

Molecular Machines of the Cell (Part 1)

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- In this presentation I would like to show you some of the current ideas regarding the complexity of the cell, including several of the "Molecular Machines" found in many of our cells. It is not my intent to overwhelm you with a bunch of cell biology details. Rather I hope, using a series of animations available on YouTube, to show you some of the complexity of the cell that has been discovered by thousands of different scientists over the last 75 or so years. The cell is definitely more complex than we realized at the beginning of the 20th. century. It is the scientists making these discoveries that often use the term "molecular machines" or "nano (very small) machines" to describe these structures within a cell, many of which are essential for proper cell function and for life in general.
 - The animations used in this presentation can be viewed by clicking on the underlined links. In some cases only a portion of the video or animation was shown and the time range used is indicated in square brackets, []. You can advance to that specific portion of the video manually in YouTube, if desired.
 - It should be noted that some of the narrations or text used in these animations may refer to "evolution", "evolutionary", or "millions/billions of years".
- **Introductory Animation:**
 - [Introduction to Cells](http://youtu.be/gFuEo2ccTPA) <http://youtu.be/gFuEo2ccTPA>
- **For the wrath of God is revealed from heaven against all ungodliness and unrighteousness of men who suppress the truth in unrighteousness, because that which is known about God is evident within them; for God made it evident to them. For since the creation of the world His invisible attributes, His eternal power and divine nature, have been clearly seen, being understood through what has been made, so that they are without excuse. [Romans 1:18-20] (NASB)**
- **The Cell Theory**
 - All living organisms are composed of cells. They may be unicellular or multicellular.
 - The cell is the basic unit of life.
 - Cells arise from pre-existing cells.
 - The modern version also includes the ideas that:
 - Energy flow occurs within cells.
 - Heredity information (DNA) is passed on from cell to cell.
 - All cells have the same basic chemical composition.
- **Cells**
 - Usually microscopic in size - a microscope is needed to visualize most of them
 - Some, however, are big enough to see with the naked eye
 - Some can be several feet long (e.g. some nerve cells)
 - Can have an incredible variety of shapes, sizes, and specialized functions
- **Cells**
 - Cells are more than a mixed bag of chemicals and enzymes
 - They have specialized structures and architectures

- Even the simplest of cells have a variety of internal machines that are needed for them to function and reproduce
 - **Molecular Machines**
 - **Animation:** [Molecular Machinery of Life](http://youtu.be/FJ4N0iSeR8U) <http://youtu.be/FJ4N0iSeR8U>
- **DNA - the Code of Life**
 - [How is it packaged to fit within a cell?](http://youtu.be/gbSIBhFwQ4s) **Animation:** <http://youtu.be/gbSIBhFwQ4s>
 - [How is it copied prior to cell division?](http://youtu.be/I9ArIJWYZHI) **Animation:** <http://youtu.be/I9ArIJWYZHI>
 - [How is the code read?](http://youtu.be/I9ArIJWYZHI) **Animation:** <http://youtu.be/I9ArIJWYZHI>
 - [How does the code make proteins?](http://youtu.be/8dsTvBaUMvw) **Animation:** <http://youtu.be/8dsTvBaUMvw>
 - Structural proteins
 - Biological catalysts (enzymes)
 - Components of other molecular machines
 - [Ribosome binding](http://youtu.be/d9SmlDY1CxE) **Animation:** <http://youtu.be/d9SmlDY1CxE>
 - [Transcription and Translation \(again\)](http://youtu.be/d9SmlDY1CxE) **Animation:** <http://youtu.be/d9SmlDY1CxE>
- **Visualizing the cell & parts of cells**
 - Light microscopes can be used to visualize cells and some of the larger components of cells
 - There are no tiny little video cameras we can put into a cell to see what is going on.
 - Electron microscopes are needed to visualize smaller parts of the cells
 - X-ray crystallography is used to determine protein and nucleic acid structure
- **Visualizing the cell & parts of cells**
 - Illustrations and animations must be used to represent the fine details and put them in motion
 - Based on techniques listed above + genetics and a large array of experiments conducted by many scientists
 - For example, Drew Barry is a scientist, biological illustrator and animator. He developed several of the DNA animations shown previously and discussed this in a recent lecture. He refers to these as "[astonishing molecular machines](http://youtu.be/DfB8vQokr0Q)" [2:05-9:00 min] **Video/Animation:** <http://youtu.be/DfB8vQokr0Q> [2:05-9:00 min]
 - Colors are added by the illustrator/animator for clarity (and dramatic effect?) since most proteins do not have color
- **Transportation Systems and Traffic within a eukaryotic cell**
 - Cytoskeletal tracks
 - Microfilaments (polymerized actin proteins)
 - Microtubules (polymerized tubulin proteins)
 - Dynamic, ever-changing (growing, changing direction, shrinking & recycling components)
 - Motor molecules
 - Specific for the type of track
 - Motor Molecules used with Microtubule tracks
 - Dyneins (move in one direction)
 - Kinesins (move in the other direction)
 - Motor Molecules used with Microfilament tracks
 - Myosins
- **Animations showing microtubules and dynein motor molecules**

- Microtubules
 - Growing, shrinking, changing direction *Animation:* <http://youtu.be/E1XczyCkN20>
 - Dynamic *Animation:* <http://youtu.be/x2EIL2VVKi8>
 - Transportation Routes *Animation:* <http://youtu.be/2-L-Ts6fsks>
 - Cytoplasmic streaming *Animation:* <http://youtu.be/7jw-N82tHjc>
- Dynein Motor Molecules
 - Dyneins *Animation:* <http://youtu.be/-7AQVbrmzFw>
 - Cilia [1:24 - 3:28 min.] *Animation:* <http://youtu.be/FQwqhblxz3I> [1:24 - 3:28 min.]
 - Cilia bending [0:54 - 4:15 min.] *Animation:* <http://youtu.be/vQ3CdSiVzUk> [0:54 - 4:15 min.]
 - 4,000 dynein motor molecules per cilium - all moving in a coordinated fashion
 - Hundreds to thousands of cilia per cell - all moving in a coordinated fashion!
 - That's a lot of motor molecules to keep track of all at once!
- **...To be continued next time**
 - Kinesin motor molecules
 - Actin and Myosin (muscle contraction)
 - Nerve cells
 - Making ATP
 - Bacterial Flagella (rotary propellers)