TUTORIAL 1

BB 101

MODULE: *PHYSICAL BIOLOGY*

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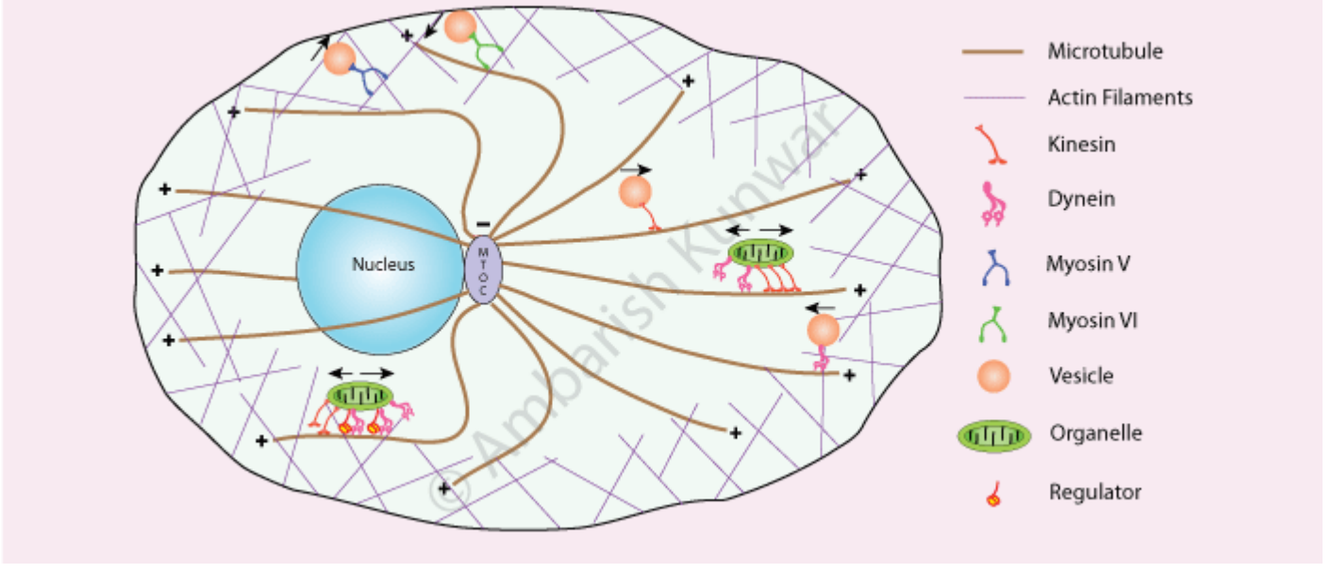
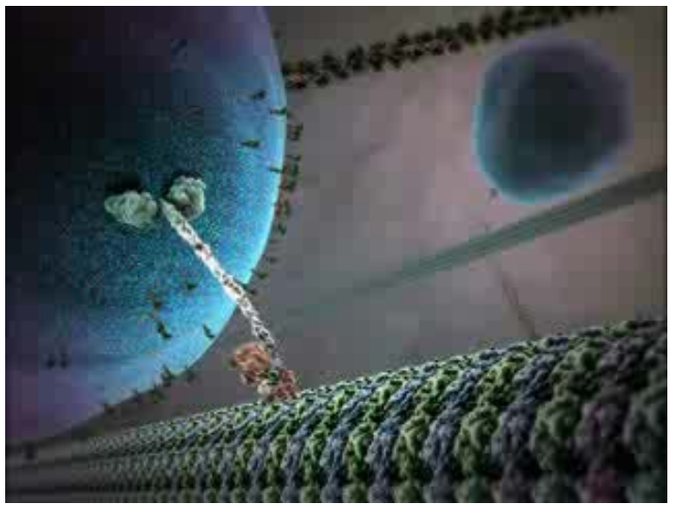
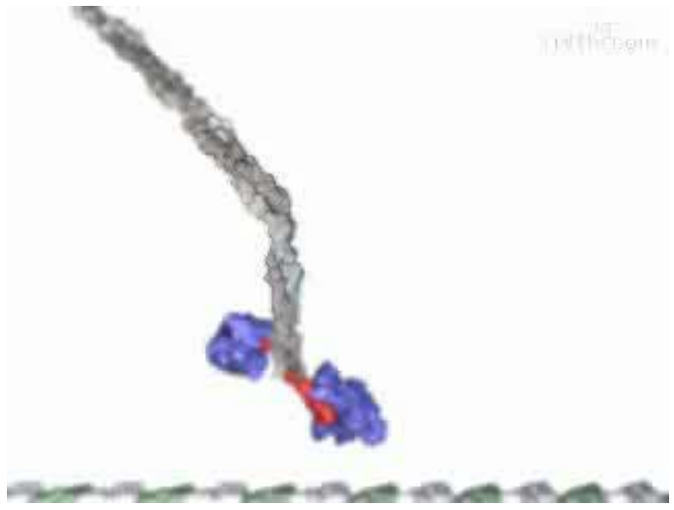
Molecular Motors





Video Source: http://multimedia.mcb.harvard.edu/

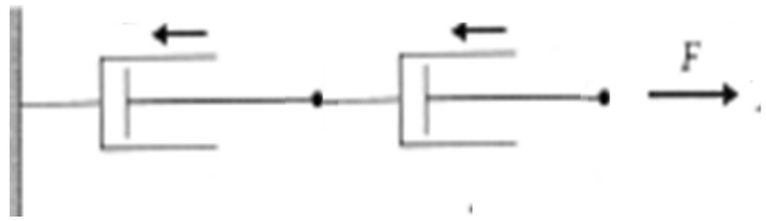


Video Source: https://valelab.ucsf.edu/external/moviepages/moviesMolecMotors.html

1. The chemical energy available from the hydrolysis of ATP is 100 X 10^{-21} J. How far can a motor protein exert a force of 5 pN by hydrolyzing 10 ATP?

2. Molecular motor protein such as Kinesin can generate a force of typically 5 pN. Given that the viscosity of cytoplasm is 1000 times that of water and bacteria can be treated as a spherical object of radius $3/\pi$ μm , how fast could a single kinesin molecule move a bacterium through a cell cytoplasm?

(Viscosity of water = 1 mPa.s)



3. If the dashpots are placed in series, show that reciprocals of the drag coefficients add.

4. An oversimplified model of viscoelastic substance consists of a spring and a dashpot in series (Initially dashpot is at rest and spring is un-stretched). Suppose a force is abruptly applied to this system at t=0 and separation between two ends is increased by x_0 (where x_0 remains constant for all t>0), how would spring and dashpot move for t>0?

5. Consider the sedimentation of a globular protein of radius 3nm and mass 100 KDa, initially right below the surface, in an Eppendorf tube filled with water upto 1cm height. How much time it would take for this protein to sediment under the effect of gravity assuming that protein attains a constant velocity as soon as it starts to descend in the tube?. (Hint: Write down the equation of motion considering gravitational force, buoyant force and drag force)

Figure Source: Mechanics of Motor Proteins and the Cytoskeleton, Jonathan Howard

6. A micron size cylindrical rod as shown in Figure B is moving with constant velocity $\vec{v}$ in x-z plane such that the angle between the axis of cylinder and velocity vector is 45^0. Consider the motion is dominated by viscous forces. What would be the angle between the direction of net drag force on the cylinder and axis of the cylinder, if drag coefficient for motion perpendicular to axis of cylinder is $\sqrt{3}$ times that of drag coefficient for the motion parallel to axis of cylinder? (Hint: Resolve velocity vector along the axis of cylinder and parallel to axis of cylinder)

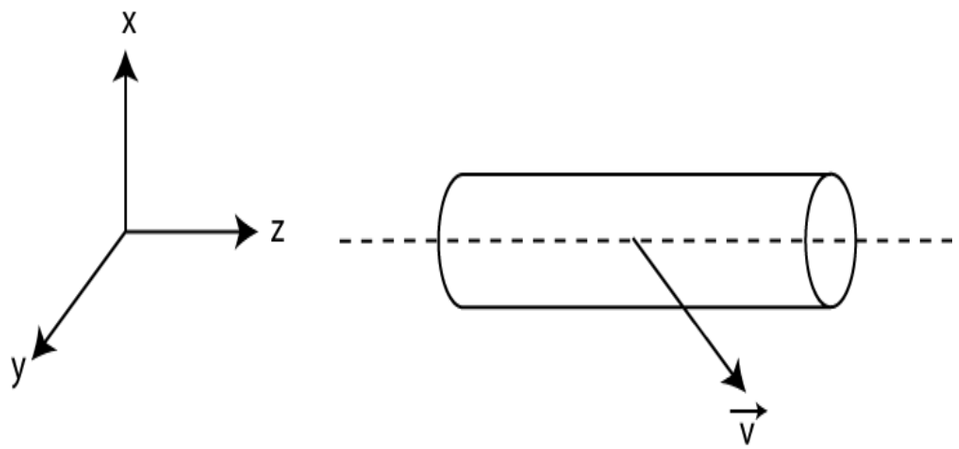


Figure B