

Part 2

The Basics of Biology: An Engineer's Perspective

Chapter 2

An Overview of Biological Basics

2.1

Cells

2.2

Cell Construction

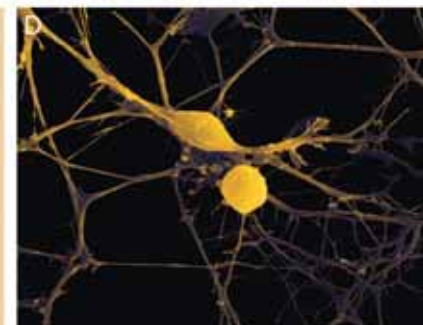
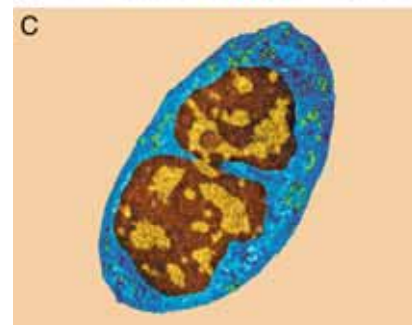
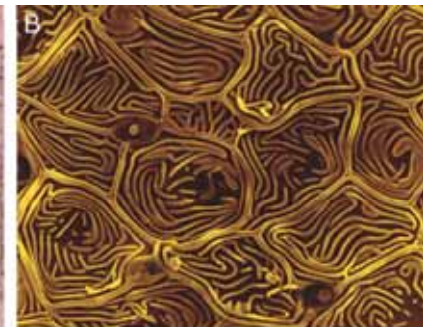
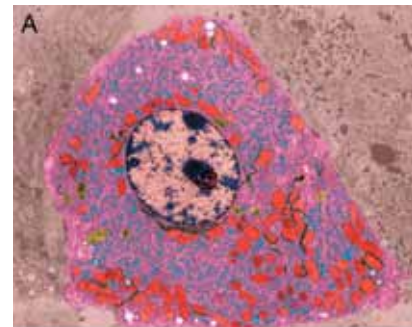
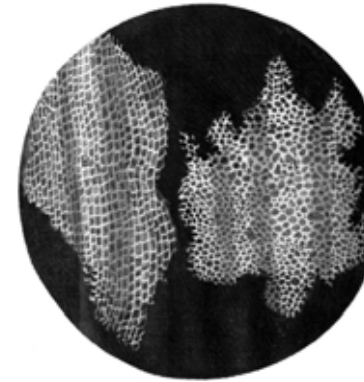
2.3

Cell Nutrient

2.1 Are all cells the same?

■ Cells

- Basic unit of living organism
- First named by Robert Hooke in the 17th century
- Different types but the same essential properties



Microbial Diversity

- **psychrophile**: optimum temp < 20°C
- **mesophile**: 20°C < optimum temp < 50°C
- **thermophile**: 50°C < optimum temp

- **aerobic**: growth in the presence of oxygen
- **anaerobic**: growth without oxygen
- **facultative**: growth under either circumstances

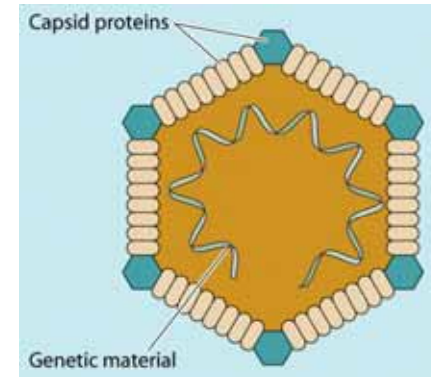
- **coccus**: spherical or elliptical
- **bacillus**: cylindrical or rod
- **spirillum**: spiral

Naming Cells

- *Escherichia coli* (*E. coli*)
 - written in italic
 - *Escherichia*: genus
 - *coli*: species
 - various strains of *E. coli* --- (ex) *E. coli* K12

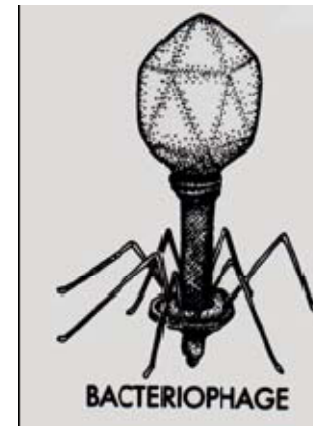
Viruses

- Not cells
- No independent reproduction (not alive by itself)
 - Genetic material (DNA or RNA)
 - Proteins (Capsid)
- “Viruses are in the semantic fog between life and non-life.”
(Campbell and Reece, *Biology*, 6e, p 339.)
- Are viruses living beings?
“The answer to that question is ‘no’, inasmuch as viruses are incapable of independent life.” (de Duve, *Life Evolving*, p.313)
- Conclusion:
Viruses do not fit the basic definition of cellular life.
 - Require host for all cellular activities
 - No metabolic capability of their own



Bacteriophage

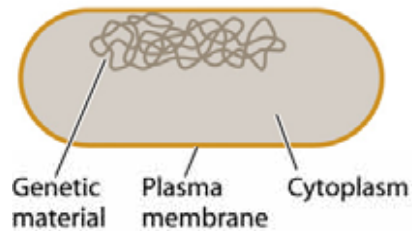
- **Bacteriophage:** virus infecting bacteria
 - lytic cycle: reproduction of virus (Fig. 2.1)
 - lysogenic cycle: Phage DNA is incorporated into the host DNA



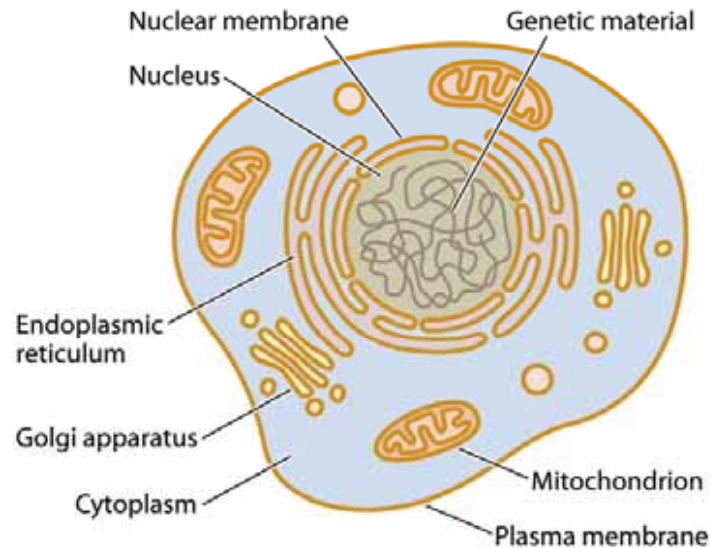
Two Fundamental Cell Types

- Prokaryote & Eucaryote
 - Primary Difference: presence or absence of nucleus
(more details in Table 2.1 and 2.2)

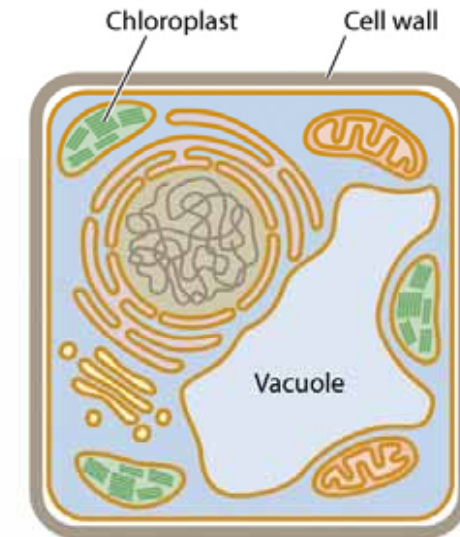
A. Prokaryotic cell



B. Eukaryotic animal cell



C. Eukaryotic plant cell



Procaryotic Cells

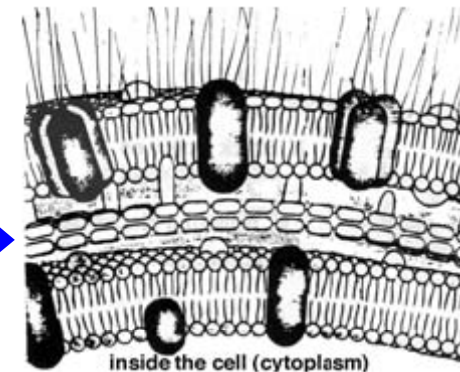
- Procaryote
 - (pro; before, karyon: kernel or nucleus)
- No nuclear membrane
- Small (0.5-3 μm), mostly single-celled organisms
 - Eubacteria : common bacteria
(e.g. *E. coli*, blue-green algae)
 - Archaea (Archaeobacteria): methanogens (methane-producing), thermoacidophiles, and halobacteria (high salt)
 - Live in extreme environments.
 - Possess unusual metabolism.

Eubacteria

- Divided into two groups by gram stain.

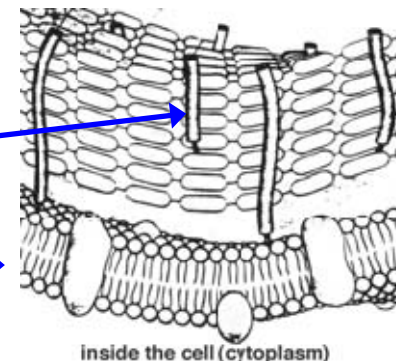
- Gram-negative cell (e.g. *E. coli*)

- Outer membrane
- Peptidoglycan
- Cytoplasmic (inner) membrane
- Periplasm
 - Between inner and outer membranes



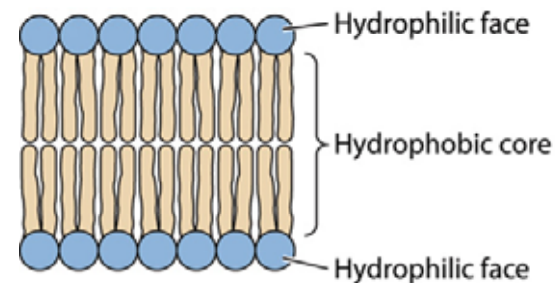
- Gram-positive cell (e.g. *Bacillus subtilis*)

- No outer membrane
- Peptidoglycan
- Teichoic acid
- Cytoplasmic membrane



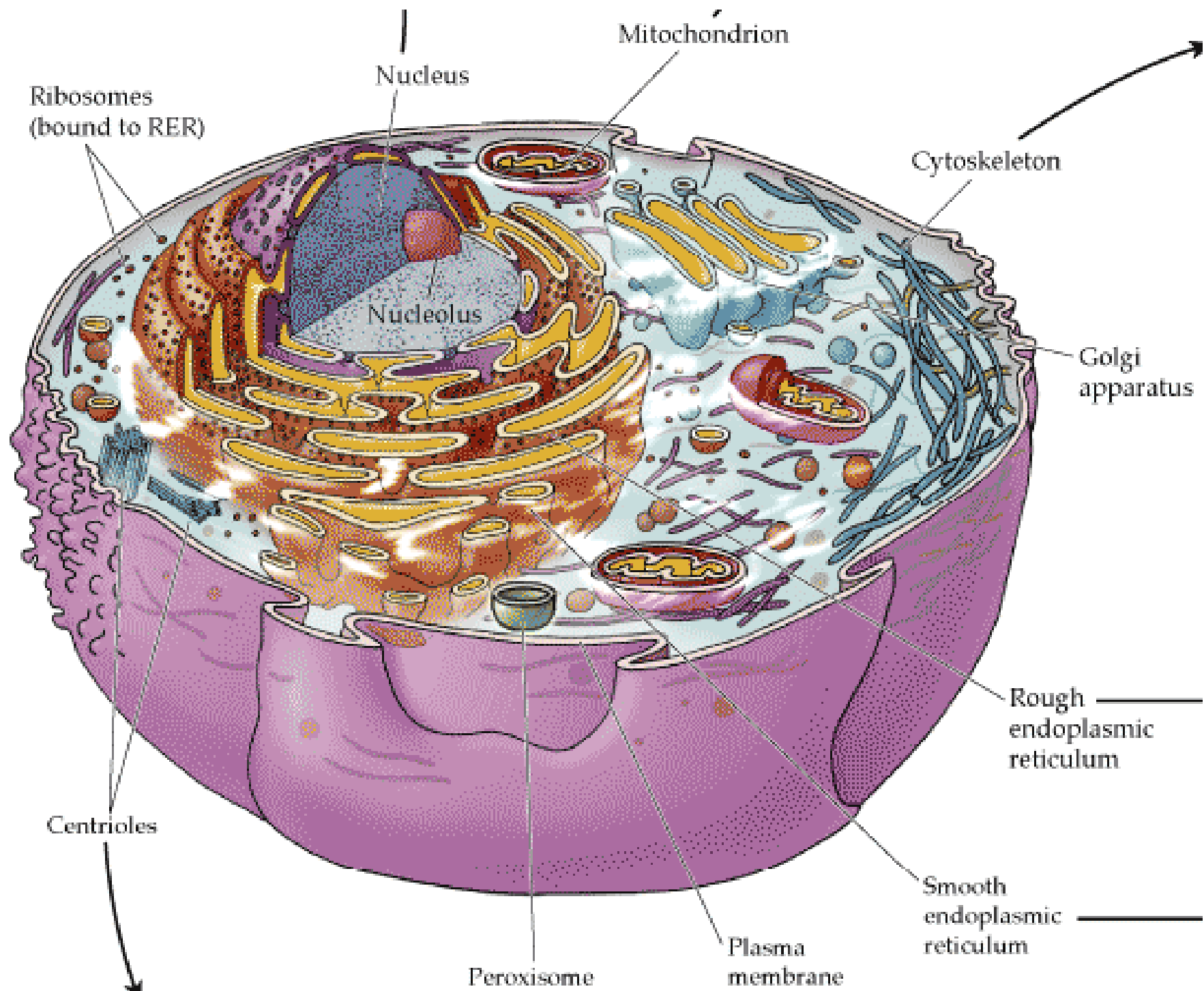
Cellular Membranes

- Provide structural organization
 - Lipid bilayer with hydrophobic core and hydrophilic face
 - Plasma (cell) membrane: Hydrophobic barrier between inside (cytoplasm) and outside of the cell
 - Internal membranes for **eucaryote**
 - Nucleus
 - Endoplasmic reticulum, Golgi apparatus
 - Mitochondria
 - Chloroplast



Eucaryote

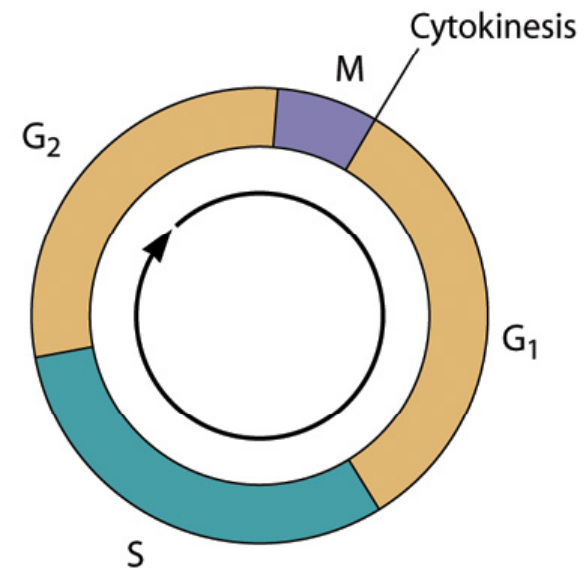
- Eucaryotic cells
 - Eukaryote (well-formed nucleus)
 - Larger than procaryotes (10-100 μm)
 - Single-celled: yeast, green algae, amoebae
 - Multicellular: fungi, plant, animal
 - Nuclear and internal membranes \rightarrow organelles
 - Nucleus --- contains chromosomes as nuclear material
 - Mitochondria --- powerhouse of a cell
 - Golgi body --- responsible for the secretion of certain proteins
 - Vacuole --- responsible for food digestion, osmotic regulation, and waste-product storage
 - Chloroplast --- responsible for photosynthesis
 - endoplasmic reticulum, lysosome, glyoxysome



Cell Cycle in a Eucaryote

- Cell Cycle (Fig. 2.4)

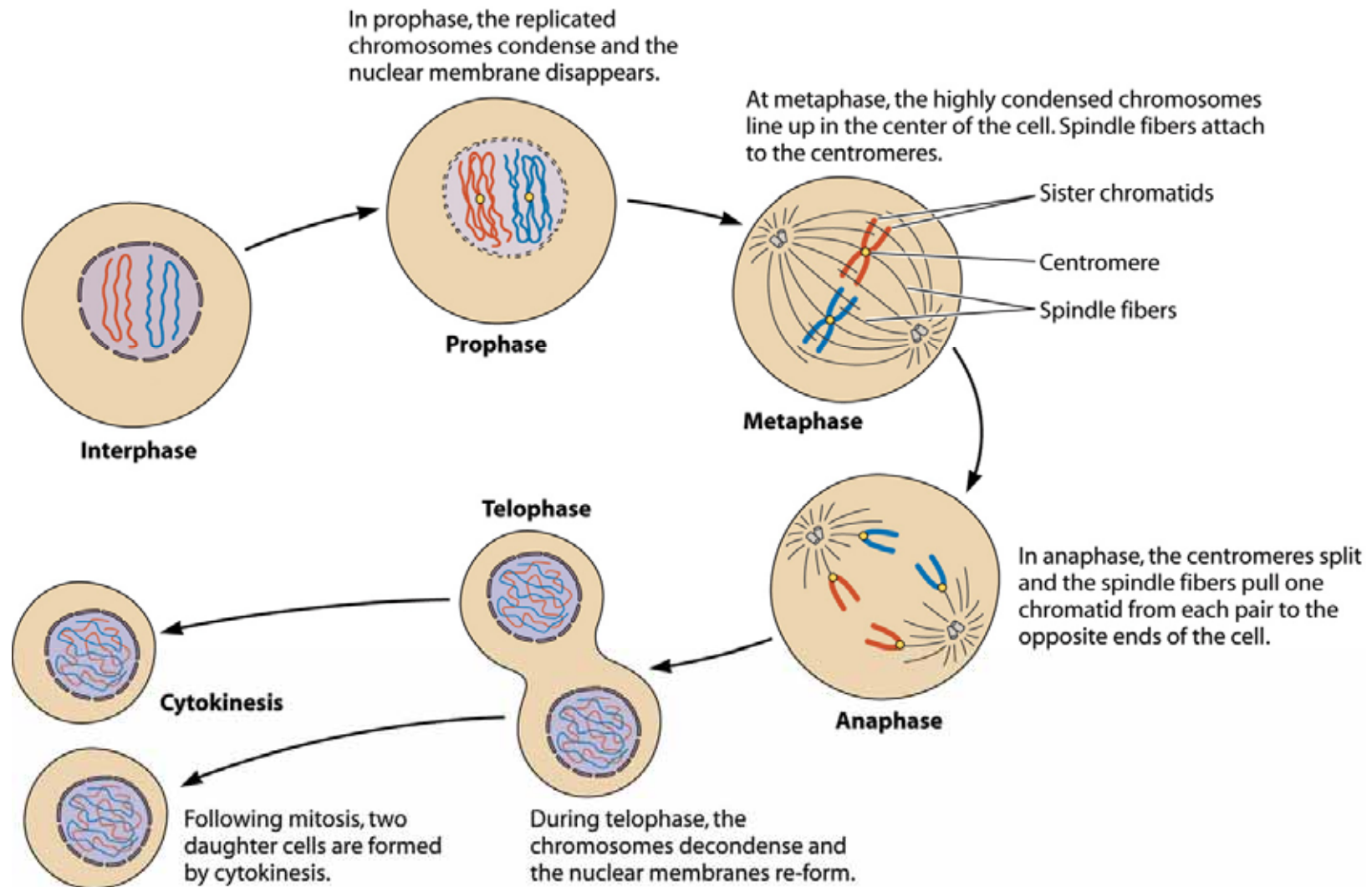
- S phase:
 - DNA synthesis
- M phase:
 - mitosis
- G_1 , G_2 :
 - G strands for gap between S and M phase
 - Cell growth



Mitosis

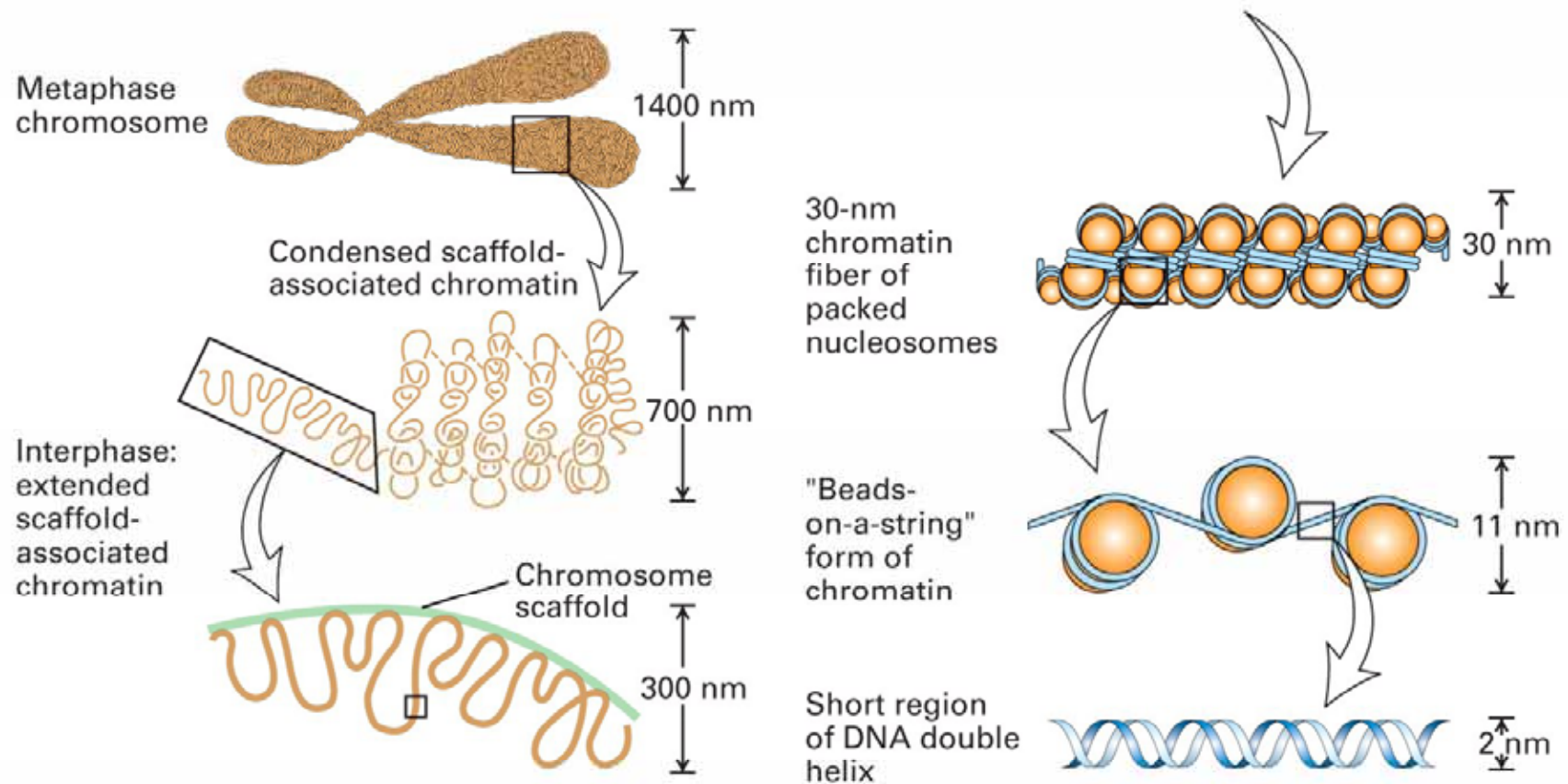
- DNA replication
- Mitosis
 - Prophase
 - Condensation of chromosomes and disappearance of nuclear membrane
 - Metaphase
 - Alignment of chromosome in the center
 - Pulling by spindle fibers attached to the kinetochore
 - Anaphase
 - Splitting of chromatids and pulling to the opposite ends of the cell
 - Telophase
 - Decondensation of chromosome
 - Formation of new nuclear membrane
- Cytokinesis
 - Cell division after mitosis
- Interphase
 - The time between cell division and the next mitosis (G_1 , S, G_2)

Mitosis and Cytokinesis



Chromosome

- Tightly packed complex of DNA and histone proteins



Eucaryotic Cells

- Fungi
 - Yeasts --- single small cells of 5- to 10- μm size
 - Molds --- filamentous fungi, have a mycelial structure
- Algae
 - Unicellular algae (microalgae) --- 10 to 30 μm
 - Plantlike multicellular algae
- Protozoa
 - Unicellular, motile, relatively large (1 - 50 μm) --- amoeba
- Plant cells
- Animal cells

The Scale of Life

