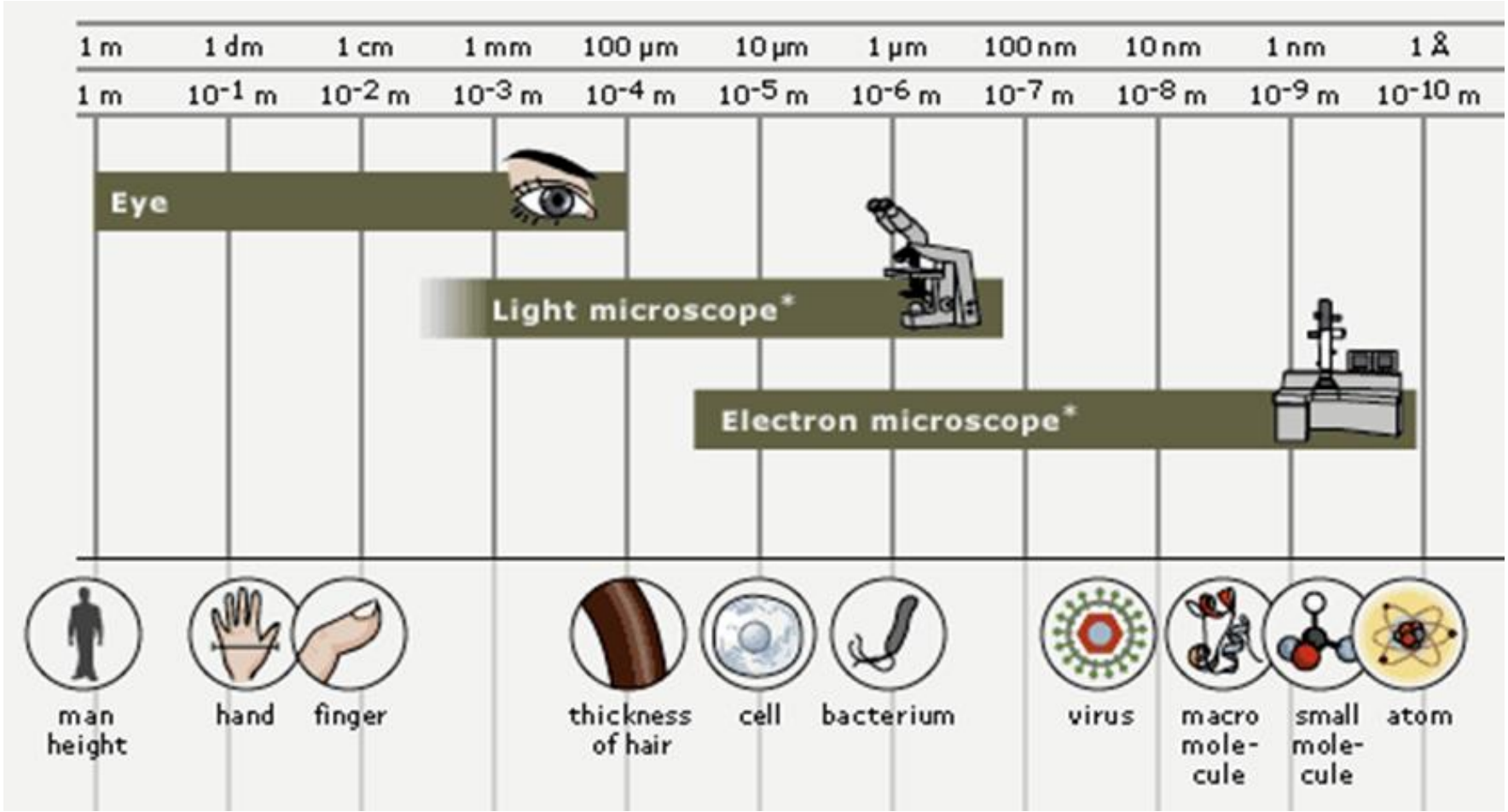
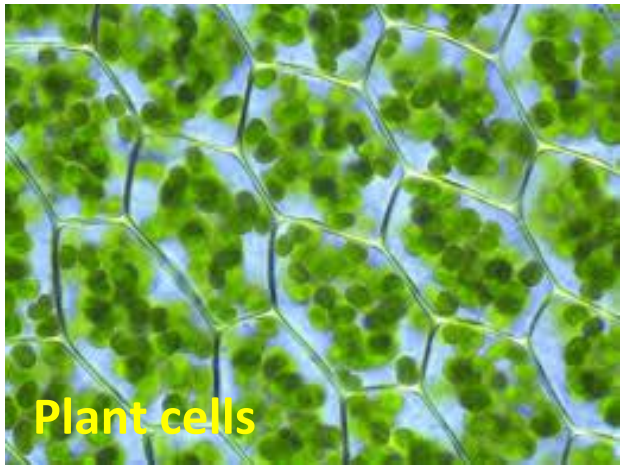
How to observe cells?

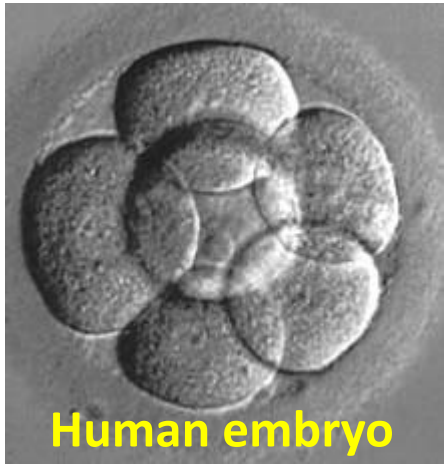


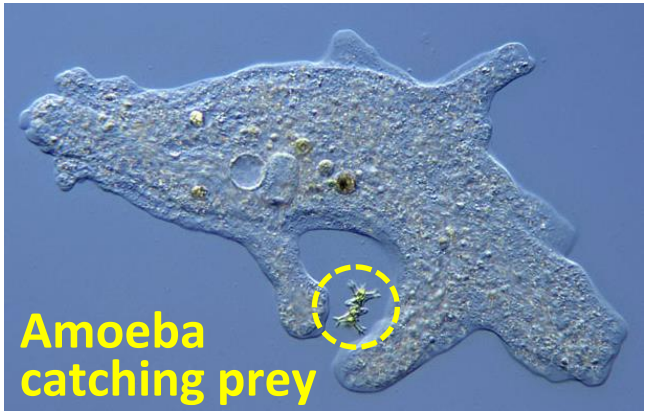
- **Magnification**: refers to the microscope's power to increase an object's apparent size.
- **Resolution**: refers to the microscope's power to show detail clearly.

Observing cells: Light Microscope

- Invented around 1590-1600, name "microscope" given in 1625.
- Uses visible light and a system of lenses.
- Magnification of up to ~2000X.
- Resolution ~200-500 nm (limited by *diffraction of visible light*).
- Makes it possible to observe living cells in true color.



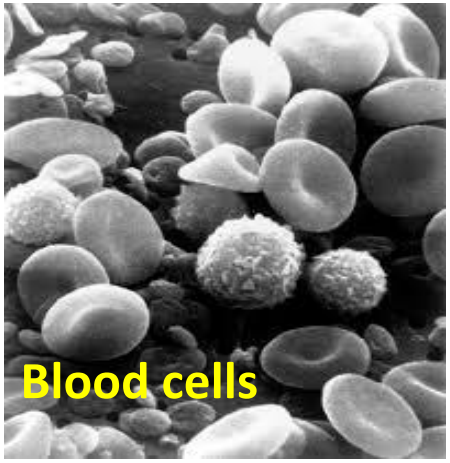


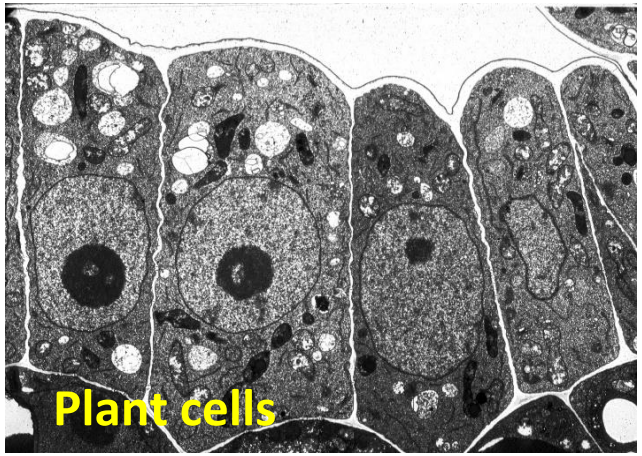


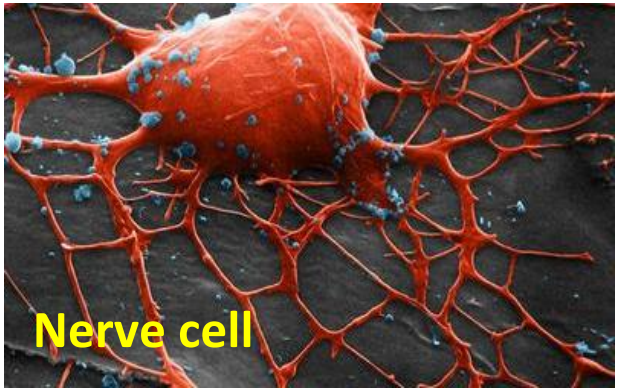
Observing cells: Electron Microscope

- Uses accelerated electrons as a source of illumination together with electrostatic and electromagnetic lenses to control the electron beam and focus it to form an image.
- 2D or 3D black and white images (may be colorized) with magnification of up to ~10,000,000X – great detail view!
- Preparation needed (for example, *chemical fixation* or *freeze drying*) kills the cells.

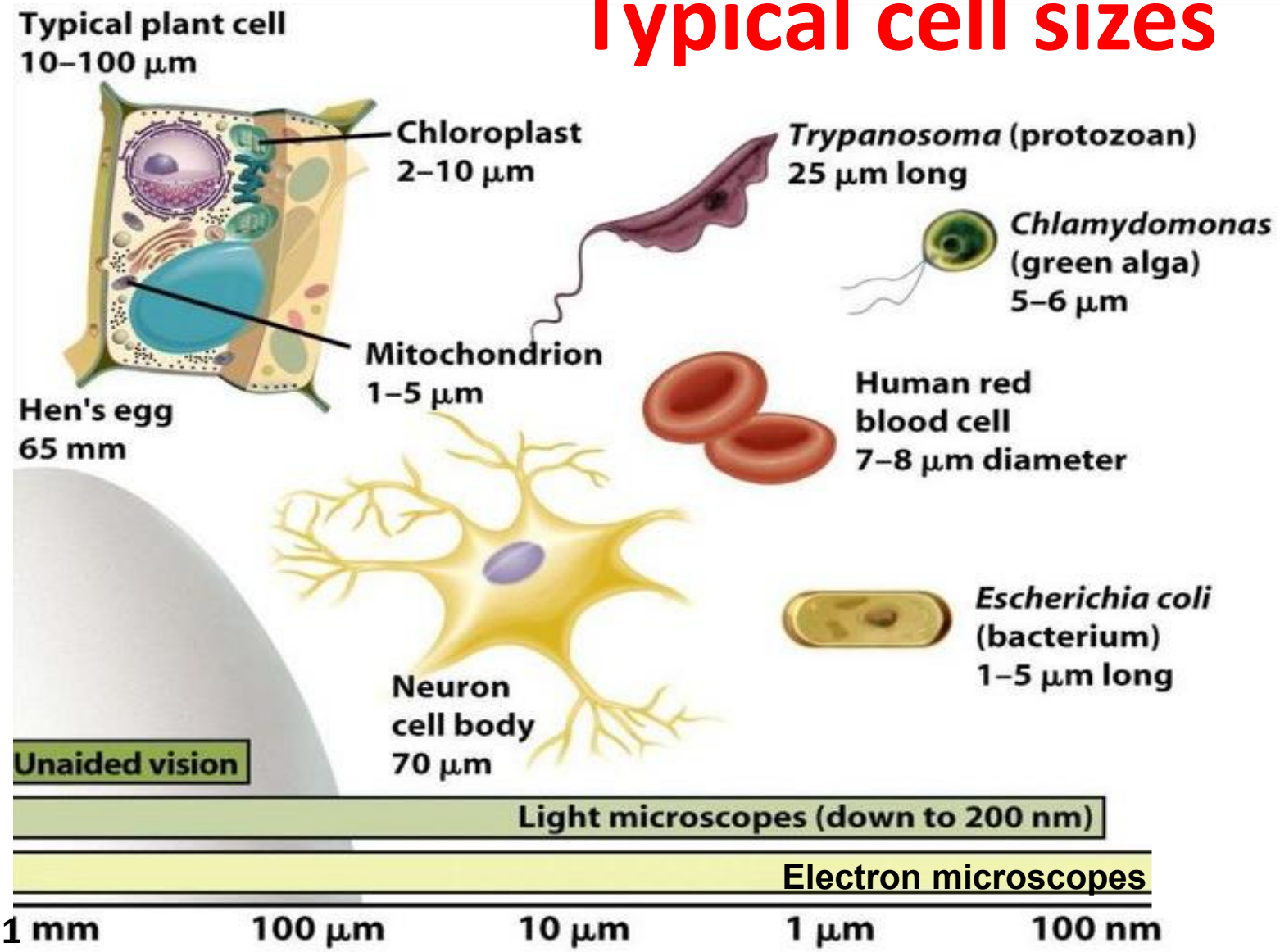
Invented ~1930; first commercial device produced by Siemens in 1939.





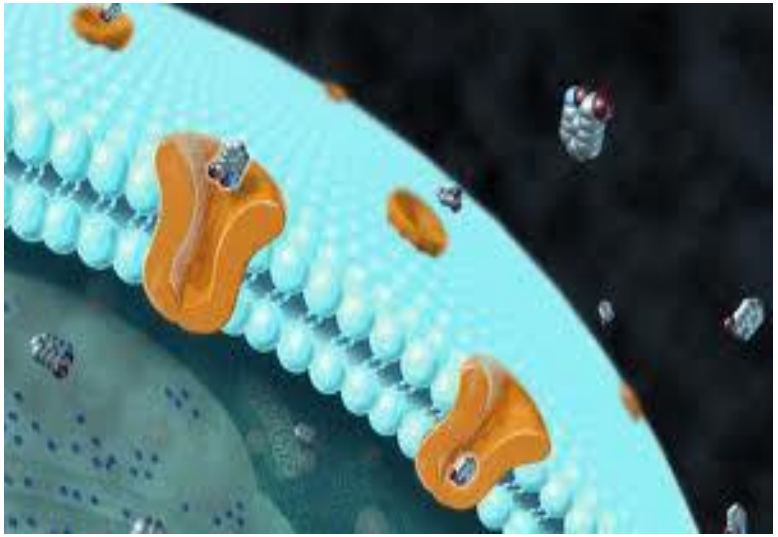


Typical cell sizes



Interactive tool https://learn.genetics.utah.edu/content/cells/scale/

Why are most cells small?



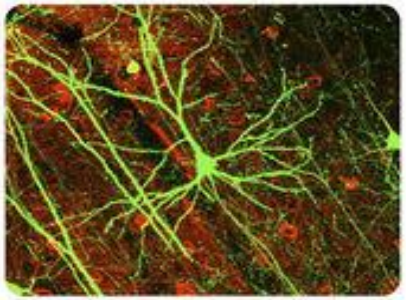
- For the processes inside cells to occur efficiently, all cells need sufficient surface area to allow adequate transport of nutrients in and wastes out.
- As cell volume increases, so does the need for the transporting of nutrients and wastes.

- However, as cell volume increases the surface area of the cell does not expand as quickly:

$$\text{Volume} \sim (\text{Radius})^3 \qquad \text{Area} \sim (\text{Radius})^2$$

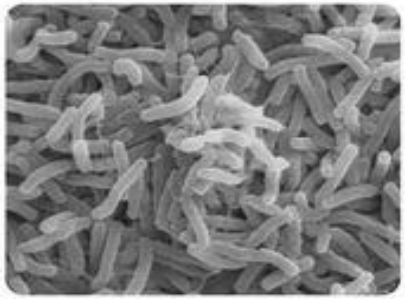
- If the cell's volume gets too large it cannot transport enough wastes out or nutrients in!
- Therefore, *surface area* limits cell volume/size.

Cell diversity: shape

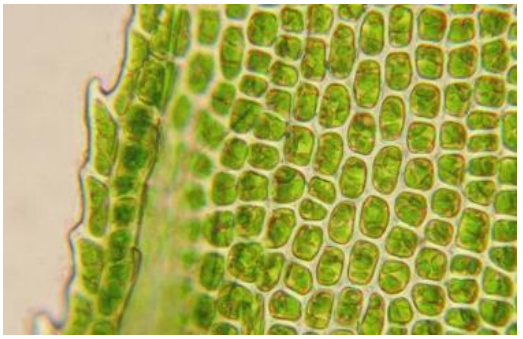


Nerve cell

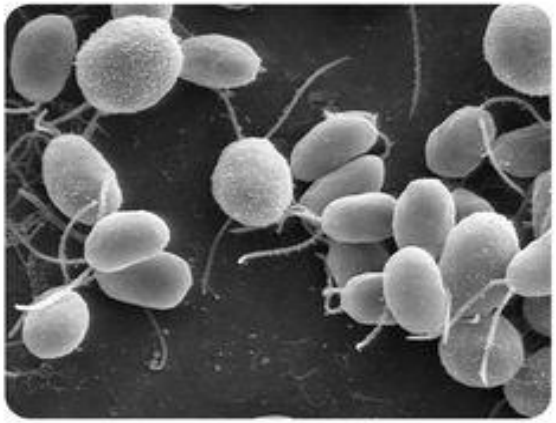
Red blood cells



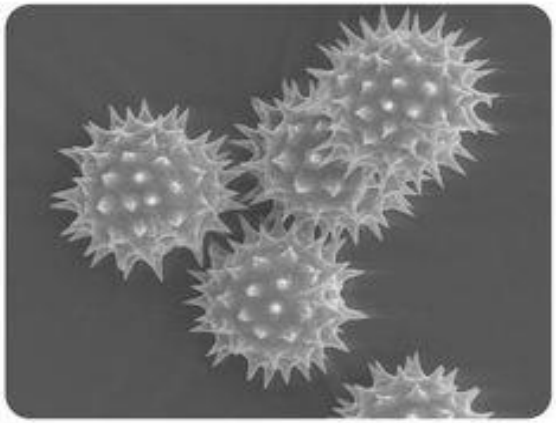
Bacteria



Plant cells



Algae



Pollen grains

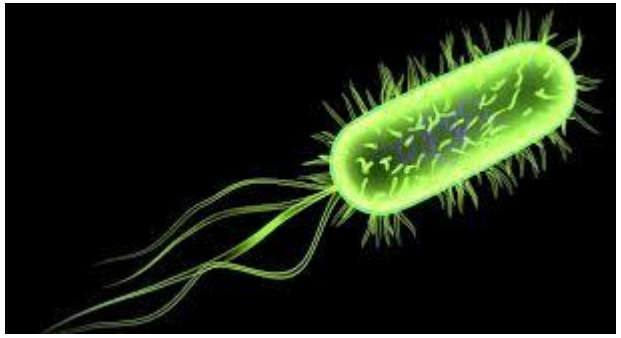
Yeast cells

Cells <u>differ widely</u> (and wildly!) in shape…

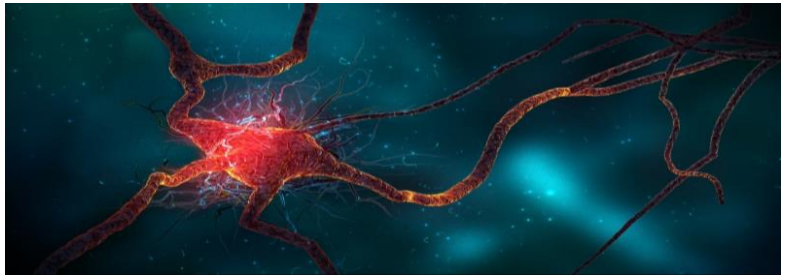
…but <u>most cells</u> are roughly cuboidal or spherical.

Cell diversity: size

Tiny: Bacterium
~1 micrometer



Long: Giraffe nerve cell
up to 2 meters long



Huge: aquatic alga
Caulerpa taxifolia, **10 feet**

Heavy: Ostrich egg
6x5 inches, 3 pounds

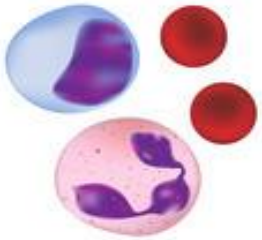
Cell diversity: specialization

- In complex multicellular organisms, cells specialize into different cell types that are adapted to particular functions.

- Cell types differ both in appearance and function, yet are genetically identical.

- In mammals, major cell types include skin cells, neurons, muscle cells, blood cells, stem cells, and others.

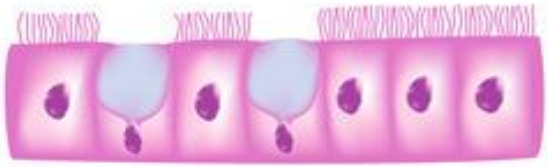
- Human body contains over 200 types of cells!



Blood cells

Surface skin cells

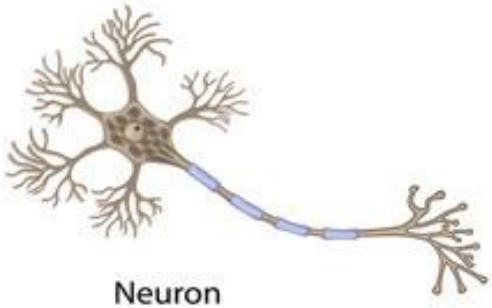
Bone cell



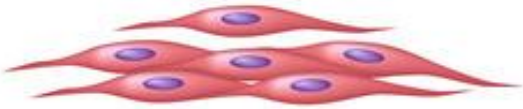
Columnar epithelial and Goblet cells

Cardiac muscle cell

Skeletal muscle cells

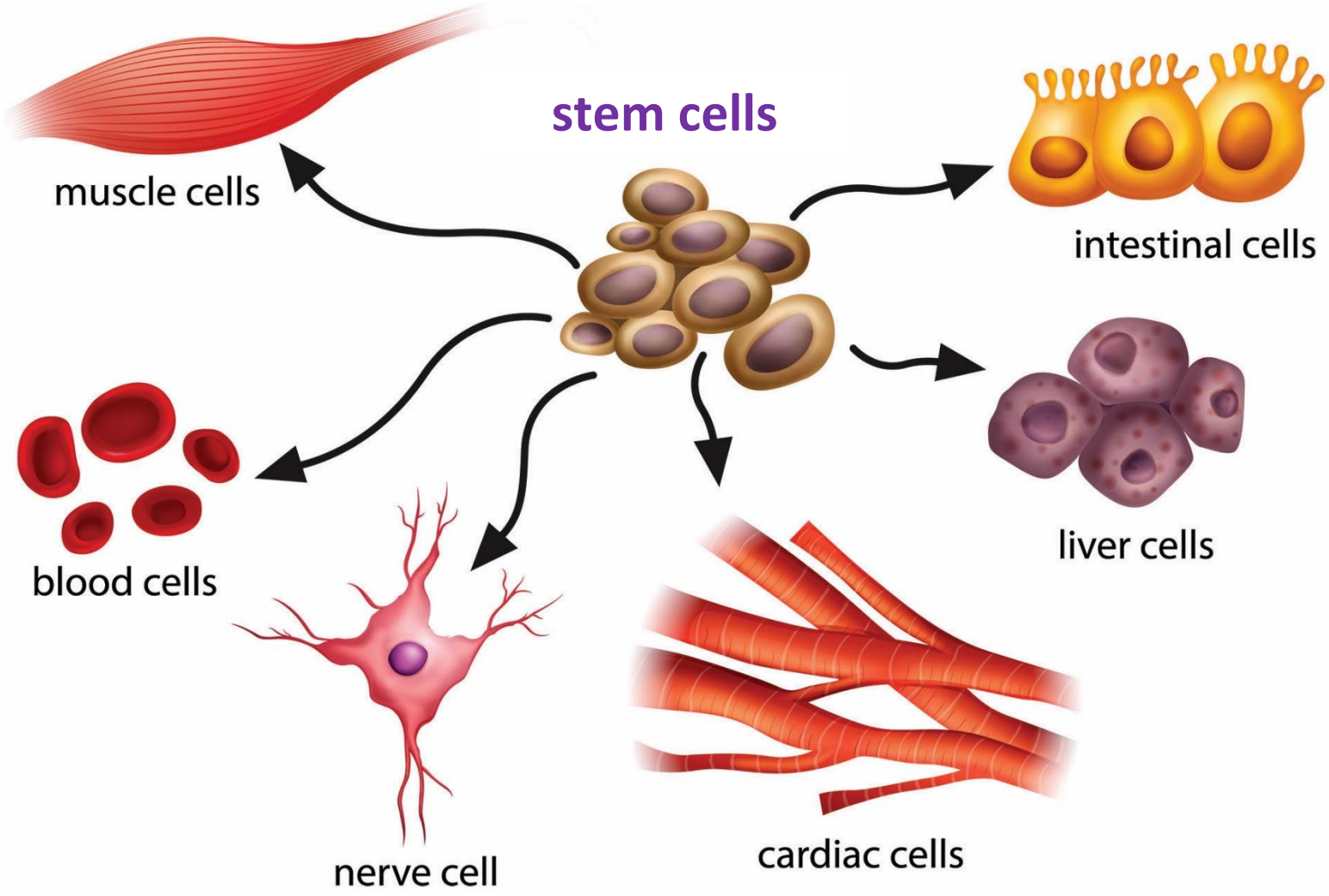


Neuron



Smooth muscle cells

Stem cells are *undifferentiated* cells that *can differentiate* into specialized cells.



10 largest single-celled organisms

https://listverse.com/2016/07/01/10-freakishly-large-single-celled-organisms/

Typical cell sizes

https://learn.genetics.utah.edu/content/cells/scale/