17.1: Motor Proteins

Many proteins act as molecular motors using an energy source to move themselves or cargo in space. They create directed motion by coupling energy use to conformational change.

Motor Classes

Translational

- Cytoskeletal motors that step along filaments (actin, microtubules)
- Helicase translation along DNA

Rotary

- ATP synthase
- Flagellar motors

Polymerization

- Cell motility

Translocation

- DNA packaging in viral capsids
- Transport of polypeptides across membranes

Translational Motors

Processivity

- Some motors stay on fixed track for numerous cycles
- Others bind/unbind often—mixing stepping and diffusion

Cytoskeletal motors

- Used to move vesicles and displace one filament relative to another
- Move along filaments—tracks have polarity (±)
- Steps of fixed size

Classes

- Dynein moves on Microtubules (+ → −)
- Kinesin Microtubules (mostly − → +)
- Myosin Actin

Molecular Motors

We can make a number of observations about common properties of translational and rotational motor proteins.

Molecular motors are cyclical

- They are “processive” involving discrete stepping motion
- Multiple cycles lead to directional linear or rotary motion

Molecular motors require an external energy source

- Commonly this energy comes from ATP hydrolysis
  - ~50 kJ/mol or ~20 kBT or ~80 pN/nm
  - ATP consumption correlated with stepping
- Or from proton transfer across a transmembrane proton gradient

Protein motion is strongly influenced by thermal fluctuations and Brownian motion

- Molecular motors work at energies close to kBT
- Short range motions are diffusive—dominated by collisions
- Inertial motion does not apply
