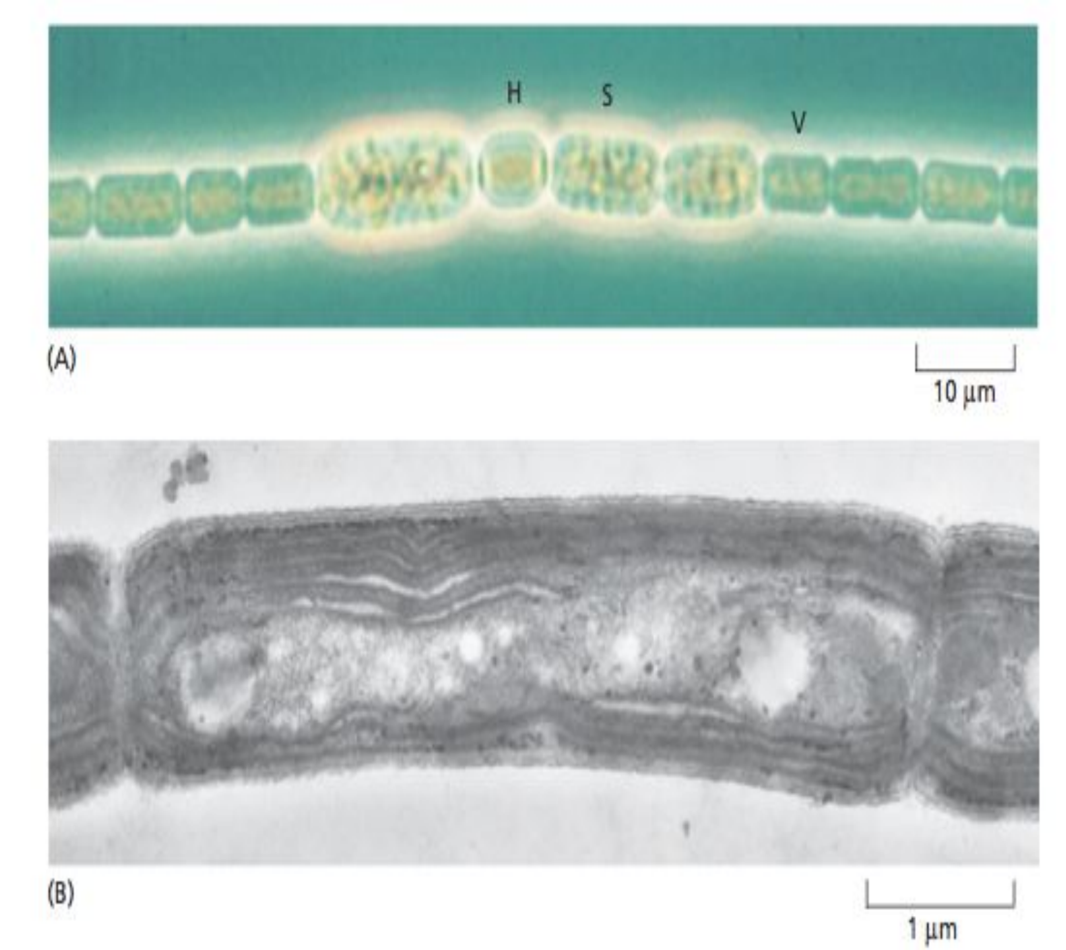
Prokaryotes are the most diverse and numerous cells on Earth

- Can be single celled and form clusters, chains
- Can live in numerous environments: hot, salty, soil and etc..
- Can be photosynthetic
- Can be aerobic or anaerobic
- E.coli serve as a model organism to study molecular biology

E.coli as a model organism

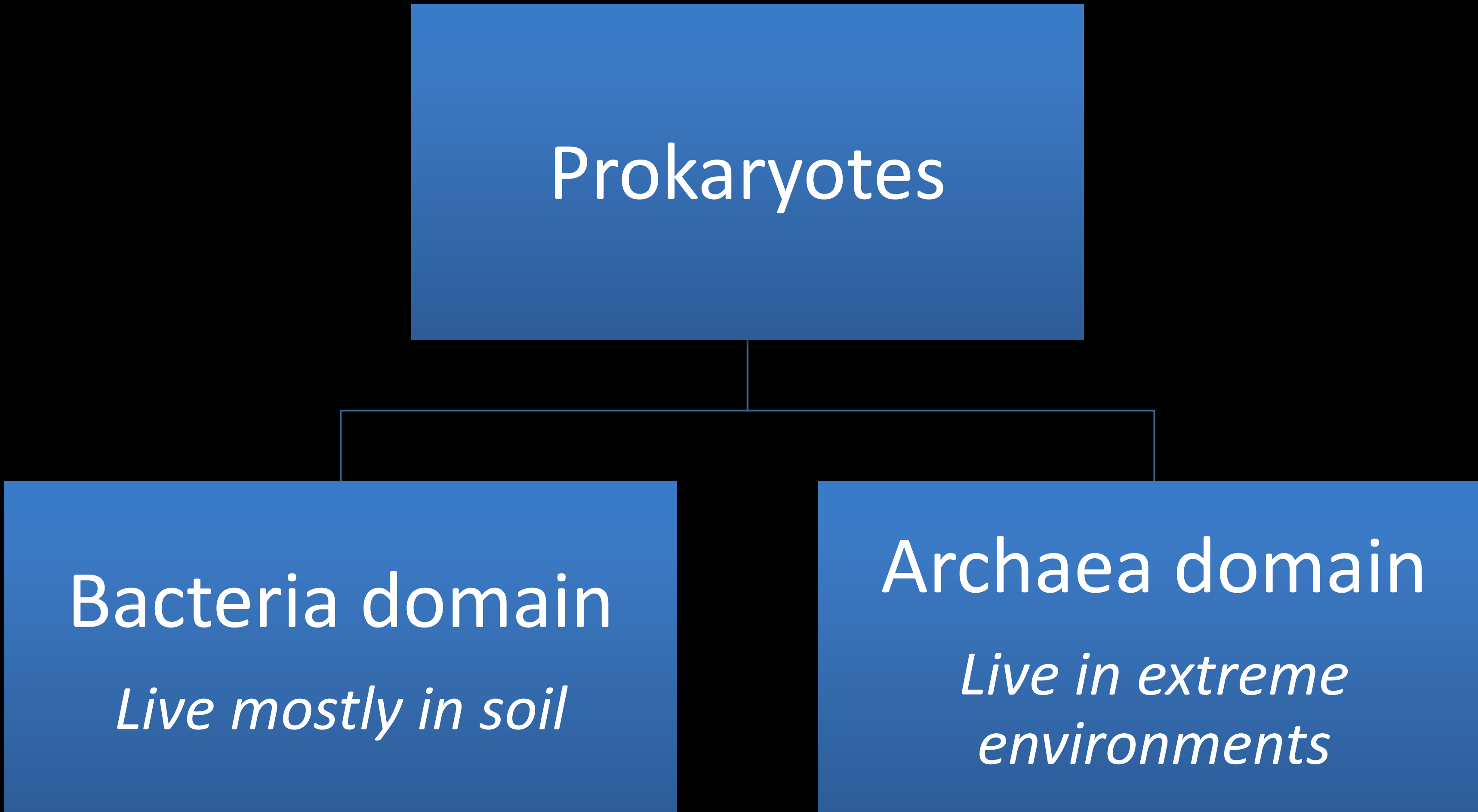


Some bacteria are photosynthetic



A. Anabaena cylindrica
H: structure that fix N_2
S: structure that become spores
V: Photosynthetic cells

B. Phormidium laminosum
Electron micrograph of another
Photosynthetic bacteria

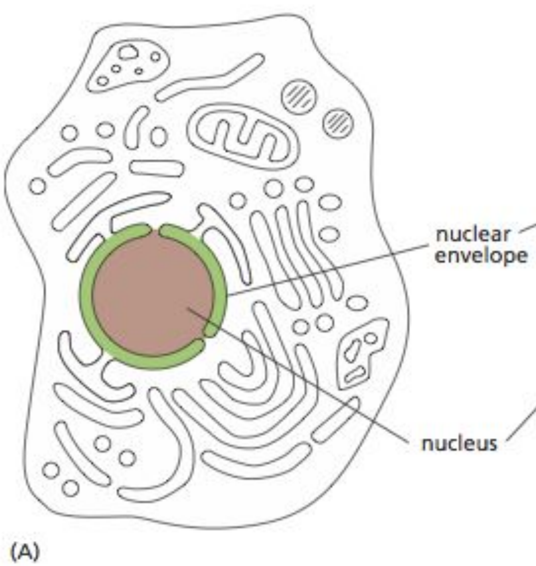

Prokaryotes
Bacteria domain
Live mostly in soil
Archaea domain
Live in extreme environments

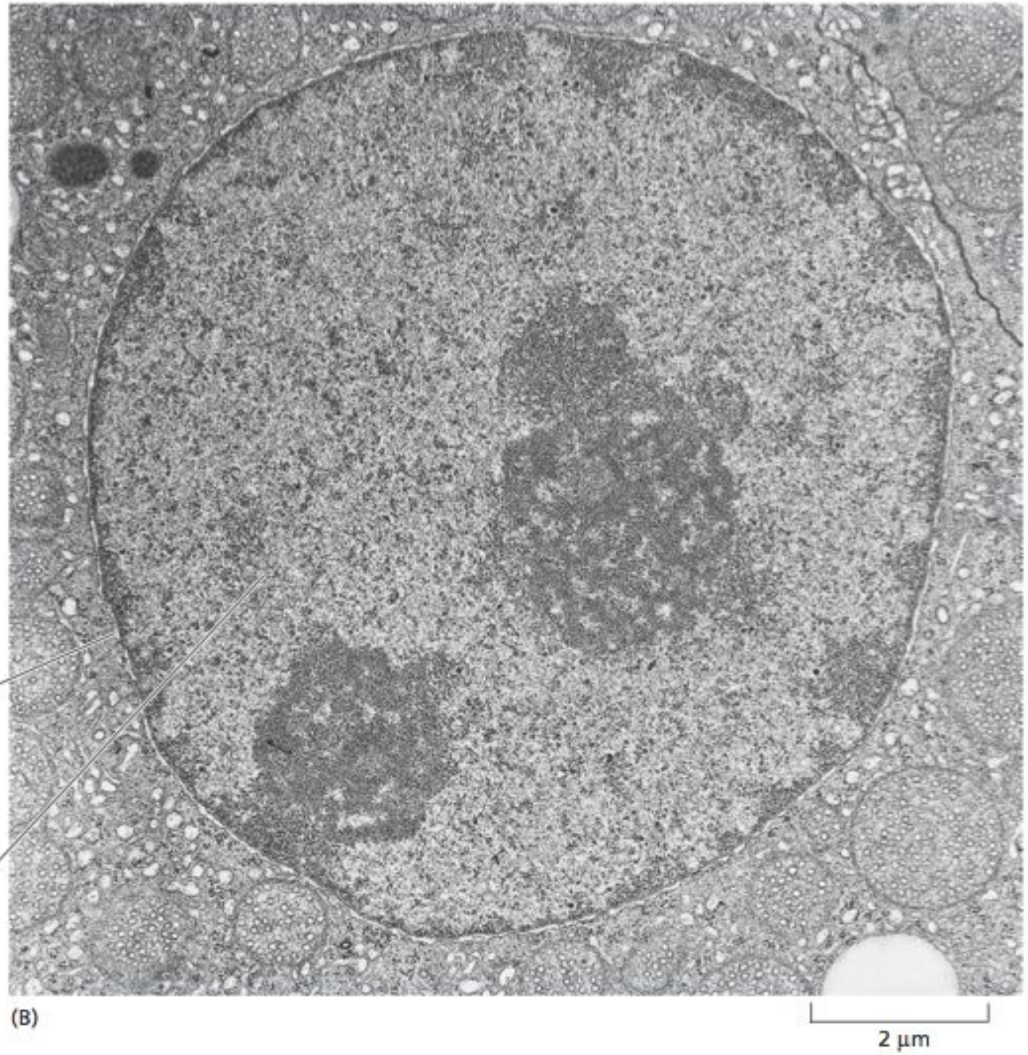
The eukaryotic cells

- Bigger in size
- Elaborate lots of forms: unicellular and multicellular
- Have nucleus and other membrane bound organelles

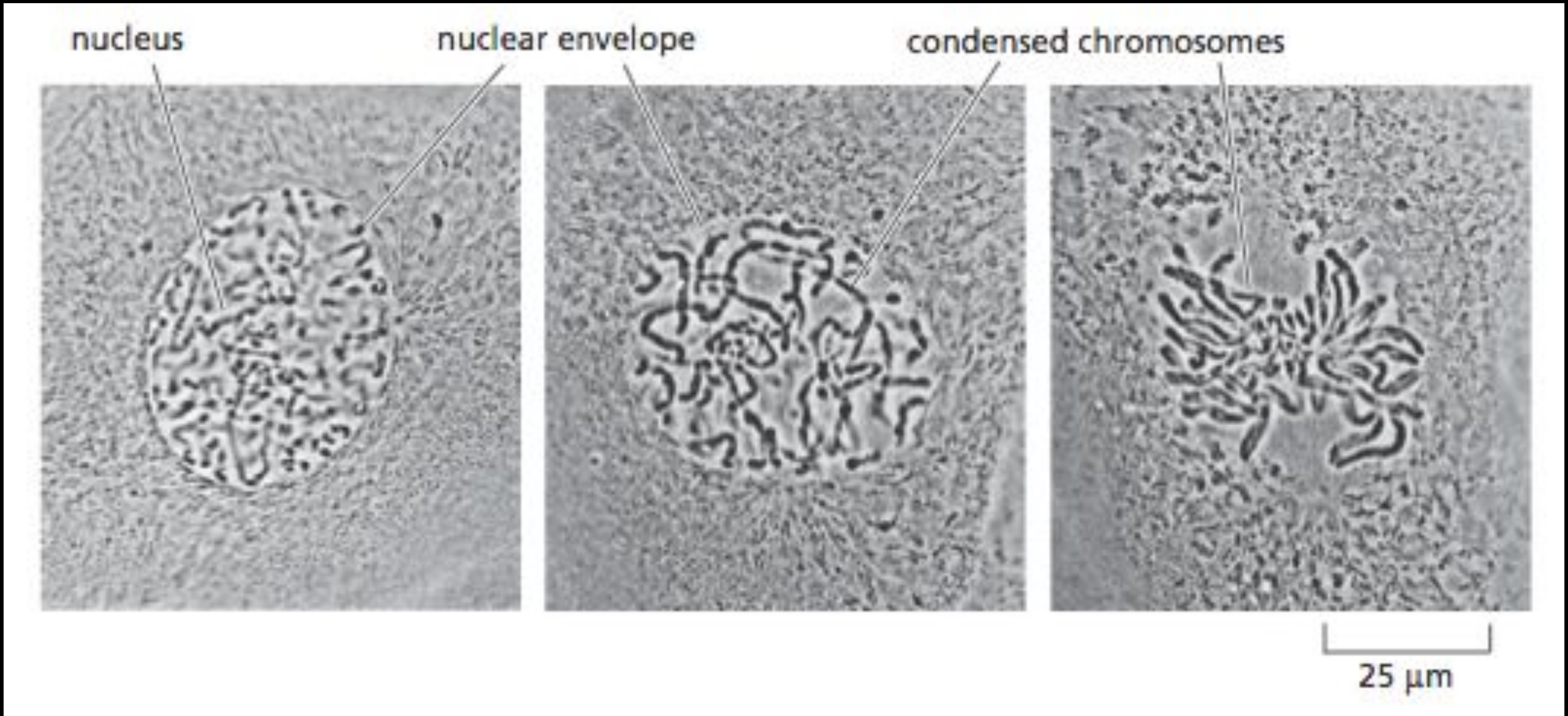
The nucleus is the information store of the cell

Figure 1–14 The nucleus contains most of the DNA in a eukaryotic cell. (A) This drawing of a typical animal cell shows its extensive system of membrane-enclosed organelles. The nucleus is colored *brown*, the nuclear envelope is *green*, and the cytoplasm (the interior of the cell outside the nucleus) is *white*. (B) An electron micrograph of the nucleus in a mammalian cell. Individual chromosomes are not visible because at this stage of the cell's growth its DNA molecules are dispersed as fine threads throughout the nucleus. (B, courtesy of Daniel S. Friend.)

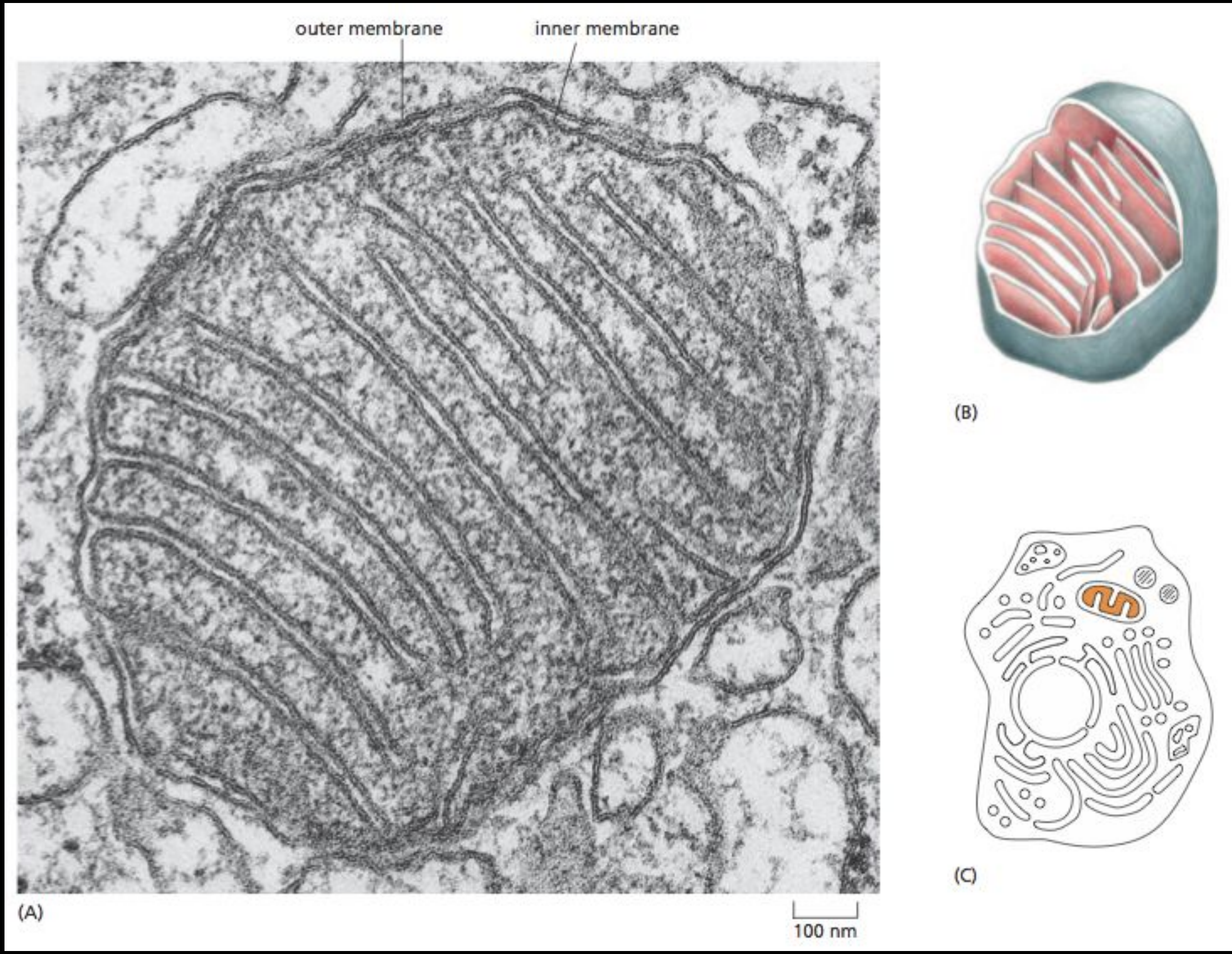




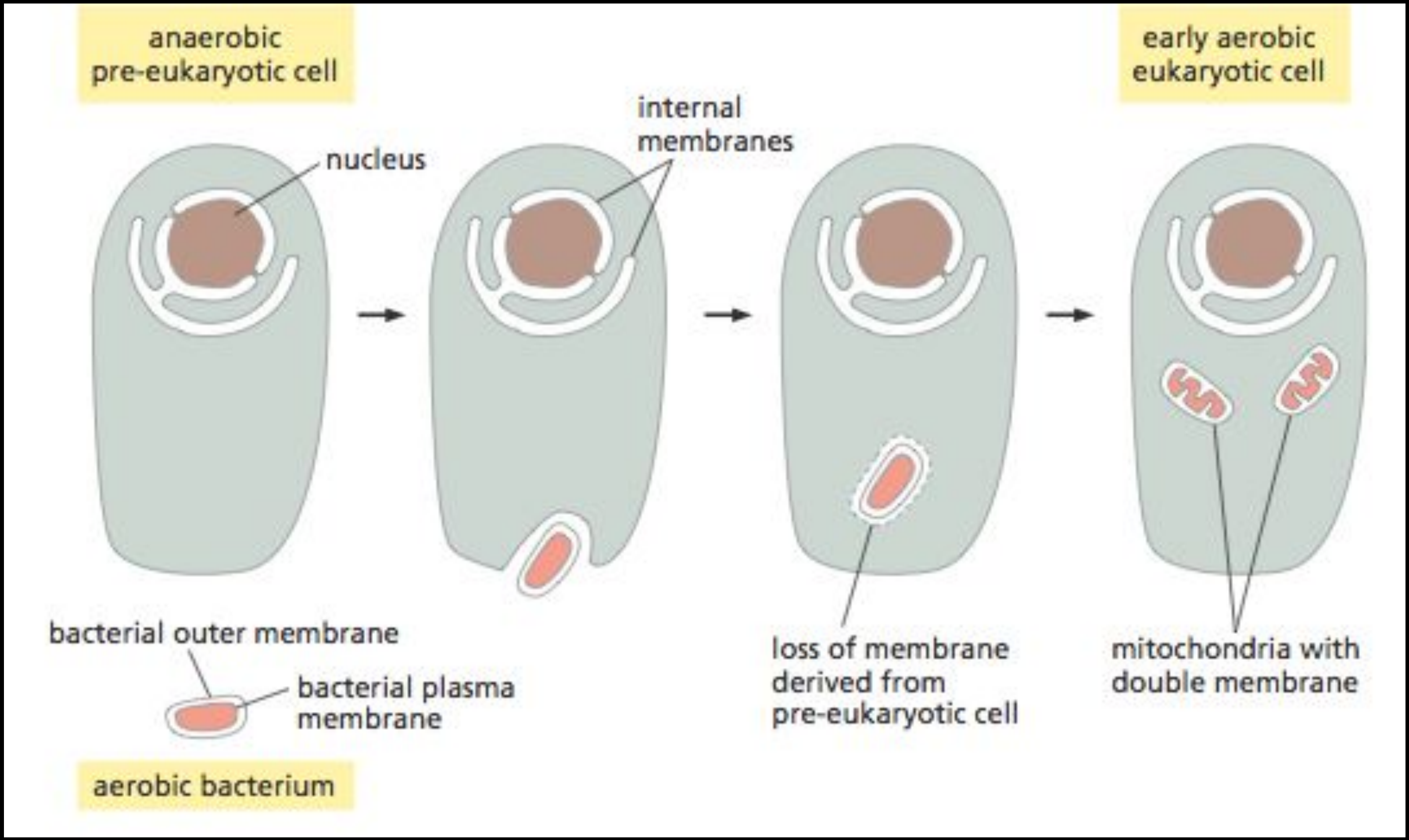
Chromosomes become visible when a cell is about to divide



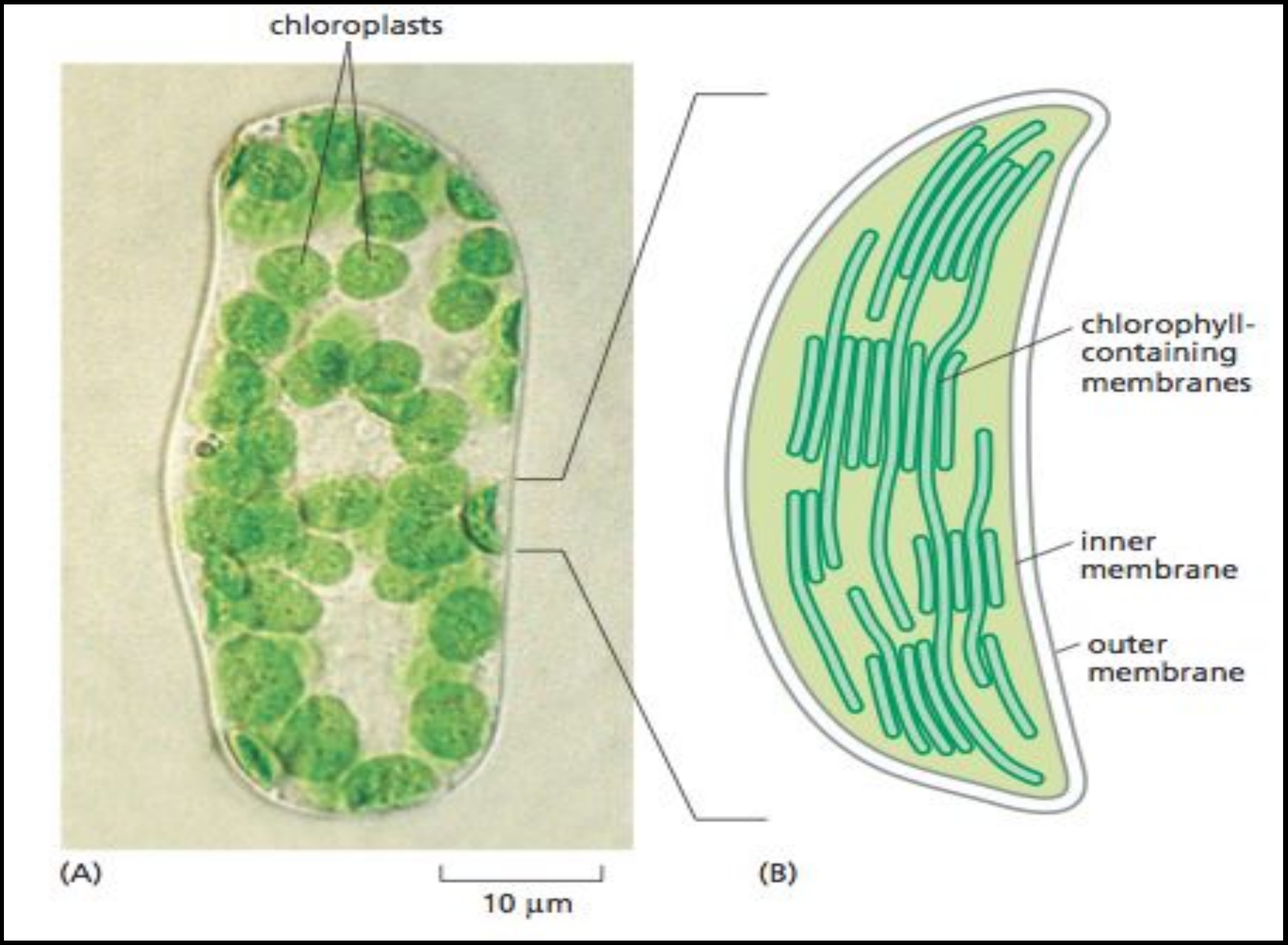
Mitochondria generate usable energy from food to power the cell



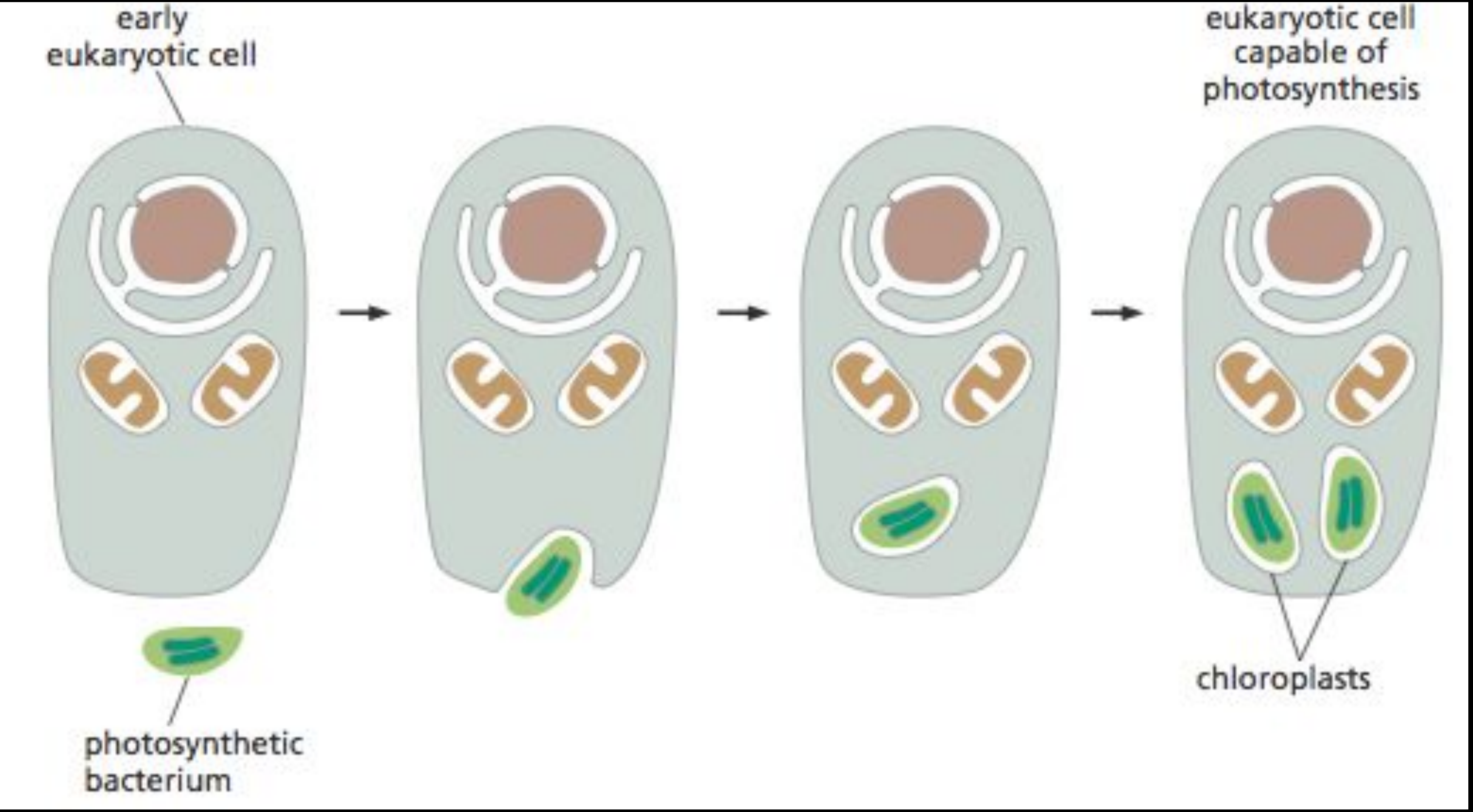
Mitochondria probably evolved from bacteria



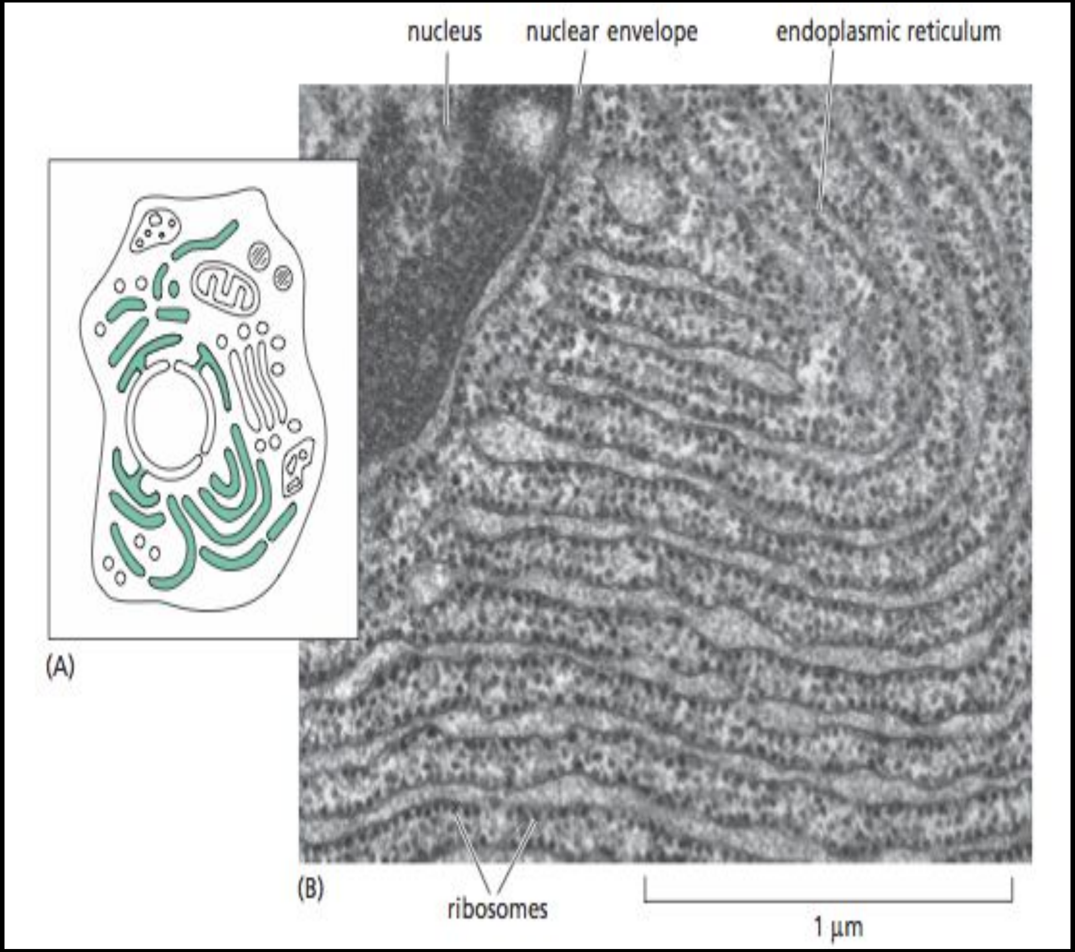
Chloroplasts capture energy from sunlight



The same story with chloroplasts



ER-the factory of many structures



- phospholipid
- Membrane bound proteins
- Post translational modification
- Place of lipid synthesis
- Place of sorting proteins inside the cell
- Continuation of nuclear envelope
- SER and RER are actually different regions of one structure

Golgi Apparatus

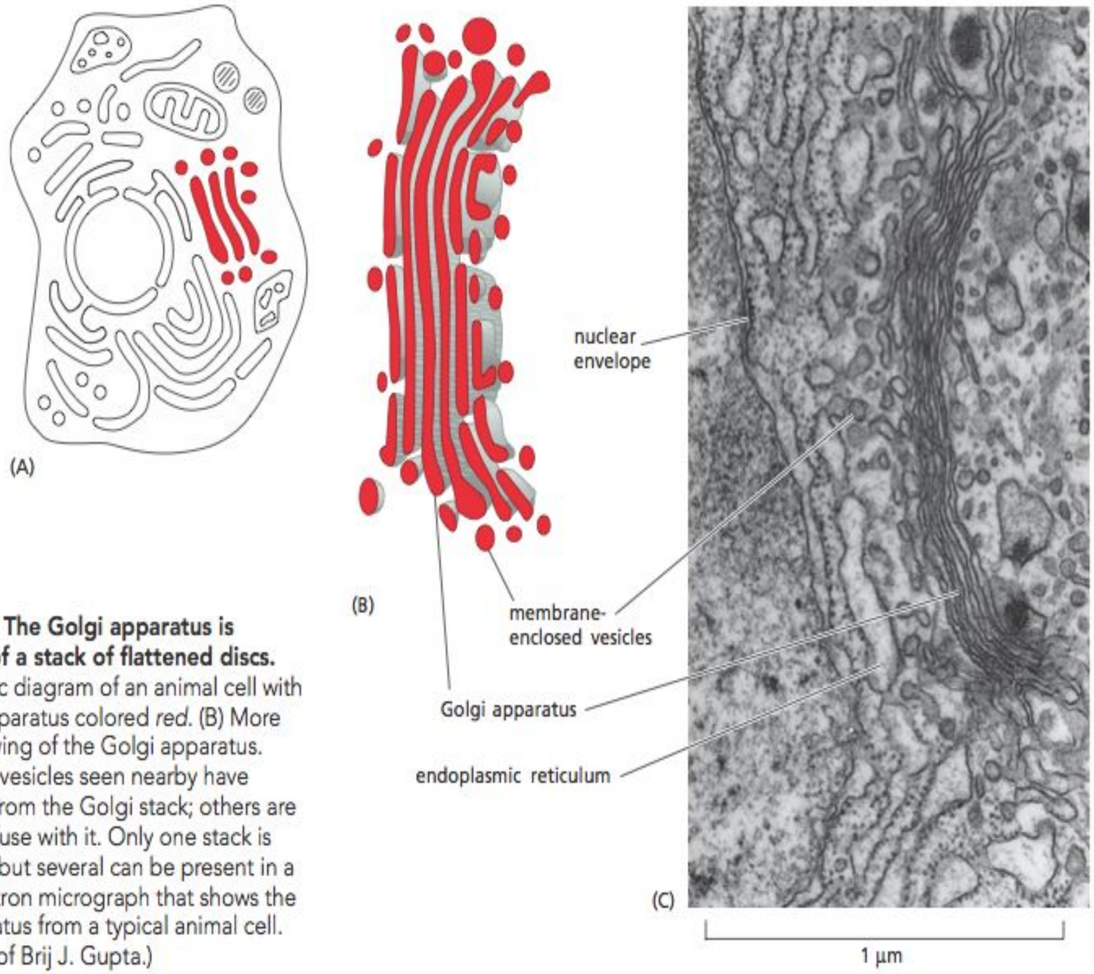
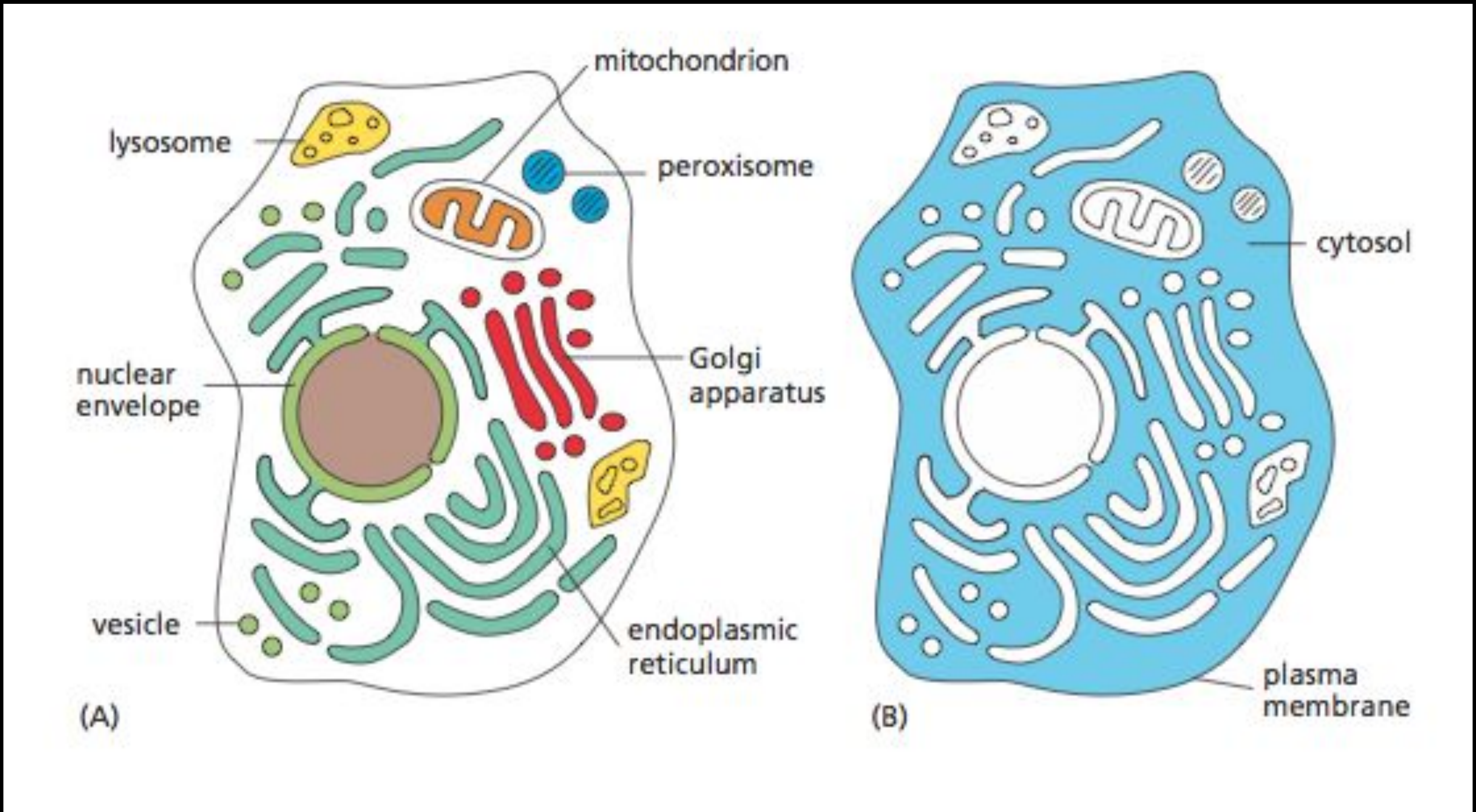


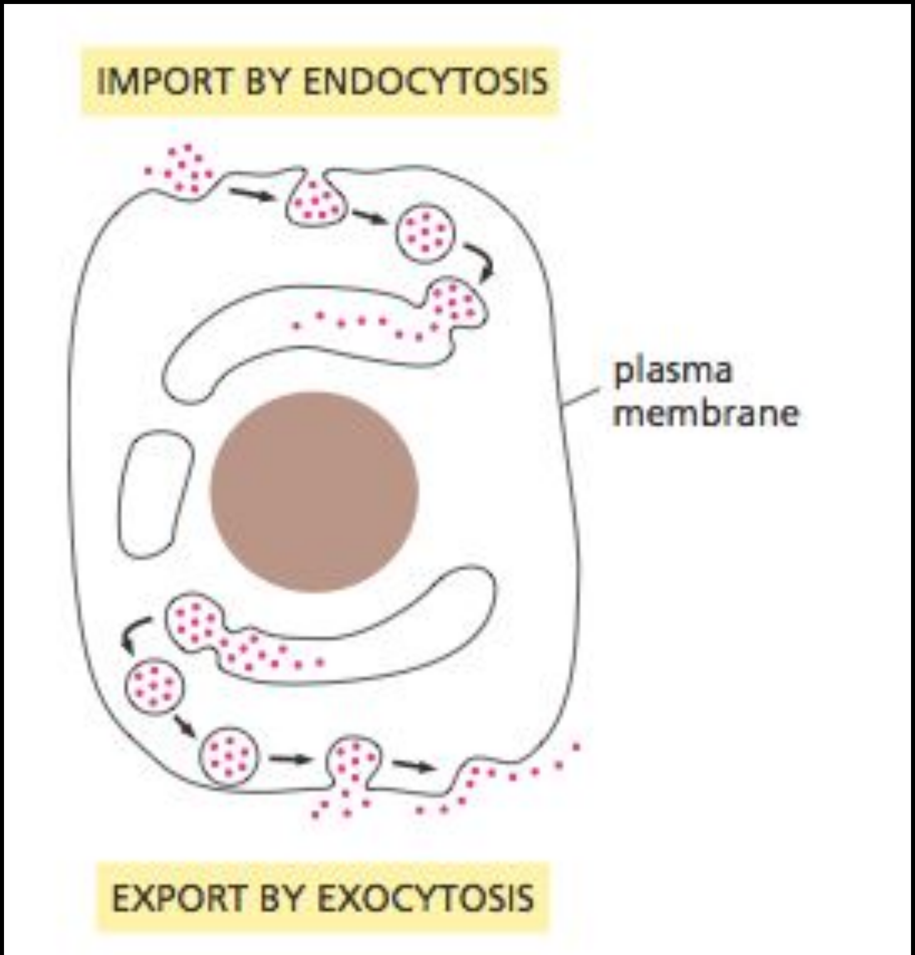
Figure 1–22 The Golgi apparatus is composed of a stack of flattened discs. (A) Schematic diagram of an animal cell with the Golgi apparatus colored *red*. (B) More realistic drawing of the Golgi apparatus. Some of the vesicles seen nearby have pinched off from the Golgi stack; others are destined to fuse with it. Only one stack is shown here, but several can be present in a cell. (C) Electron micrograph that shows the Golgi apparatus from a typical animal cell. (C, courtesy of Brij J. Gupta.)

- Proteins are further mod
Ified in GA
- Stack of membrane
Vesicles
Cis: ER facing site
Trans: PM facing site
- Produce vesicles to
transport proteins
ER->GA->PM

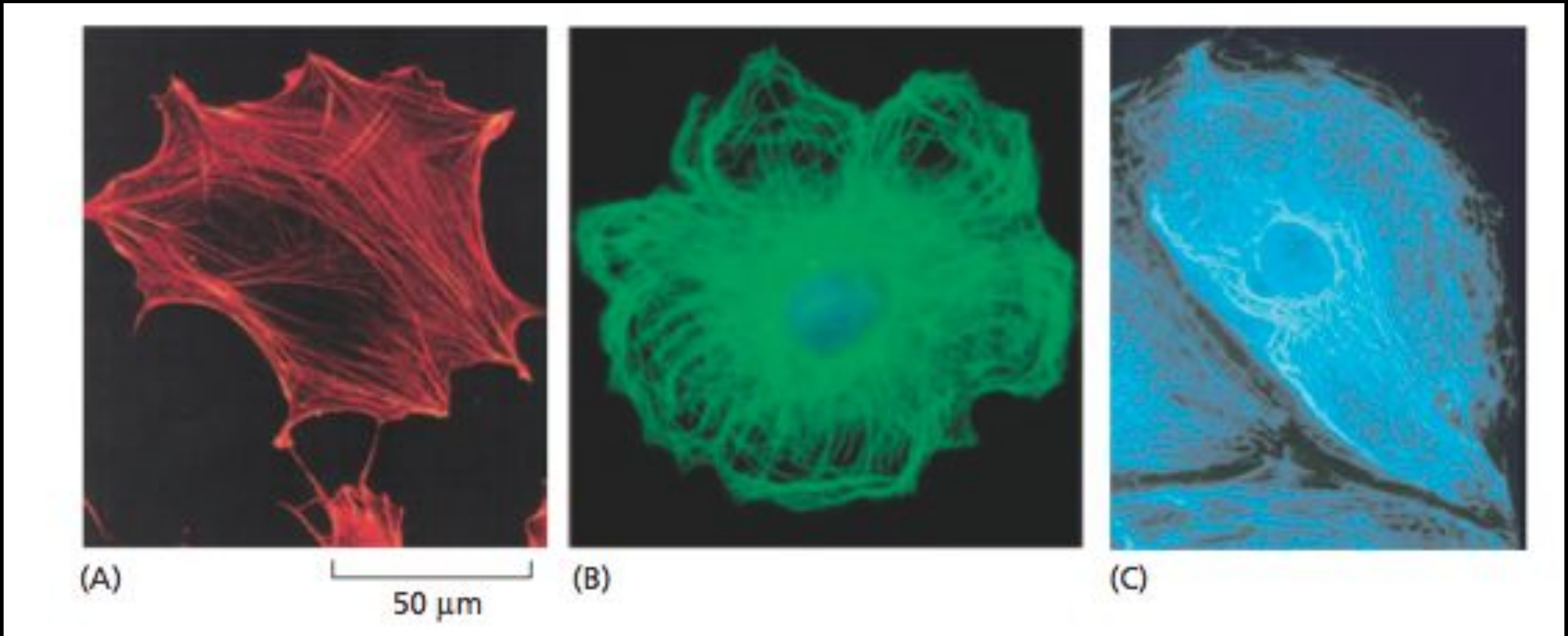
Membrane enclosed organelles



Enter and exit the cell



Cytoskeleton

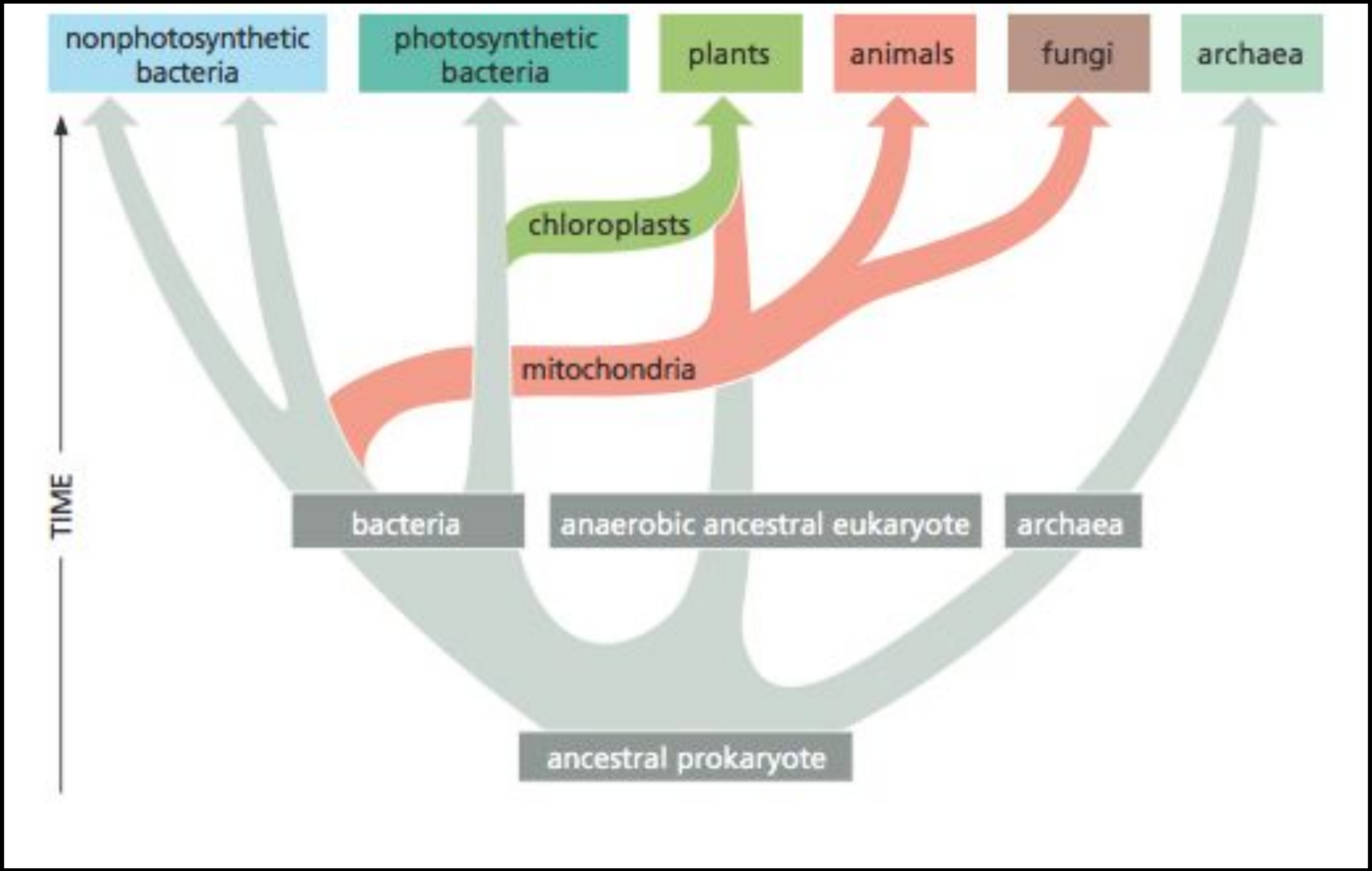


Actin filaments
- Cell crawling
- Muscle contraction
- Cell shape

Microtubules
- Cell division
- Cell movement
- Intercellular transport
- Cell shape

Intermediate filaments
- Holds the nucleus
- Cell shape
- Forms the nuclear lamella

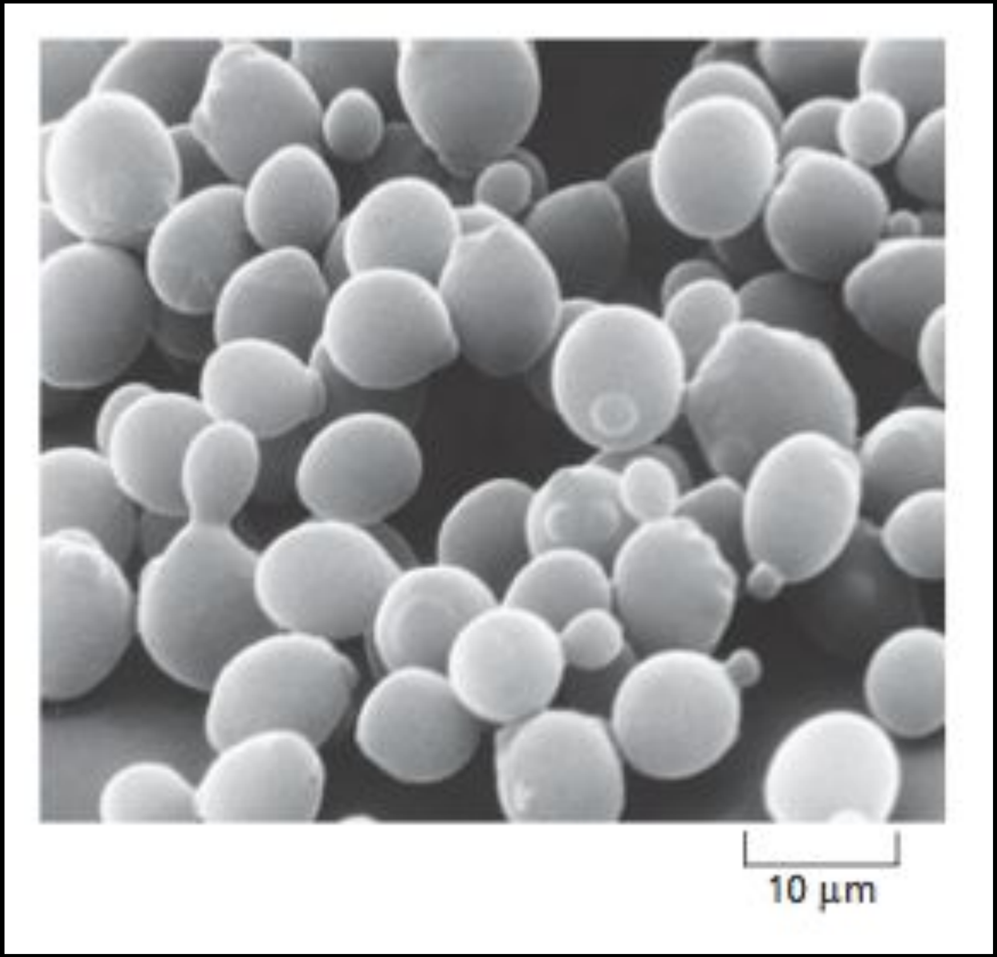
Eukaryotic Cells may have originated as predators



Model organisms

- E.coli
   - Simple structure (small genome size)
   - Easy to grow (37C) in agar media
   - 20 min doubling time
   - Many conserved genes
   - Easy to manipulate

Yeast cells



Short doubling time
Unicellular
Eukaryotic cell
Many conserved genes
Easy to grow
Easy to manipulate

C. elegans: nematode

Figure 1–34 ***Caenorhabditis elegans*** **is a small nematode worm that normally lives in the soil.** Most individuals are hermaphrodites, producing both sperm and eggs (the latter of which can be seen along the underside of the animal). *C. elegans* was the first multicellular organism to have its complete genome sequenced. (Courtesy of Maria Gallegos.)

First animal genome sequenced
Fixed number of cells
Developmental stage is clear
Easy to grow
Easy to manipulate

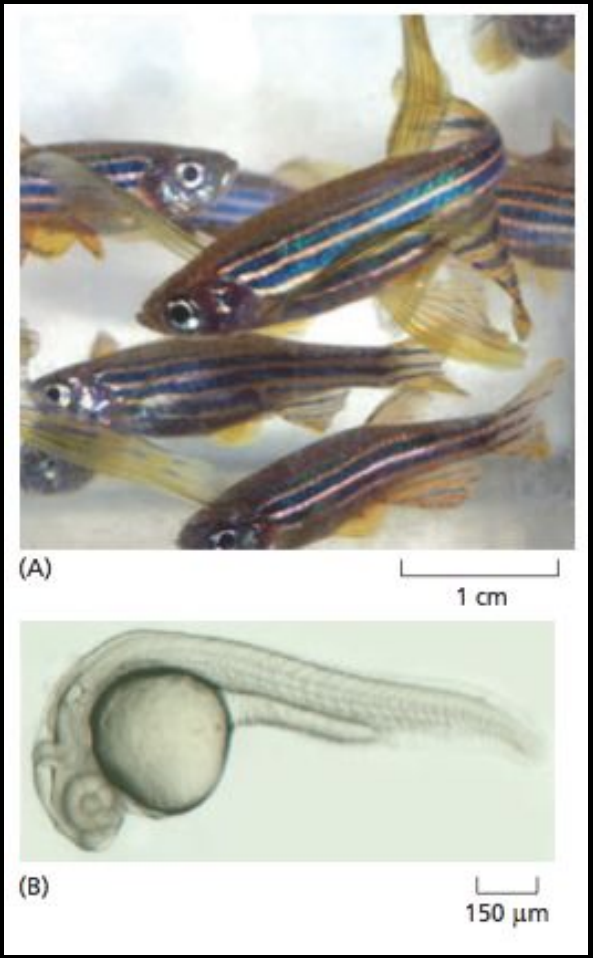
Arabidopsis

Fast growing plant
Easy to grow and maintain
Good model organism to study plants

Drosophila melanogaster

Great model to study animals
Insects are the most numerous
Conserved genes
Easy to grow
Great for genetical analysis

Zebra fish

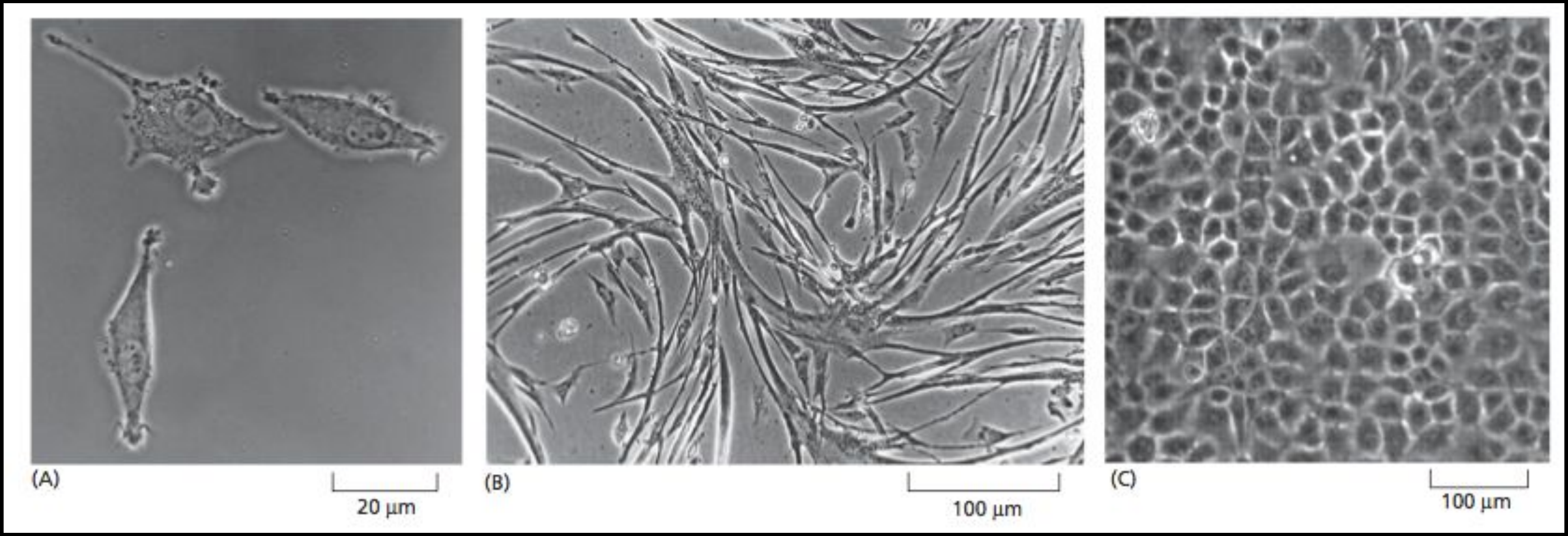


First developmental stages are transparent
Good model to study vertebrate development
Easy to grow

Mouse model

Easy to breed. Many conserved genes with human genome. Easy to manipulate

Cell lines



Fibroblasts Nerve cells Epithelial cells

Genome information

TABLE 1–2 SOME MODEL ORGANISMS AND THEIR GENOMES

Organism	Genome size* (nucleotide pairs)	Approximate number of genes
Homo sapiens (human)	3200×10^6	30,000
Mus musculus (mouse)	2800×10^6	30,000
Drosophila melanogaster (fruit fly)	200×10^6	15,000
Arabidopsis thaliana (plant)	220×10^6	29,000
Caenorhabditis elegans (roundworm)	130×10^6	21,000
Saccharomyces cerevisiae (yeast)	13×10^6	6600
Escherichia coli (bacteria)	4.6×10^6	4300

*Genome size includes an estimate for the amount of highly repeated DNA sequence not in genome databases.

Literature to read

- Essential cell biology 4th edition by Alberts

Chapter 1.