Cilium or flagellum movement using axonemal dyneins:

+ ATP: Causes dynein to walk toward minus end and pull toward plus end

Microtubule doublet

Dynein arms walk along microtubule doublets on one side of an axoneme

Link

Dynein arms

Central microtubules

Microtubule doublet

Spoke

Plasma membrane

Link

Dynein arms
The **Cell Theory**:

- The cell is the fundamental unit of life
- All living organisms are made of one or more cells
- All cells come from pre-existing cells

The Cell Theory has been around since the late 1800’s, and was accompanied by additional observations:

- **1882**: Walther Flemming introduced the term Mitosis (from the Greek word “mitos” meaning “thread”) to describe the thread-like appearance of chromosomes prior to cell division
- **1883**: Edouard van Beneden reported that the total number of threads in a cell remains constant during subsequent divisions
- **1888**: Wilhelm Waldeyer introduced the term Chromosome (“colored body”) to refer to the thread-like structures in dividing cells
Life cycles of most cells consist of four major processes, to ensure that daughter cells receive intact genomes:

- Cell growth
- DNA replication
- Distribution of replicated chromosomes
- Cell division

In bacteria, growth and DNA replication happen throughout the cell’s life.

In eukaryotes, growth is mostly continuous, but DNA replication occurs in only one phase, and distribution is a series of steps.

The eukaryotic cell cycle:

- Our model system is cultured human cells
  - Divide once every 24 hours

- Consists of M-phase (~5%) and Interphase (~95%)
  - M-phase is mitosis and cytokinesis; Interphase is DNA replication and (mostly steady) growth in preparation for next M-phase

- DNA is only synthesized in a specific portion of interphase, so the cell cycle is broken down into 4 distinct phases...
The eukaryotic cell cycle:

- **G₁**
- **S**
- **G₂**
- **M**

Time spent in each phase depends on the organism (and often on the cell type in a given organism):

- Cultured human cells:
  - 11 hours in G₁, 8 hours in S, 4 hours in G₂, 1 hour in M

- Some budding yeast cells:
  - All 4 phases in 90 minutes!
Time spent in each phase depends on the organism (and often on the cell type in a given organism):

- Early embryonic cells divide without growing:

- Some adult cells cease dividing altogether, but are still metabolically active
  - Exit G₁, enter what is called G₀

Analysis of the cell cycle requires identification of cells in each of the phases

- Mitotic cells can be distinguished microscopically
- G₁-S-G₂ cells must be distinguished biochemically
- S-phase cells incorporate radioactive thymidine
Cells at different stages of the cell cycle can also be distinguished by their DNA content:

- Label liquid culture of cells with fluorescent dye that binds DNA
- Pass cells through flow cytometer, which measures fluorescence
- Plot cell number vs. fluorescence intensity

Identifying phases of the cell cycle based on DNA content in liquid cell culture:
Cell culture analysis of DNA content:

- All phases of the cell cycle will be represented in this culture