

Molecular Machines of the Cell (Part 2)

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- **Introductory Animation:** [Molecular Machinery of Life](http://youtu.be/FJ4N0iSeR8U) <http://youtu.be/FJ4N0iSeR8U>
- **Worthy are You, our Lord and our God, to receive glory and honor and power; for You created all things, and because of Your will they existed, and were created. [Revelation 4:11] (NASB)**
- **Kinesin - a linear motor molecule**
 - Travels along microtubule tracks
 - 100 steps a second
 - 10 steps to move a distance equivalent to the width of a human hair
 - 15" per day. At the very tiny molecular scale, this is quite a far distance
 - To put this in perspective: If the kinesin motor (7.5 nm tall) was the same size as me (5' 9", or 1.75 billion nm), the kinesin motor would "walk" about 55,000 miles per day. (This is slightly more than two times the 25,000 mile circumference of the earth)
 - (I am 234 million times taller than kinesin; so 15" X 234 million = 3.5 billion inches, which is about 55,000 miles)
 - FYI –this is handy measurement units conversion web site: <http://www.convert-me.com/en/>
 - 3-4 days to move some type of cargo from the spine to the foot within a long nerve cell
 - There are 100's of vesicles or organelles (cargo containers) per cell that need to be moved around
- **Kinesin**
 - A type of motor molecule that moves along microtubule tracks
 - [How they "walk"](http://youtu.be/YAva4g3Pk6k) **Animation:** <http://youtu.be/YAva4g3Pk6k>
 - [How they move cargo](http://youtu.be/7sRZy9PgPvg) **Animation:** <http://youtu.be/7sRZy9PgPvg>
 - [Kinesins - "trucking"](http://youtu.be/mzEODMz6WGU) **Animation:** <http://youtu.be/mzEODMz6WGU>
- **Muscle Cells**
 - Actin cytoskeleton (tracks)
 - Myosin motor molecules
 - Example: Muscle Cells
 - Each muscle fiber is a single cell with multiple nuclei
 - The muscle fiber is formed from the fusion of several individual cells - "modular construction"
 - [Muscle contraction and relaxation](http://youtu.be/EhfFpKwQJLY) **Animation:** <http://youtu.be/EhfFpKwQJLY>
 - [Muscle contraction \(2\)](http://youtu.be/gJ309LfHQ3M) **Animation:** <http://youtu.be/gJ309LfHQ3M>
 - Other functions of actin/myosin
 - Cellular traffic
 - Movement of cells
 - Phagocytosis (important part of our defense mechanisms)
 - Cell division
- **Nerve Cells**
 - [Nerve impulses](http://youtu.be/ifD1YG07fB8) **Animation:** <http://youtu.be/ifD1YG07fB8>
 - Nerve cells have voltage-gated (voltage-controlled) ion channels

- Sort of act like transistors, except that the flow of positively-charged ions is controlled, instead of negatively-charged electrons
 - Voltage-gated sodium ion channels, initially in the closed but “ready” condition, open during nerve stimulation, but quickly close again to help keep nerve impulse moving in one direction
 - Voltage-gated potassium ion channels open to help develop the nerve impulse. They close shortly after the sodium-ion channels.
 - Voltage-gated chloride channels and Sodium/Potassium/ATPase "pumps" restore the proper ion balance to the resting potential and get the nerve cell ready to refire.
 - Voltage-gated sodium ion channels return to the closed but ready condition to respond to the next stimulus a few milliseconds late
 - All this happens within a few milliseconds (thousandths of a second)
 - Speeding up nerve impulses in long nerve cells
 - Myelin Sheath (made of precisely-spaced specialized cells (Schwann cells) that wrap around a nerve cell)
 - Acts like an electrical insulator
 - Nodes of Ranvier (gaps between the Schwann cells that make up the myelin sheath)
 - Contain a very high concentration of ion channels
 - Spaced *just the right distance apart* to continue and amplify the nerve impulse before it weakens
 - Speeds up the nerve impulse about 100 times (200 miles per hour or more)
 - [The Schwann Cell and Action Potential](http://youtu.be/DJe3_3XsBOg) *Animation:* http://youtu.be/DJe3_3XsBOg
- **ATP**
 - Muscle and nerve cells use an incredibly huge amount of ATP per second and so do other cells as well.
 - ATP is one of the energy currencies of the cell
 - All cells consume A LOT of ATP per second
 - 2,407,000 (about 2 1/2 million) ATP molecules per second needed for macromolecule synthesis in just one *Escherichia coli* bacterial cell
 - There are billions of *E. coli* bacteria living in our large intestine and billions of other types of bacteria, all using ATP
 - There are trillions of our own cells in each of our bodies
 - There are billions of people on the planet and billions of other organisms on the planet as well.
 - If only we could have a penny for every ATP molecule made in the world in just one second
 - Cells must, therefore, produce A LOT of ATP per second to keep up. ATP synthase is one of the primary means for making ATP.
- **ATP Synthase**
 - [Energy converting molecular machine](http://youtu.be/PjdPTY1wHdQ) *Animation:* <http://youtu.be/PjdPTY1wHdQ>
 - [Structure](http://youtu.be/ShS31FU_OFM) *Animation:* http://youtu.be/ShS31FU_OFM
- **The bacterial flagellum**
 - Semi-rigid helical (slightly twisted) propeller
 - Uses a proton gradient or other ion gradient as a source of energy
 - Essentially a molecular electric motor composed of axel, bearings, rotor, stator, etc. all made of proteins

- Coordinated action coupled to sensory system
- [Assembly Process & Structure Animation:](http://youtu.be/Ey7Emmddf7Y) <http://youtu.be/Ey7Emmddf7Y>
- Over the last two sessions we have looked at a number of amazing molecular machines necessary for cell function and for life itself. There are more examples that scientists know about than have been presented here, and undoubtedly there are more that have yet to be discovered.

- **So, Who came up with all this neat stuff in the first place?**