BIOLOGICAL FRAMEWORKS FOR ENGINEERS

Session #15 [Cellular Motion and Shape Change]

General Objectives:
- ✓ Discuss the importance of cell movement and shape change
- ✓ Discuss mechanisms of cell motion

Central Framework:
- ✓ Cellular movement and shape change is central to the life of an organism and is accomplished via different mechanisms.

Interactive Activity:
- ✓ Videos of cellular motion

Session Outline:

A. Importance of Cell Movement

B. Cytoskeleton

Actin

Microtubules

Intermediate Filaments

C. Mechanisms of Cell Movement

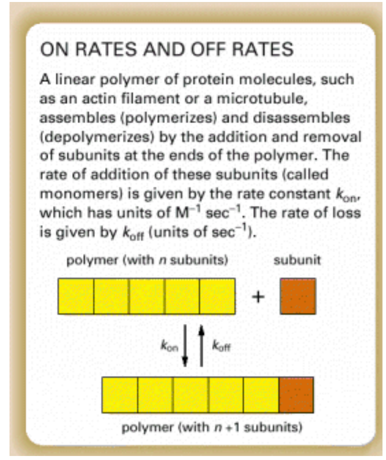
Polarization

Protrusion

Adhesion

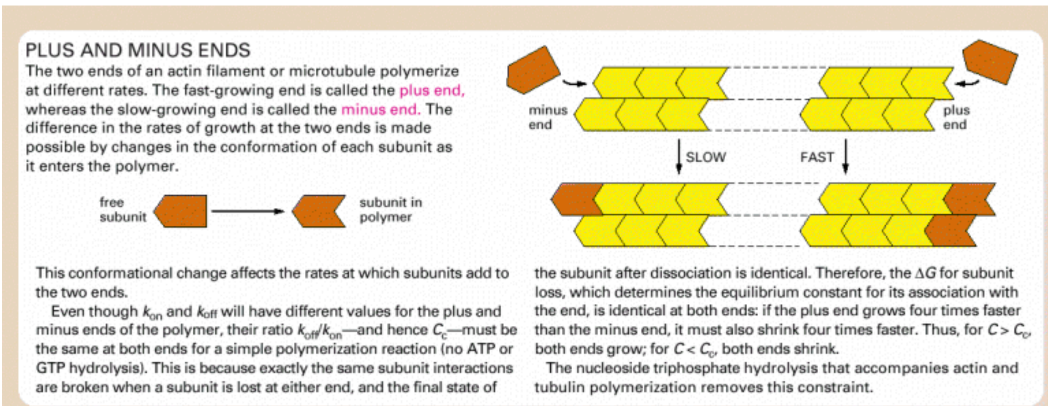
Motor Proteins

Assembly / Disassembly



ON RATES AND OFF RATES

A linear polymer of protein molecules, such as an actin filament or a microtubule, assembles (polymerizes) and disassembles (depolymerizes) by the addition and removal of subunits at the ends of the polymer. The rate of addition of these subunits (called monomers) is given by the rate constant k_{on}, which has units of M^{-1} sec^{-1}. The rate of loss is given by k_{off} (units of sec^{-1}).



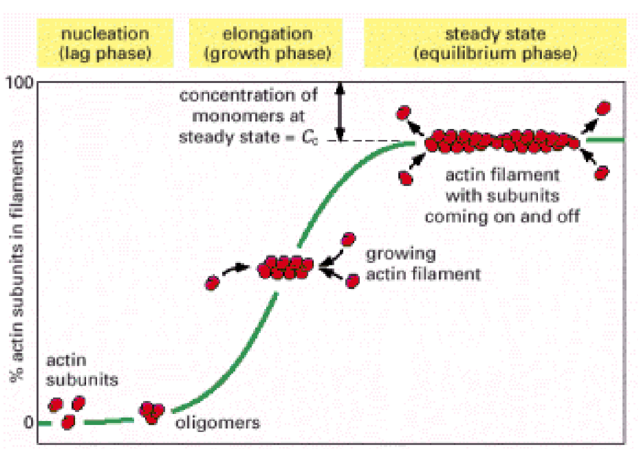
PLUS AND MINUS ENDS

The two ends of an actin filament or microtubule polymerize at different rates. The fast-growing end is called the plus end, whereas the slow-growing end is called the minus end. The difference in the rates of growth at the two ends is made possible by changes in the conformation of each subunit as it enters the polymer.

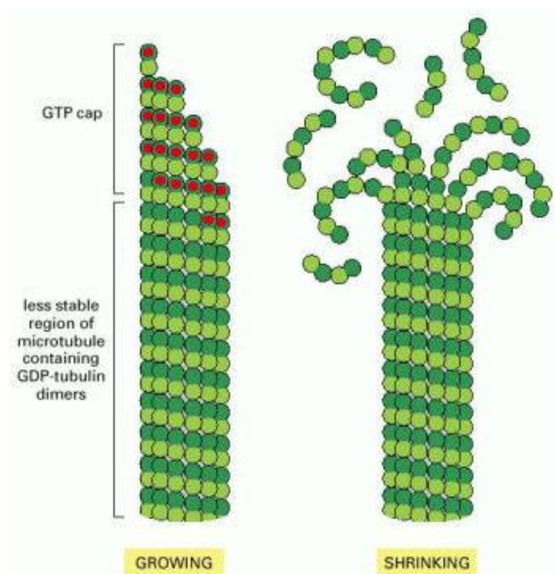
This conformational change affects the rates at which subunits add to the two ends.

Even though k_{on} and k_{off} will have different values for the plus and minus ends of the polymer, their ratio k_{off}/k_{on}—and hence C_c—must be the same at both ends for a simple polymerization reaction (no ATP or GTP hydrolysis). This is because exactly the same subunit interactions are broken when a subunit is lost at either end, and the final state of the subunit after dissociation is identical. Therefore, the ΔG for subunit loss, which determines the equilibrium constant for its association with the end, is identical at both ends: if the plus end grows four times faster than the minus end, it must also shrink four times faster. Thus, for $C > C_c$, both ends grow; for $C < C_c$, both ends shrink.

The nucleoside triphosphate hydrolysis that accompanies actin and tubulin polymerization removes this constraint.

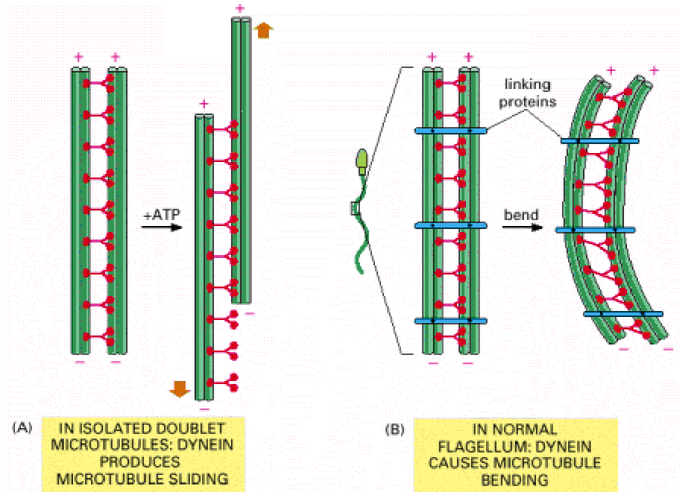


(A)



(C)

D. Flagella and Cilia



E. Muscle Cell Contraction