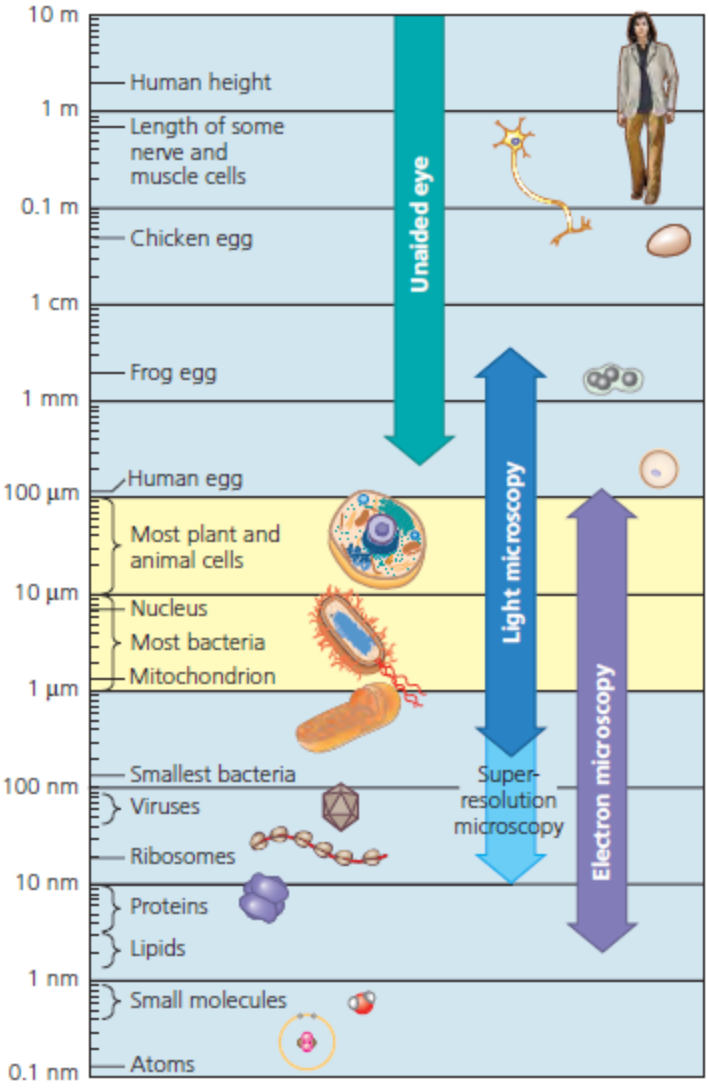
Biology Cheat Sheet

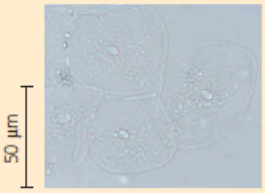


1 centimeter (cm) = 10^{-2} meter (m) = 0.4 inch
1 millimeter (mm) = 10^{-3} m
1 micrometer (µm) = 10^{-3} mm = 10^{-6} m
1 nanometer (nm) = 10^{-3} µm = 10^{-9} m

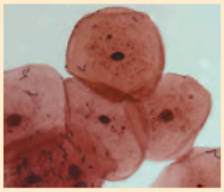
▲ **Figure 6.2 The size range of cells.** Most cells are between 1 and 100 µm in diameter (yellow region of chart) and are therefore visible only under a microscope. Notice that the scale along the left side is logarithmic to accommodate the range of sizes shown. Starting at the top of the scale with 10 m and going down, each reference measurement marks a tenfold decrease in diameter or length. For a complete table of the metric system, see Appendix C.

Light Microscopy (LM)

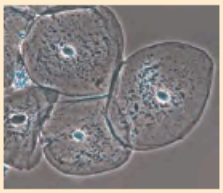
Brightfield (unstained specimen). Light passes directly through the specimen. Unless the cell is naturally pigmented or artificially stained, the image has little contrast. (The first four light micrographs show human cheek epithelial cells; the scale bar pertains to all four micrographs.)



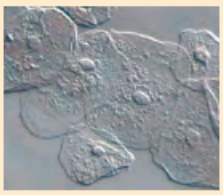
Brightfield (stained specimen). Staining with various dyes enhances contrast. Most staining procedures require that cells be fixed (preserved).



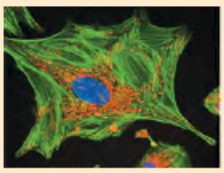
Phase-contrast. Variations in density within the specimen are amplified to enhance contrast in unstained cells, which is especially useful for examining living, unpigmented cells.



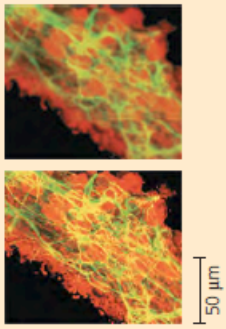
Differential-interference-contrast (Nomarski). As in phase-contrast microscopy, optical modifications are used to exaggerate differences in density, making the image appear almost 3-D.



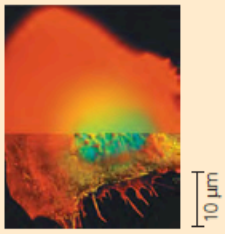
Fluorescence. The locations of specific molecules in the cell can be revealed by labeling the molecules with fluorescent dyes or antibodies; some cells have molecules that fluoresce on their own. Fluorescent substances absorb ultraviolet radiation and emit visible light. In this fluorescently labeled uterine cell, nuclear material is blue, organelles called mitochondria are orange, and the cell's "skeleton" is green.



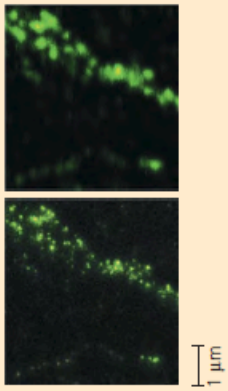
Confocal. The top image is a standard fluorescence micrograph of fluorescently labeled nervous tissue (nerve cells are green, support cells are orange, and regions of overlap are yellow); below it is a confocal image of the same tissue. Using a laser, this "optical sectioning" technique eliminates out-of-focus light from a thick sample, creating a single plane of fluorescence in the image. By capturing sharp images at many different planes, a 3-D reconstruction can be created. The standard image is blurry because out-of-focus light is not excluded.



Deconvolution. The top of this split image is a compilation of standard fluorescence micrographs through the depth of a white blood cell. Below is an image of the same cell reconstructed from many blurry images at different planes, each of which was processed using deconvolution software. This process digitally removes out-of-focus light and reassigns it to its source, creating a much sharper 3-D image.

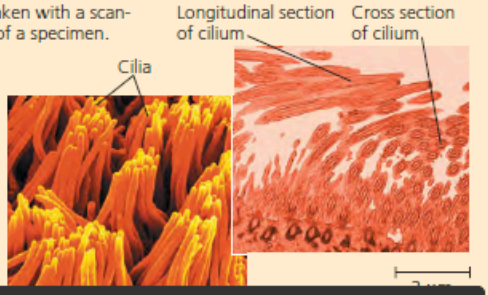


Super-resolution. On the top is a confocal image of part of a nerve cell, using a fluorescent label that binds to a molecule clustered in small sacs in the cell (vesicles) that are 40 nm in diameter. The greenish-yellow spots are blurry because 40 nm is below the 200-nm limit of resolution for standard light microscopy. Below is an image of the same part of the cell, seen using a new "super-resolution" technique. Sophisticated equipment is used to light up individual fluorescent molecules and record their position. Combining information from many molecules in different places "breaks" the limit of resolution, resulting in the sharp greenish-yellow dots seen here. (Each dot is a 40-nm vesicle.)



Electron Microscopy (EM)

Scanning electron microscopy (SEM). Micrographs taken with a scanning electron microscope show a 3-D image of the surface of a specimen. This SEM shows the surface of a cell from a trachea (windpipe) covered with cilia. Beating of the cilia helps move inhaled debris upward toward the throat. The SEM and TEM shown here have been artificially colorized. (Electron micrographs are black and white, but are often artificially colorized to highlight particular structures.)



Abbreviations used in this book:
LM = Light Micrograph
SEM = Scanning Electron Micrograph
TEM = Transmission Electron Micrograph

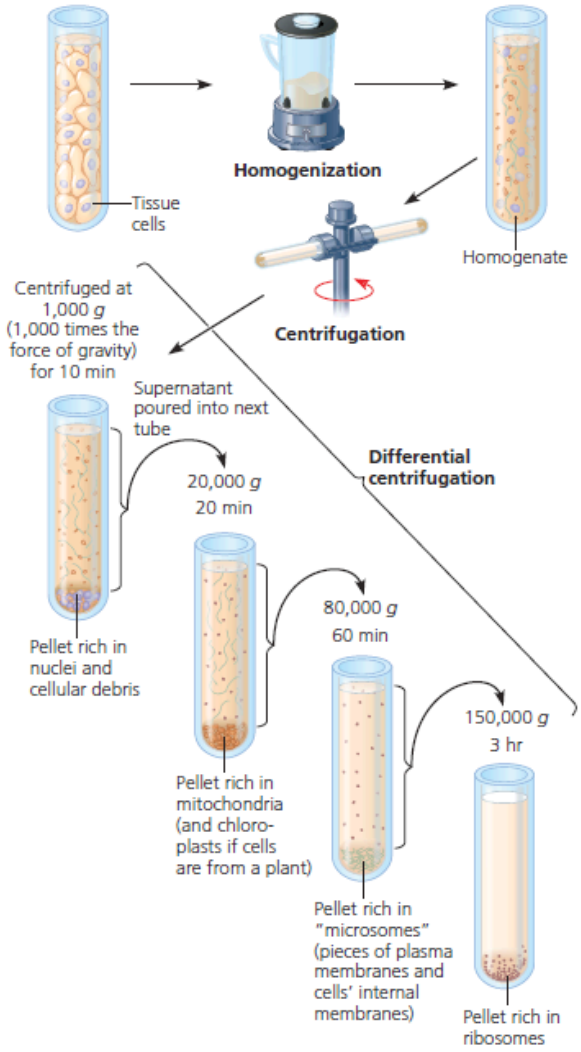
Transmission electron microscopy (TEM). A transmission electron microscope profiles a thin section of a specimen. Here we see a section through a tracheal cell, revealing its internal structure. In preparing the TEM, some cilia were cut along their lengths, creating longitudinal sections, while other cilia were cut straight across, creating cross sections.

▼ Figure 6.4 **RESEARCH METHOD**

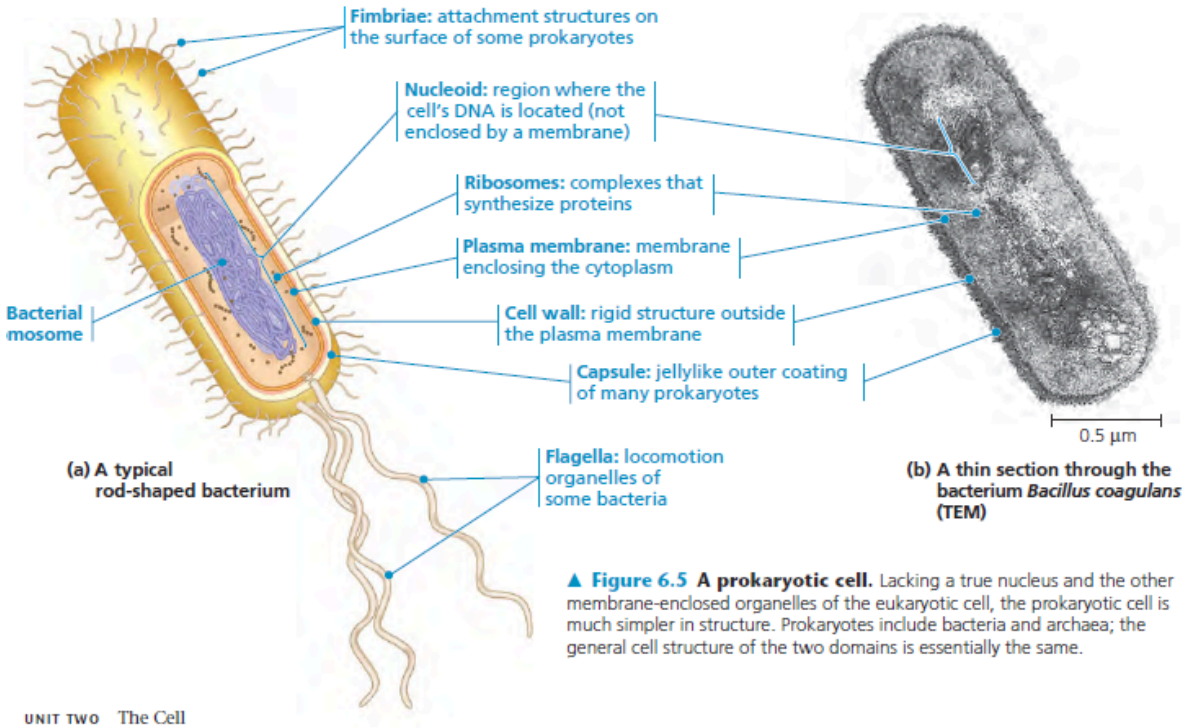
Cell Fractionation

APPLICATION Cell fractionation is used to isolate (fractionate) cell components based on size and density.

TECHNIQUE Cells are homogenized in a blender to break them up. The resulting mixture (homogenate) is centrifuged. The supernatant (liquid) is poured into another tube and centrifuged at a higher speed for a longer time. This process is repeated several times. This "differential centrifugation" results in a series of pellets, each containing different cell components.

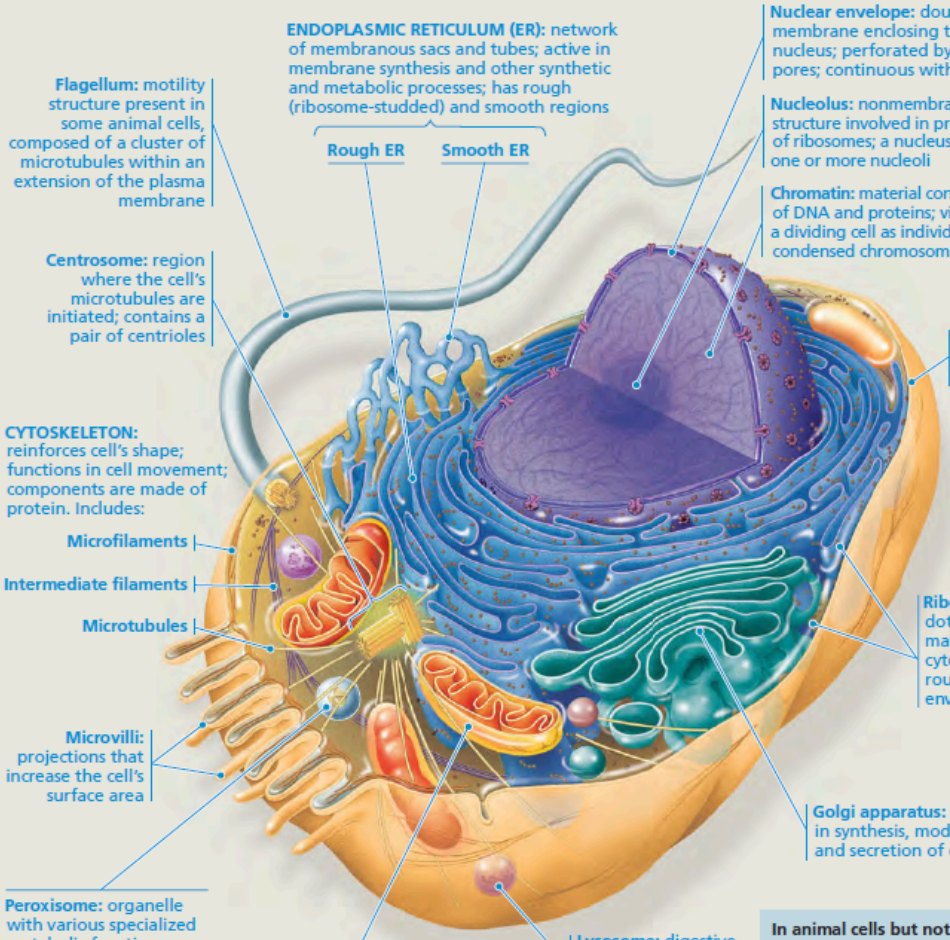


RESULTS In early experiments, researchers used microscopy to identify the organelles in each pellet and biochemical methods to determine their metabolic functions. These identifications established a baseline for this method, enabling today's researchers to know which cell fraction they should collect in order to isolate and study particular organelles.



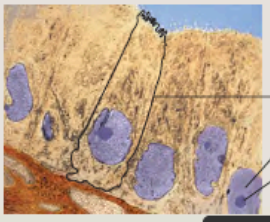
▲ **Figure 6.5 A prokaryotic cell.** Lacking a true nucleus and the other membrane-enclosed organelles of the eukaryotic cell, the prokaryotic cell is much simpler in structure. Prokaryotes include bacteria and archaea; the general cell structure of the two domains is essentially the same.

Animal Cell (cutaway view of generalized cell)



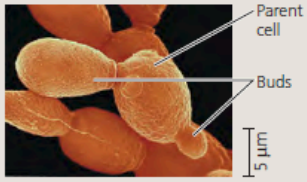
In animal cells but not plant cells:
Lysosomes
Centrosomes, with centrioles
Flagella (but present in some plant sperm)

Animal Cells

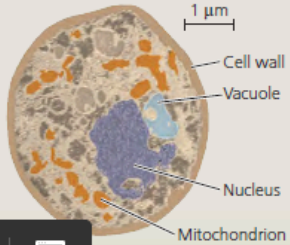


Human cells from lining of

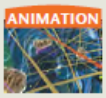
Fungal Cells



Yeast cells: reproducing by budding (above, colorized SEM) and a single cell



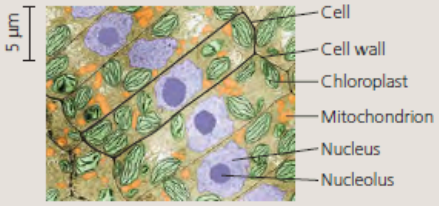
Plant Cell (cutaway view of generalized cell)



BioFlix Visit the Study Area at **www.masteringbiology.com** for the BioFlix® 3-D Animations Tour of an Animal Cell and Tour of a Plant Cell.

In plant cells but not animal cells:
Chloroplasts
Central vacuole
Cell wall
Plasmodesmata

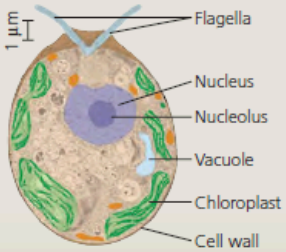
Plant Cells



Cells from duckweed (*Spirodela oligorrhiza*), a floating plant (colorized TEM)

Protistan Cells

Unicellular green alga *Chlamydomonas* (above, colorized SEM; right, colorized TEM)



Biology Worksheet

Find the approximate size of each of the following objects:

1. Human height 2. Length of some nerve and muscle cells **3. Chicken egg** **4. Frog egg** **5. Human egg** **6. Most plant and animal cells** **7. Most bacteria** 8. Nucleus	1. Mitochondrion **2. Smallest bacteria** **3. Viruses** **4. Ribosomes** **5. Proteins** **6. Lipids** **7. Small molecules** **8. Atoms** 9. Space between nuclear membranes **10. Diameter of pore structures of nucleus**

List the characteristics of the following microscopy techniques:

1. Brightfield (unstained specimen) 2. Brightfield (stained specimen) 3. Phase-contrast 4. Differential-interference-contrast 5. Fluorescence	1. Confocal 2. Deconvolution 3. Super-resolution 4. Scanning electron microscopy 5. Transmission electron microscopy

List the characteristics of the following parts of a cell:

1. Cytosol
2. Nucleus
3. Nucleoid
4. Glycocalyx
5. Flagella
6. Endoplasmic reticulum (ER)
  a. ER lumen
  b. Cisternae
  c. Smooth ER
  d. Rough ER
7. Cytoskeleton (structure, diameter, subunits, functions)
  a. Microfilaments
  b. Intermediate filaments
  c. Microtubules
8. Microvilli
9. Plasmodesmata
10. Chloroplast
  a. Double membrane
  b. Length
  c. Shape
	13. Ribosomes
	  a. Large, small subunit
	14. Chromosomes
	15. Fimbriae
	16. Plasma membrane
	17. Cell Wall
	18. Centrosome
	19. Peroxisome
	  a. Shape
	  b. Liver
	  c. Glyoxysomes
	  d. Growth
	20. Lysosome
	  a. Phagocytosis
	  b. Autophagy
	  c. Tay Sach's disease
	21. Mitochondria
	  a. Endosymbiont theory
	  b. Double membrane
	  c. Internal compartments
	  d. Length

d. Thylakoids e. Granum f. Stroma 11. Central vacuole a. Solution inside 12. Vacuole a. Food vacuole b. Contractile vacuoles c. Plant/fungi vacuoles	22. Golgi apparatus a. cis/trans b. Cisternae maturation model 23. Ribosomes 24. Plasma membrane 25. Nucleus a. Nuclear envelope b. Nucleolus c. Chromatin 26. Transport Vesicles 27. Plastids a. Amyloplast b. Chromoplast 28. Cell Wall a. Primary Cell Wall b. Middle Lamella 29. ECM 30. Tight Junctions 31. Desmosomes 32. Gap Junctions

Answer the following questions:

1. **What is the magnification, resolution, and workings of a LM?**
2. **How does an EM work and what is its resolution?**
3. **How are resolution and wavelength related?**
4. **How does a SEM work?**
5. **Hows does a TEM work?**
6. **What is the main disadvantage of electron microscopy?**
7. **What is the study of cell structure called?**
8. **What is the purpose of cell fractionation and how does it work (explain the 4 stages)?**
9. **What is the semifluid, jellylike substance inside all cells?**
10. **What is the cytoplasm?**
11. **What are the smallest cells known?**
12. **What is a pore complex?**
13. **What is the nuclear lamina?**
14. **What is the difference between the nuclear lamina and matrix?**
15. How many chromosomes does a fruit fly have?
16. **Where and how are ribosomes synthesized?**
17. **What is the difference between bound and free ribosomes?**
18. **Which organelles are part of the endomembrane system?**
19. **What is a dimer?**
20. What are the pseudopodia of a macrophage called?

Answer key:

1. Cytosol
    a. Jellylike, semifluid substance inside cells
2. Nucleus
    a. Membrane bound organelle in eukaryotes that houses DNA
3. Nucleoid
    a. Area where DNA is condensed in prokaryotes, no membrane
4. Glycocalyx
    a. Outer coating of many prokaryotes (capsule or slime layer)
5. Flagella
    a. Motile organelle in animal cells
    b. Not present in plant cells (except sperm)
6. Endoplasmic reticulum (ER)
    a. Network of membranes, accounts for more than ½ of total membrane in many eukaryotic cells
    b. Consists of network of membranous tubules and sacs called cisternae
    c. ER lumen (cavity) or cisternal space is internal compartment of ER (membrane separates lumen and cytosol, continuous with nuclear envelope)
    d. Lumen continuous with space between nuclear membranes
    e. Smooth ER functions in synthesis of lipids, metabolism of carbohydrates, detoxification of drugs and poisons, storage of calcium ions
    f. Rough ER helps secrete proteins (mostly glycoproteins, proteins with carbs bonded covalently to them by enzymes built into ER membrane) and is membrane factory (produces

13. Ribosomes
    a. Large and small subunit (proteins and rRNA)
    b. Synthesized in nucleolus
    c. Not membrane bound (not organelles)
14. Chromosomes
    a. Packages of Chromatin
    b. Structures that carry genetic info
15. Fimbriae
    a. Attachment structures on some prokaryotes
16. Cell Wall
    a. Cellulose, protein, protective wall, structural
17. Centrosome
    a. Region where microtubules are initiated, contains pair of centrioles
    b. Not present in plant cells
18. Peroxisome
    a. Specialized metabolic functions, byproduct hydrogen peroxide, converts to water
    b. Roughly spherical, often have granular or crystalline core thought to be dense collection of enzyme molecules
    c. Single membrane
    d. Contain enzymes that remove hydrogen atoms from substrates, transfer to O_2, producing H_2O_2
    e. Some use oxygen to break fatty acids down
    f. In liver, detoxify alcohol by transferring hydrogens from compounds to oxygen
    g. H_2O_2 converted to water by enzyme
    h. Glyoxysomes found in fat-storing tissues of plant seeds, contain enzymes that

phospholipids and membrane proteins to grow in place)
    g. Vesicles bud from transitional ER
7. Cytoskeleton
    a. Network of fibers extending throughout cytoplasm
    b. Present in prokaryotes
    c. Plays role in organizing structures and activities of cells
    d. MEchanical support to cell
    e. Cell motility generally requires interaction of cytoskeleton with motor proteins
    f. Can change shape quickly
    g. Manipulates plasma membrane
    h. Microtubules thickest
        i. Hollow tubes
        ii. 25 nm with 15 nm lumen (diameter)
        iii. globular tubulin (dimer with α-tubulin and ß-tubulin)
        iv. Orientation of tubulin creates plus end (can accumulate or release dimers faster than other end)
        v. Maintenance of cell shape (compression-resisting)
        vi. cell motility (cilia or flagella can sweep liquid over tissue or move cell)
        vii. cilia in large numbers on surface, flagella limited to one or a few, longer than cilia
        viii. Flagellum has undulating motion, cilia have alternating power and recovery strokes
        ix. Cilia may act as antenna, only one per initiate conversion of fatty acids to sugar
    i. Grow by incorporating protein, can split in two when reach certain size
19. Lysosome
    a. Digestive organelle where macromolecules are hydrolyzed
    b. Membranous sac
    c. Enzymes best in acidic environment in lysosomes
    d. Some probably arise from budding from trans face of Golgi apparatus
    e. 3D shapes of proteins prevent bonds from enzymatic attack
    f. Unicellular eukaryotes engulf food, creating food vacuole (fuses with lysosome, whose enzymes digest food)
    g. Digestion products pass into cytosol
    h. Autophagy - Double membraned vesicle binds with lysosome and disabled organelles inside vesicles are digested (inner membrane digested, outer fused to lysosome)
    i. Tay Sach's disease caused by missing/inactive lipid-digesting enzyme, causing brain to be impaired by accumulation of lipids in cells
    j. not present in plant cells
20. Mitochondria
    a. Powerhouse of cell (sites of cellular respiration)
    b. Endosymbiont theory
        i. Early ancestor of eukaryotic cells engulfed oxygen-using nonphotosynthetic prokaryotic cell
        ii. Engulfed cell formed relationship with host

cell, nonmotile (primary cilium, in almost all cells of vertebrates)
x. Membrane proteins of primary cilium transmit molecular signals to interior, triggering STPs
xi. Cilia and flagella has group of microtubules sheathed in extension of plasma membrane (9 doublets of microtubules arranged in ring with 2 single microtubules in center, called “9+2” pattern”, found in nearly all motile, “9+0” pattern found in nonmotile”)
xii. chromosome movements
xiii. organelle movements
xiv. Grow out from centrosome in animal cells, located near nucleus
xv. pair of centrioles (nine sets of triplets arranged in ring) make up centrosome
xvi. Basal body anchors cilium and flagellum, similar to centriole with “9+0” pattern of triplets, from sperm flagella becomes centriole, triplets connected by non tubulin proteins
xvii. Bending of flagella involves large motor proteins (dyneins), attached along each outer microtubule doublet, has 2 feet that walk along adjacent doublet, using ATP
i. Microfilaments (actin filaments)

cell, becoming endosymbiont (cell living within another)
iii. Host cell/endosymbiont merge
c. Bounded by two membranes
d. Contains ribosomes and circular DNA
e. Somewhat autonomous
f. Amount correlates with metabolic activity
g. Both membranes are phospholipid bilayers, outer membrane smooth, inner membrane has infoldings called cristae
h. Intermembrane space between inner and outer bilayers
i. Mitochondrial matrix enclosed by inner membrane
j. Contains enzymes and mitochondrial DNA and ribosomes
k. 1-10 μm long
l. Form branched, tubular network

21. Golgi apparatus
a. Warehouse for receiving sorting, shipping, and even some manufacturing
b. products of ER (from transport vesicles) modified and stored and then sent to destination
c. Consists of associated, flattened membranous sacs (cisternae)
d. cis face for receiving, trans for shipping (structural directionality)
e. cis located near ER
f. Vesicle fuses with cis fase
g. trans face gives rise to vesicles
h. products from ER modified from cis to trans
i. Manufactures many secreted

thinnest
    i. 2 intertwined strands of globular actin, thin and solid
    ii. present in all prokaryotic cells
    iii. cortical microfilaments = microfilaments just inside membrane
    iv. Cortex = outer cytoplasmic layer of cell, more gel like than inner cytoplasm because of network formed by cortical microfilaments
    v. Bundles make up core of microvilli
    vi. Actin filaments and thicker myosin filaments cause muscle cells to contract
    vii. Pseudopodia = cellular extensions by which cell crawls
    viii. 7 nm diameter
    ix. Maintenance of cell shape(tension bearing)
    x. changes in cell shape
    xi. Muscle contraction
    xii. Cytoplasmic streaming in plant cells, circular flow of cytoplasm within cells
    xiii. cell motility (amoeboid movement)
    xiv. division of animal cells
j. Intermediate filaments middle
    i. Fibrous proteins coiled into cables
    ii. Only found in cells of some animals (e.g. vertebrates)
    iii. Most permanent
    iv. 8-12 nm diameters
    v. One of several different proteins (e.g. keratins)

polysaccharides such as pectins and other non cellulose polysaccharides
    j. Different cisternae, different enzymes
    k. Cisternal maturation model (cisternae progress from cis to trans, carrying and modifying cargo)
    l. Added phosphate groups may act as zip codes
    m. Transport vesicles may have external molecules that recognize docking sites
22. Plasma membrane
    a. Selectively permeable membrane
    b. Phospholipid bilayer
23. Nucleus (5 μm diameter)
    a. Nuclear envelope
        i. Two membranes (20-40 nm space)
    b. Nucleolus
        i. Condensed area of DNA where ribosomes are manufactured
    c. Chromatin
        i. Material that makes up chromosomes (DNA and proteins)
24. Transport vesicles - Transit from one part of cell to another
    a. Bud from transitional ER
25. Plastids
    a. Plant organelles
    b. Amyloplast is colorless plastid that stores amylose (in roots and tubers particularly
    c. Chromoplast has pigments that give fruits and flower color
26. Cell Wall
    a. Extracellular structure of plant cells
    b. Protects cell, maintains shape, prevents excessive uptake of water
    c. Hold plant up

vi. Maintenance of cell shape (tension-bearing)
vii. Anchorage of nucleus and other organelles
viii. Formation of nuclear lamina
ix. Network anchors microfilaments supporting intestinal microvilli

8. Microvilli
    a. Thin, fingerlike projections, increase surface area without increasing volume
9. Plasmodesmata
    a. Pores in cell wall that allow transfer of material between plant cells
    b. membranes of adjacent cells line channel
10. Chloroplast
    a. House of photosynthesis in plant cells
    b. First photosynthetic eukaryote from engulfing photosynthetic prokaryote
    c. Two membranes separated by narrow intermembrane space, internal system of membranous sacs
    d. Contains ribosomes and circular DNA
    e. Somewhat autonomous
    f. Contains chlorophyll (green pigment)
    g. 3-6 μm in length
    h. Lens-shaped
    i. Thylakoids = flattened interconnected sacs
    j. Granum - Stacks of thylakoid
    k. Stroma - Liquid outside thylakoids
        i. Contains chloroplast DNA, ribosomes, and enzymes
    l. Space in thylakoids called
    d. 0.1 μm to several micrometers
    e. microfibrils of cellulose synthesized by cellulose synthase, secreted to extracellular space, become embedded in matrix of other polysaccharides and proteins (ground substance)
    f. Young plant cell first secretes relatively thin and flexible wall called primary cell wall
    g. Middle lamella = thin layer rich in sticky polysaccharides called pectins, between primary walls, glues adjacent cells together
    h. Some plant cells secrete hardening substances into primary wall, others add secondary wall between plasma membrane and primary wall (often deposited in several laminated layers with strong durable matrix)
27. Extracellular matrix
    a. Around animal cells, main ingredients are glycoproteins and other carb-containing molecules secreted by cells
    b. Collagen is most abundant glycoprotein in ECM, forms strong fibers outside cells, accounts for about 40% of total protein
    c. Collagen fibers embedded in network of proteoglycans secreted by cells (consists of small core protein with man carb chains covalently attached, may be up to 95% carb)
    d. Some cells attached to ECM by ECM glycoproteins such as fibronectin, binds to cell-surface receptor proteins called integrins (built into plasma membrane, span

thylakoid space

11. Central vacuole
    a. Massive vacuole in plant cells that accounts for quick growth (by absorption of water) and storage
    b. Develops by coalescence of small vacuoles
    c. Cell sap is solution inside, main repository of inorganic ions
    d. Less cytosolic volume for total cell volume
12. Vacuoles - Large vesicles derived from ER and Golgi, selectively permeable
    a. Food vacuoles formed by phagocytosis
    b. Contractile vacuoles pump excess water out of cells, maintaining suitable concentration of ions and molecules in cell
    c. In plants and fungi, some vacuoles carry out enzymatic hydrolysis (equivalent to lysosomes in animal cells)
    d. IN plants, small vacuoles hold reserves of important organic compounds

membrane and bind to proteins attached to microfilaments of cytoskeleton, transmit signals between ECM and cytoskeleton)

28. Tight Junctions
    a. Plasma membranes tightly pressed together, bound by proteins
    b. Establish barrier that prevents leakage of extracellular fluid across layer of epithelial cells
29. Desmosomes (type of anchoring junctions)
    a. Function like rivets, fasten cells into strong sheets
    b. Intermediate filaments of keratin anchor desmosomes in cytoplasm
    c. Attach muscles to each other
30. Gap Junctions (communicating junctions)
    a. Provide cytoplasmic channels from one cell to adjacent
    b. Consist of membrane proteins that surround pore
    c. Not lined with membrane

1. 1000 times, 0.2 μm (200 nm), shines light through subject and refracts light
2. Focuses beam of electrons through specimen or onto its surface, theoretical resolution of 0.002 nm but in practice is 2 nm
3. Resolution and wavelength are inversely proportional (accounts for resolution of electron microscopes)
4. Electron beam excites electrons on surface (usually coated with thin film of gold) and electrons are detected by device that translates it into image (electromagnet used to bend path of electrons to focus image onto monitor)
5. Aims electron beam through very thin section of specimen (stained with atoms of heavy metals that attach to certain cellular structures, enhancing electron density). Fewer electrons transmitted in denser area, electromagnet used to bend path of electrons to focus image on monitor
6. Preparation kills cells, may introduce artifacts (structural features seen in micrographs that do not exist in living cell)

7. Cytology
8. Separate cell components based on size and density; First homogenize cell in blender (forms mixture called homogenate). Homogenate centrifuged, supernatant poured out and centrifuged faster and longer
   Stage 1: 1,000 g for 10 minutes, yields nuclei and cellular debris
   Stage 2: 20,000 g for 20 minutes, yields mitochondria and chloroplasts
   Stage 3: 80,000 g for 60 minutes, yields microsomes (parts of plasma membranes and cells' internal membranes)
   Stage 4: 150,000 g for 3 hr, yields ribosomes
9. Cytosol
10. Interior of cell
11. Bacteria called mycoplasmas (diameter 0.1-1.0 μm)
12. Protein structure that lines each nuclear pore and plays important role in regulating entry and exit compounds, diameter 100 nm
13. Lines nuclear side of envelope (except at pores), netlike array of protein filaments (intermediate filaments in animal cells) that maintains shape of nucleus by mechanically supporting nuclear envelope
14. Matrix extends throughout nuclear interior, lamina only at envelope
15. 8
16. Ribosomes synthesized in nucleolus, rRNA and proteins assembled into large and small subunits of ribosomes *not considered organelles*
17. Bound ribosomes are in nuclear membrane and membrane of ER, free ribosomes suspended in ER. Free ribosomes produce proteins for cytosol, bound produce proteins for secretion and use inside organelles and membranes
18. ER, nuclear envelope, Golgi apparatus, lysosomes, vesicles and vacuoles, plasma membrane
19. Pair of identical molecules
20. filopodia