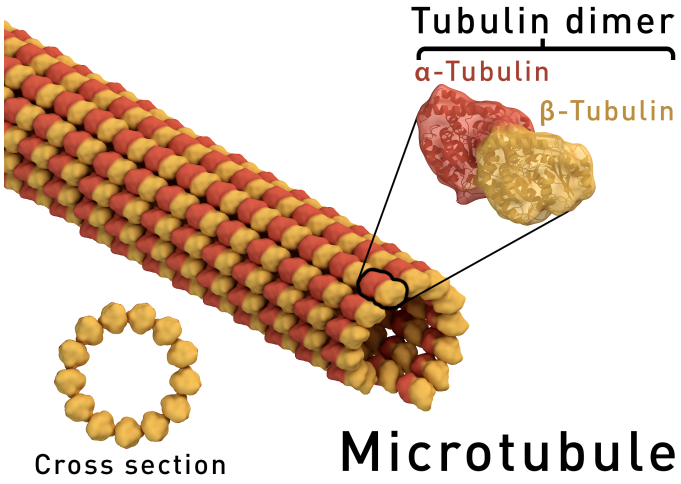
CONCEPT: MICROTUBULES

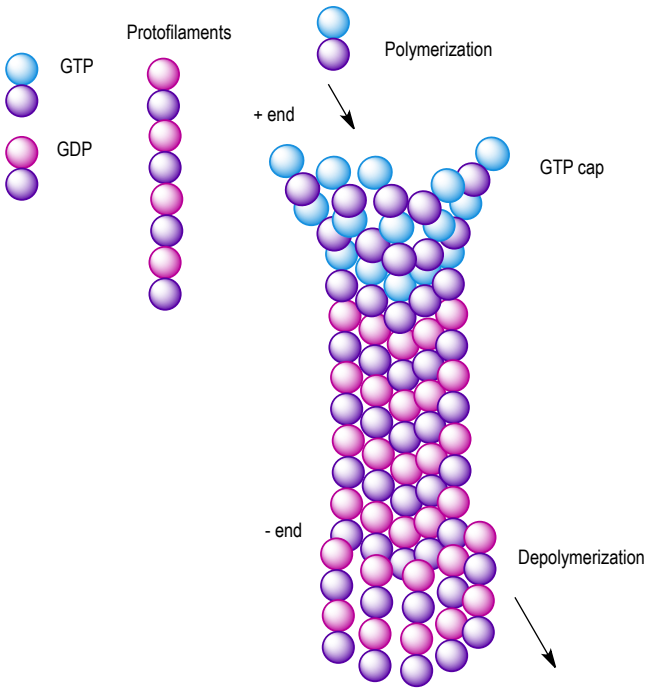
- **Microtubules** are cytoskeletal elements that act as cellular _____ for moving vesicles and organelles
  - □ **Tubulin** is the subunit that makes up microtubules
    - Each tubulin subunit is a dimer composed of an alpha-tubulin and a beta-tubulin
    - Position of the subunits provides tubulin with polarity (plus end = beta and minus end = alpha)
    - Tubulin dimers add more quickly to the plus end
  - □ **Microtubule associated proteins** bind to microtubules and stabilize them against disassembly

EXAMPLE: Microtubule dimers



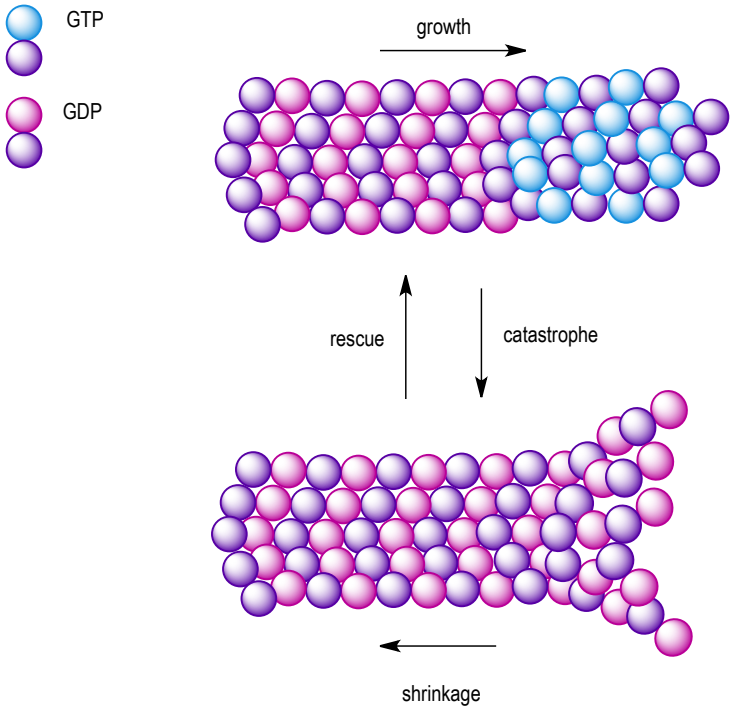
- Tubulin is attached to GTP which effect microtubule _____
  1. **Protofilaments** (small aggregates of tubulin) form at **microtubule-organizing centers** in the cell (*nucleation)*
  2. Tubulin **polymerization** occurs, which caused by adding to a growing molecule at either end
  3. Tubulin dimers hydrolyze GTP (T form) to GDP (D form) - BUT speed of hydrolysis results in growth or instability
     - *Hydrolyzed slowly:* If GTP is hydrolyzed to GDP after the next dimer is added the filament will grow
       - A **GTP cap** is formed by attaching multiple tubulin-GTPs without immediately hydrolyzing them
     - *Hydrolyzed quickly:* if GDP is hydrolyzed before the next dimer is added it will destabilize the microtubule

EXAMPLE: Tubulin polymerization and depolymerization



- Two terms describe the addition and destabilization of microtubules
  - □ **Dynamic instability** is when a microtubule end switches between polymerization and depolymerization
  - □ **Treadmilling** is when subunits are recruited to the plus end, and shed from the minus end

EXAMPLE: Dynamic instability



Microtubules and Cell Division

● **Centrosomes** are responsible for organizing microtubule _____ during cell division

□ Contains **centriole pairs** which act as a *nucleation* site for microtubule growth

- Tubulin dimers are added with minus end towards the centrioles, and plus end towards cytoplasm

EXAMPLE: Centriole pairs

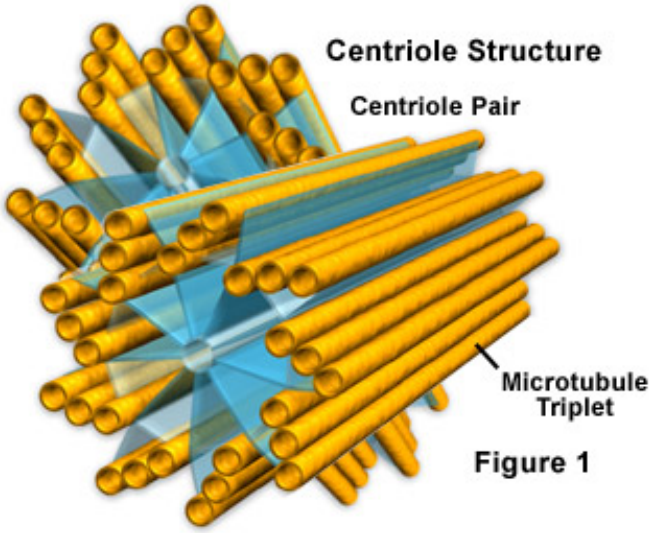


Figure 1

PRACTICE:

1. Under which condition is a GTP cap formed during microtubule formation?
    a. If the microtubule end is hydrolyzed slowly
    b. If the microtubule end is hydrolyzed quickly

2. True or False: Treadmilling is when a microtubule end switches from polarization to depolarization.
    a. True
    b. False

3. A single tubulin subunit is composed of which of the following components?
    a. An alpha tubulin
    b. A beta tubulin
    c. A dimer of alpha and beta tubulin
    d. A tetramer of alpha and beta tubulin