Chem 452 - Lecture 11
Molecular Motors
111207

For living cells, location means everything. In multicellular organisms location determines what a cell does and how it interacts with its neighbors. Many organisms, both multicellular and unicellular, must also be able to move in order to locate foods sources and to avoid dangerous situations. Location is also important at the intracellular level, where the cellular components must be able to locate themselves where they are needed for the cell to function properly. In this section we will examine the molecular motors that are used to move the components within a cell as well as whole organisms. There are many common themes for these molecular motors, such as movement along tracks, including actin filaments and microtubules, and the use of nucleotide triphosphates to both influence the polymerization of these tracks and to fuel the movement along them. We will also look at the bacterial flagella, which looks and functions remarkably like an electrical motor, but which derives its free energy not from the hydrolysis of nucleotides, but from and ion gradient across the cell membrane.

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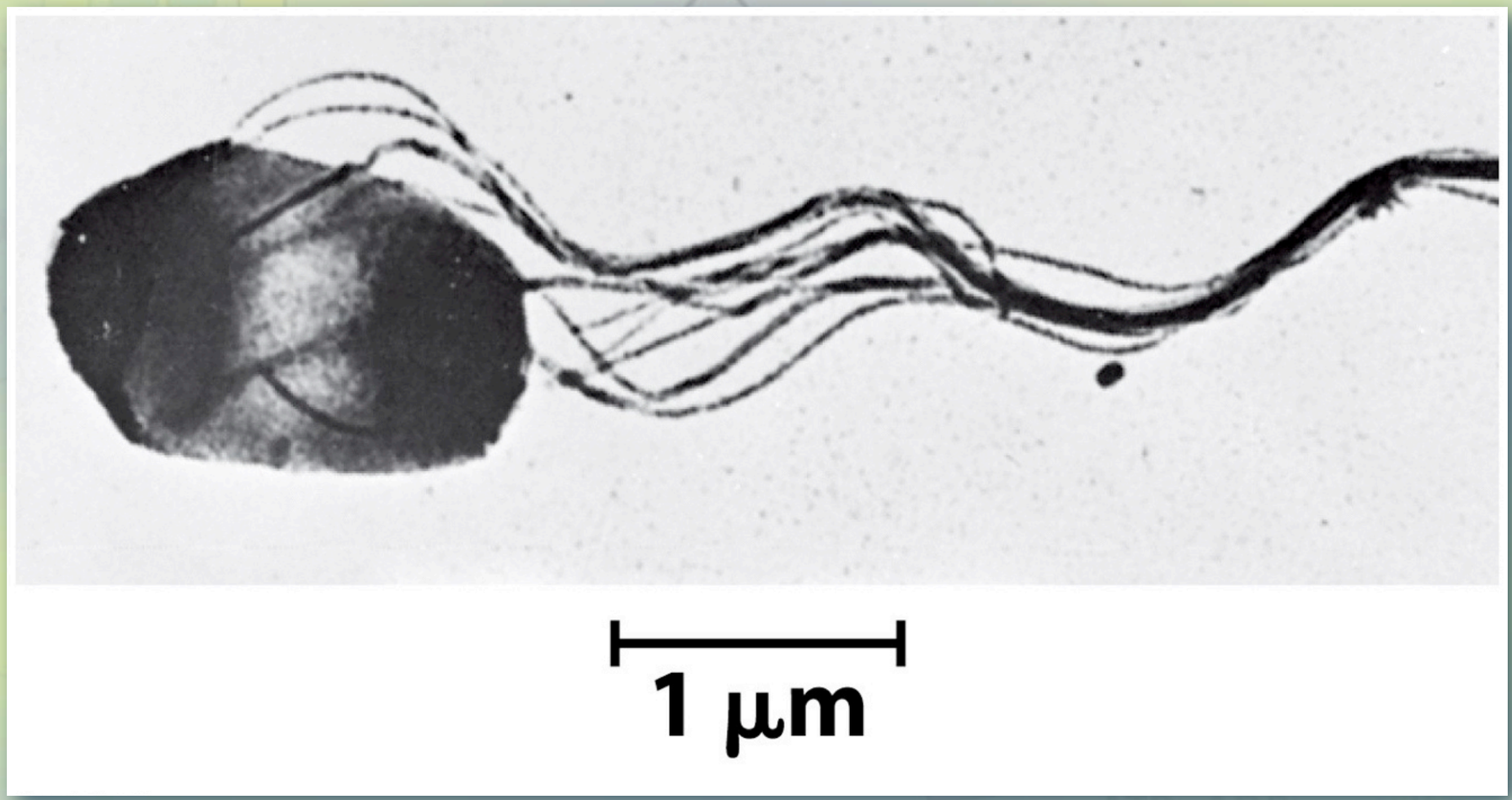
Bacterial Flagella

- Bacterial flagella are remarkably similar to an electrical motor.



Bacterial Flagella

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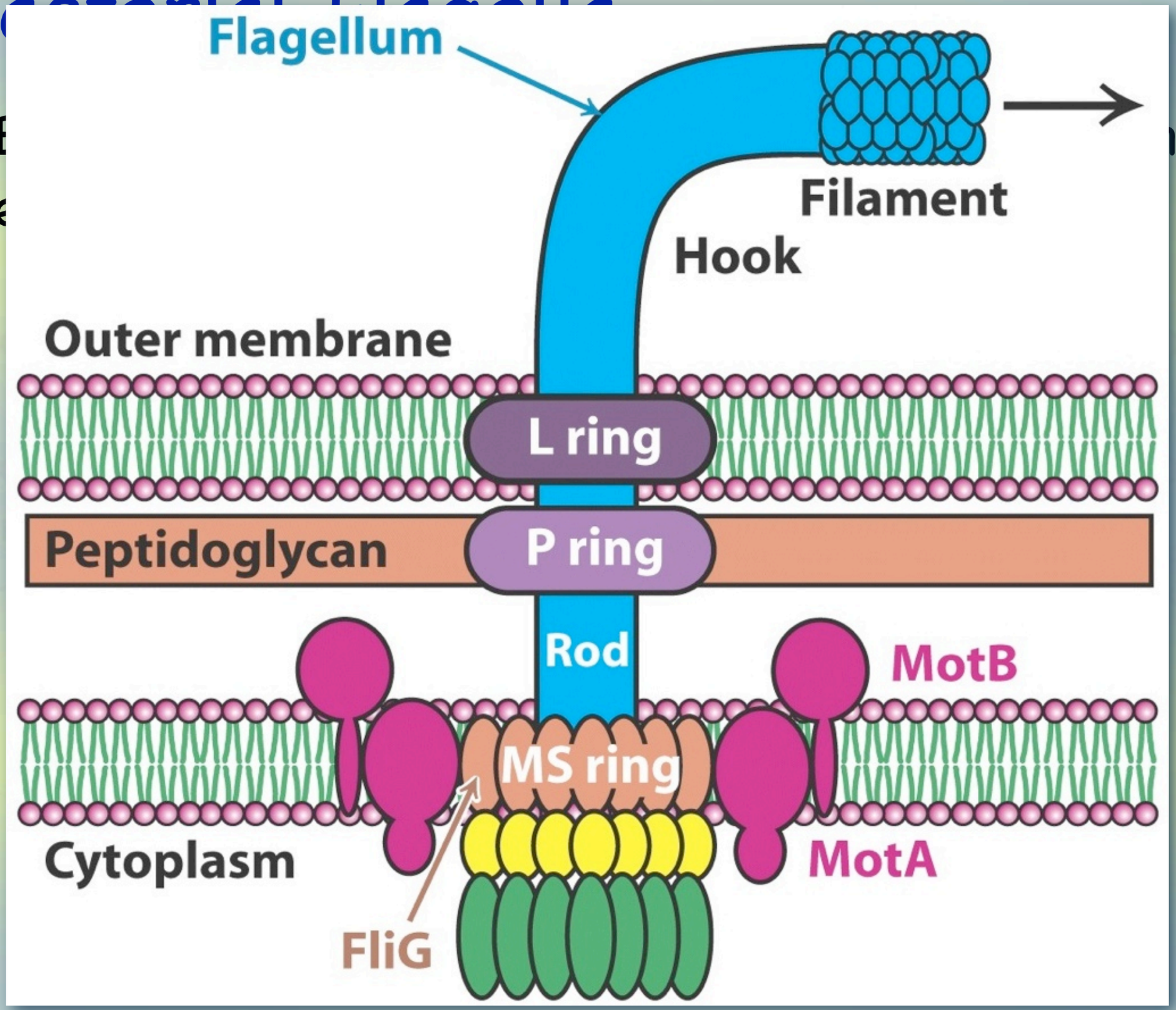
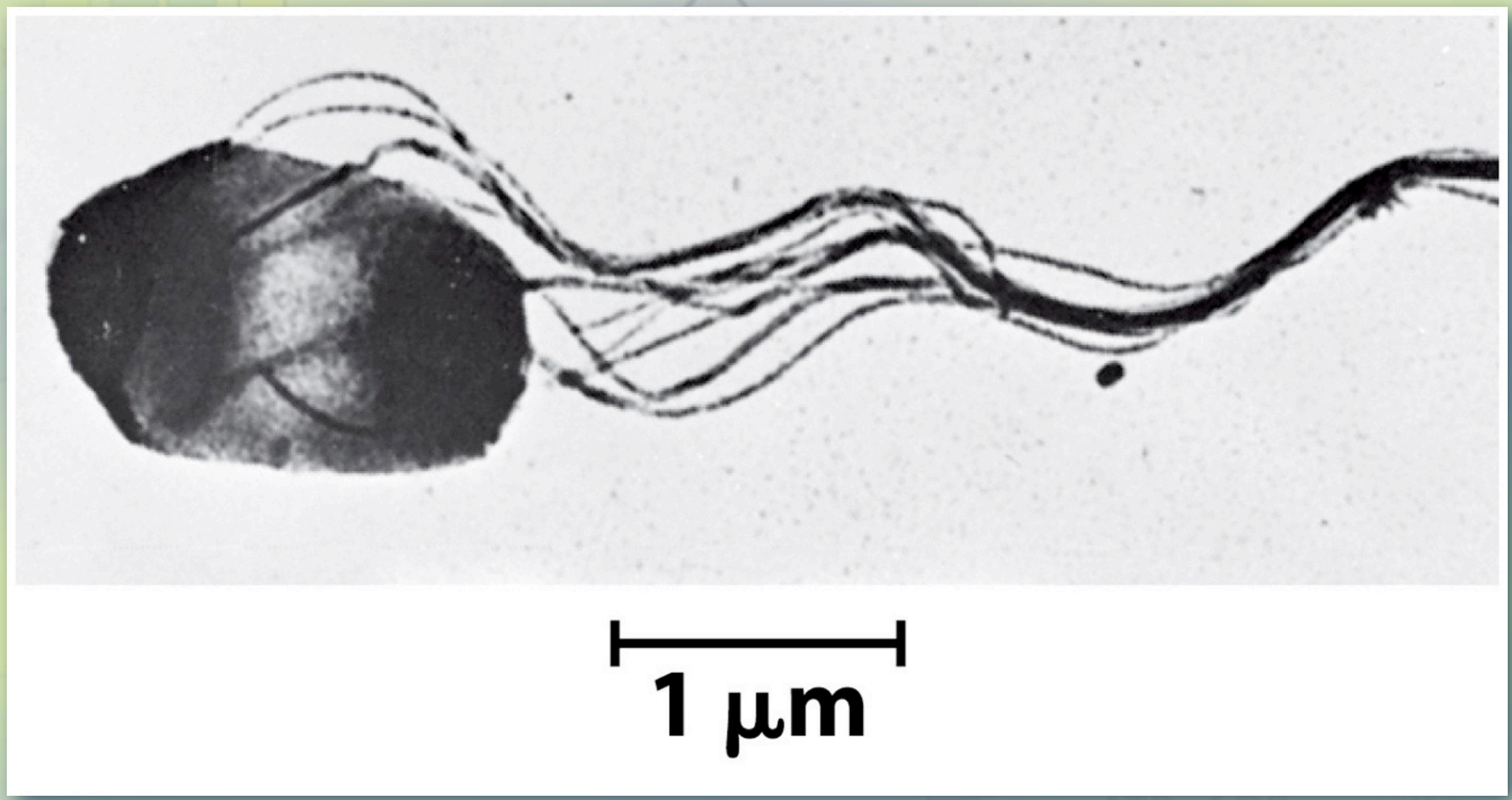


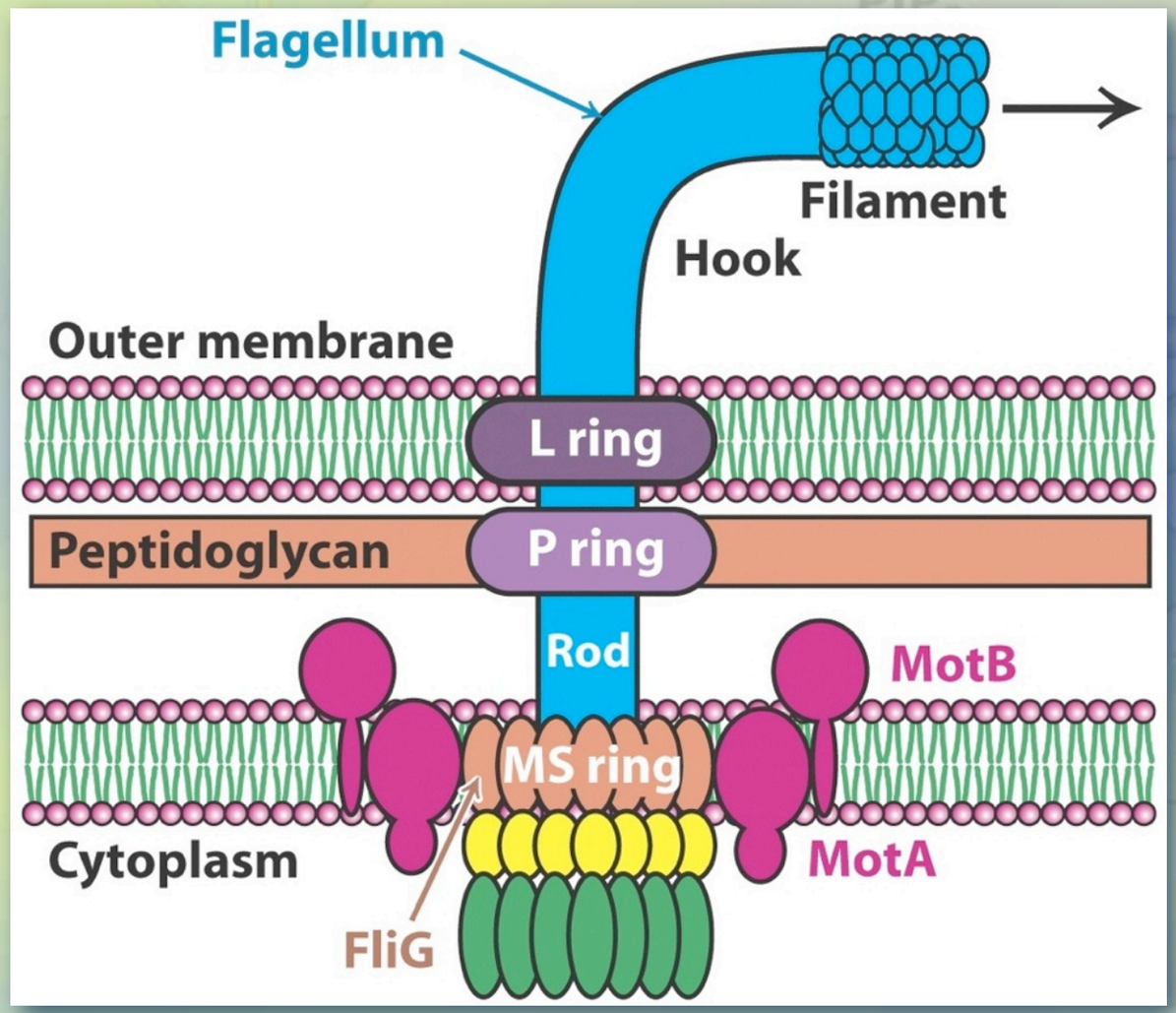
Bacterial Flagella

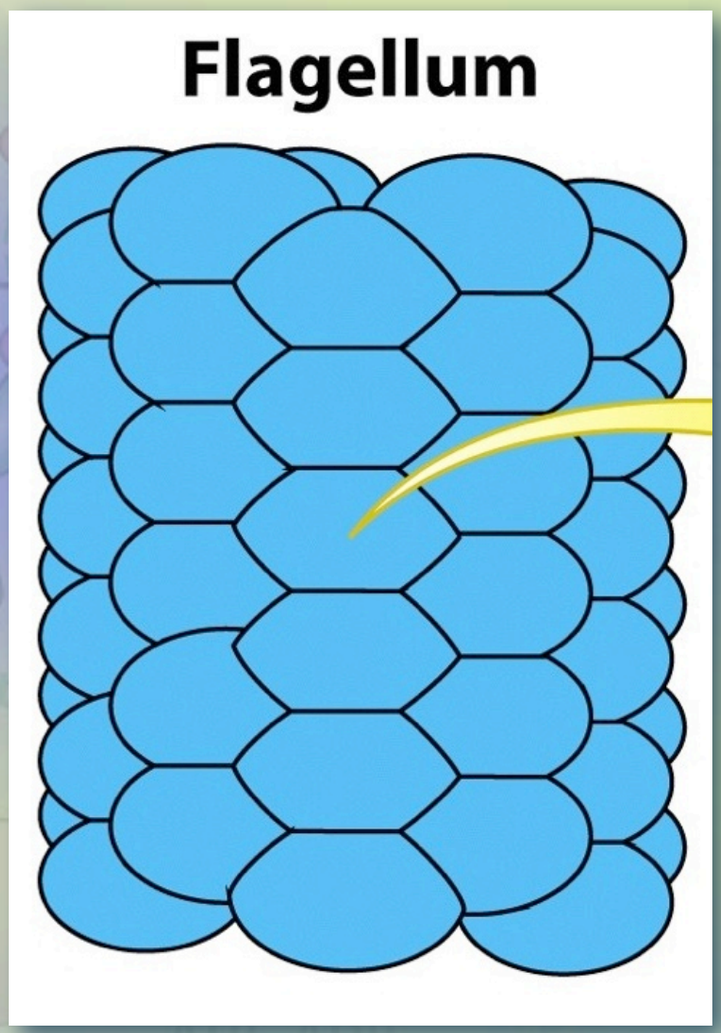
- Bacterial flagella are remarkably similar to an electrical motor.



Bacterial Flagella

- Bacterial flagella are made from the 56 kd flagellin protein.





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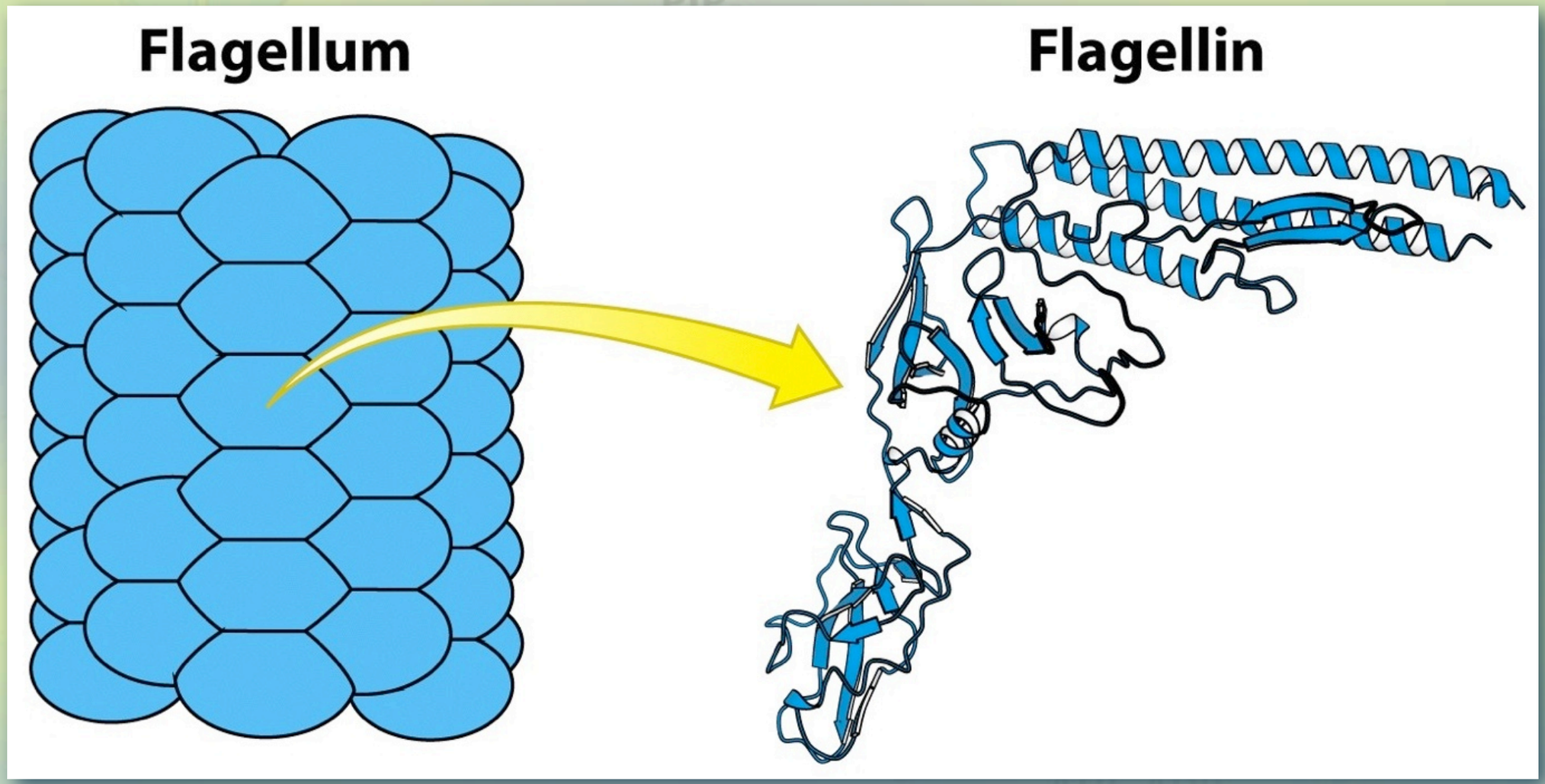
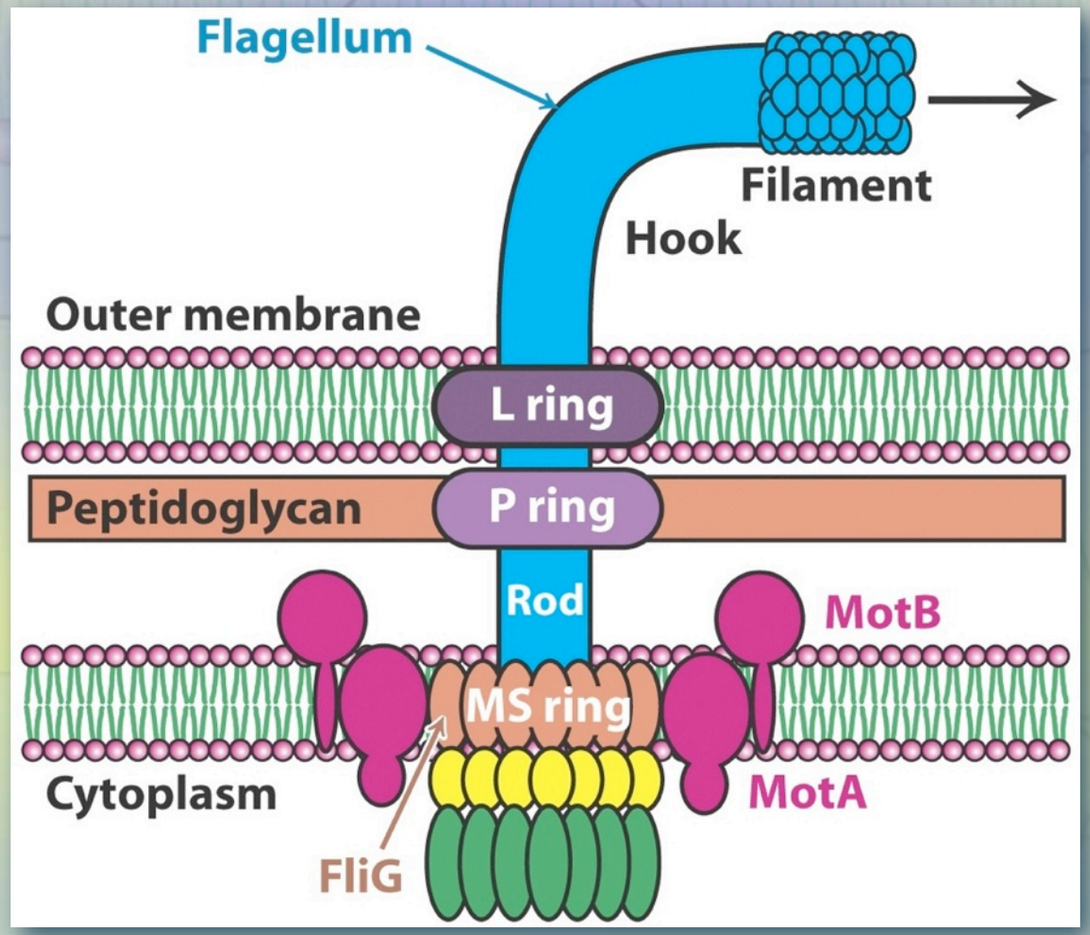


Bacterial Flagella

- Bacterial flagella are made from the 56 kd flagellin protein.
- Flagella grow from their distal ends
- Unlike G-actin and tubulin, flagellin is not an NTPase.

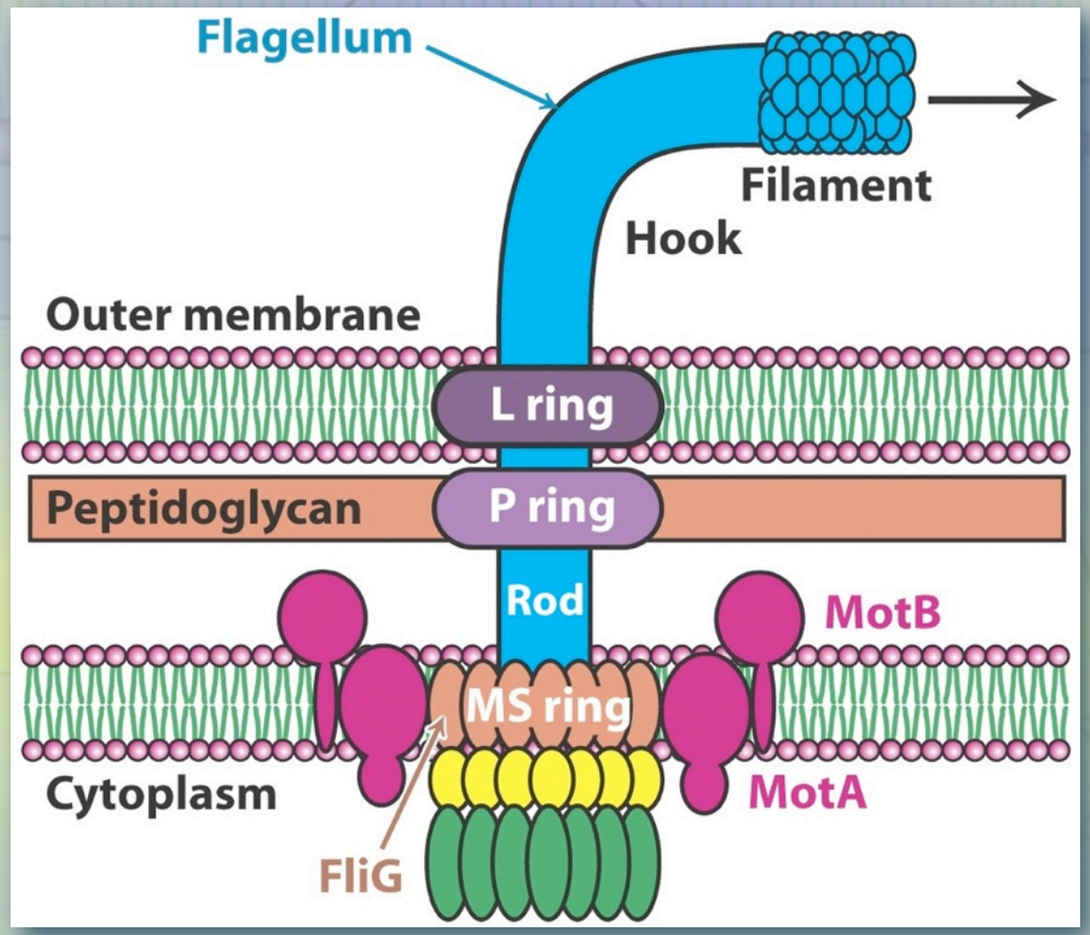
Bacterial Flagella

- The MotA and MotB proteins are paired.
  - Approximately 11 copies assemble together to make up the stator at the base of the flagellum.



Bacterial Flagella

- The FliG, FliM and FliN assemble to form the MS (membrane and supramembane) ring.
  - Approximately 30 copies of FliG form the rotor that is located in the cytoplasmic membraine.



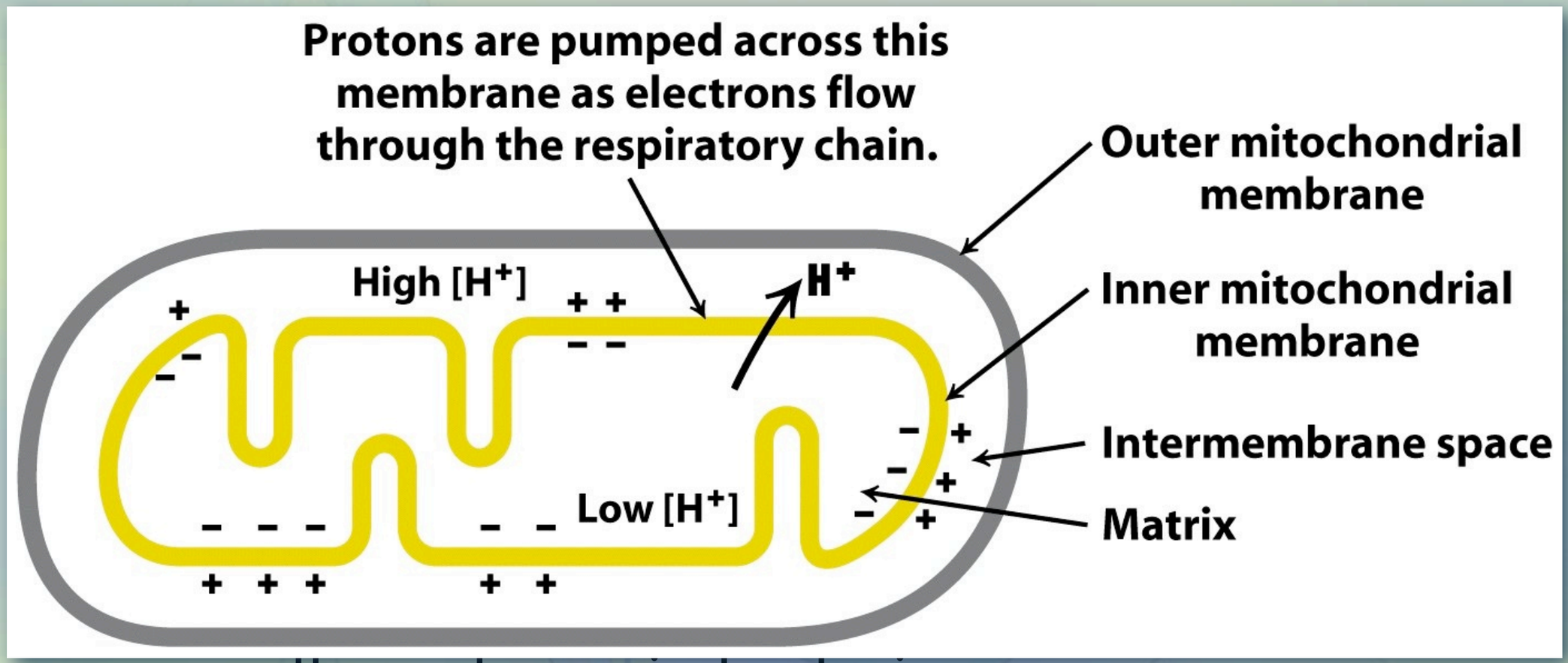
Bacterial Flagella

- The MotA/MotB stator and the FliG rotor work together to couple proton flow across the membrane to rotation of the flagellum.
  - The mechanism is believed to be similar to that used by ATP Synthase, which couples proton flow across the membrane to the synthesis of ATP

ATP Synthase

- ATP Synthase is used by bacteria, plants and animals to synthesize ATP.
  - ATP Synthase (pp.545-550, Chapter 18)
  - The free energy ultimately comes either from photosynthesis or from the oxidation of food molecules.
  - This free energy is used to establish a proton gradient accross membranes.
    - cell membrane in bacteria
    - inner mitochondrial membrane in animals and plants
    - thylakoid membrane in photosynthetic plants

ATP Synthase



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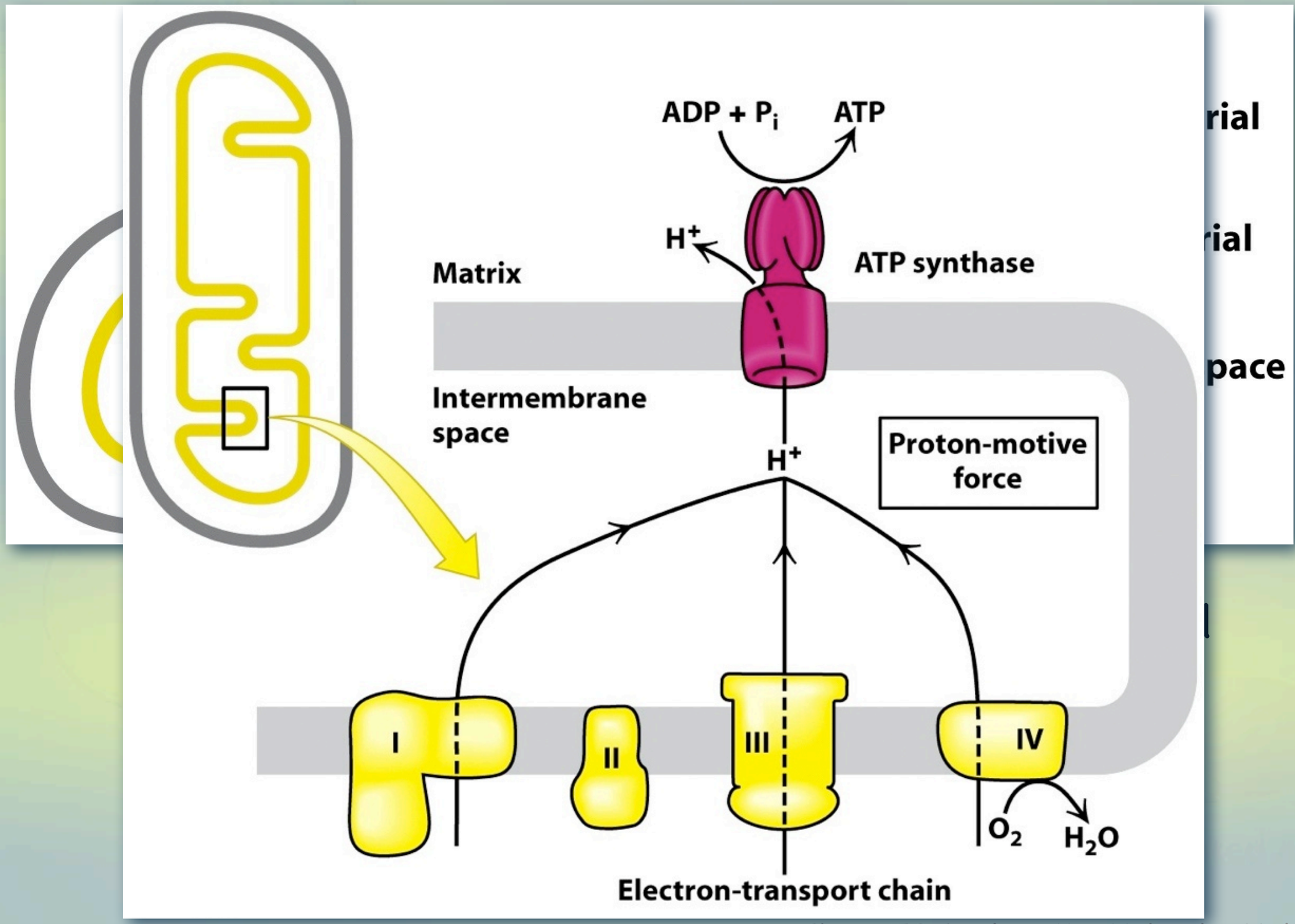

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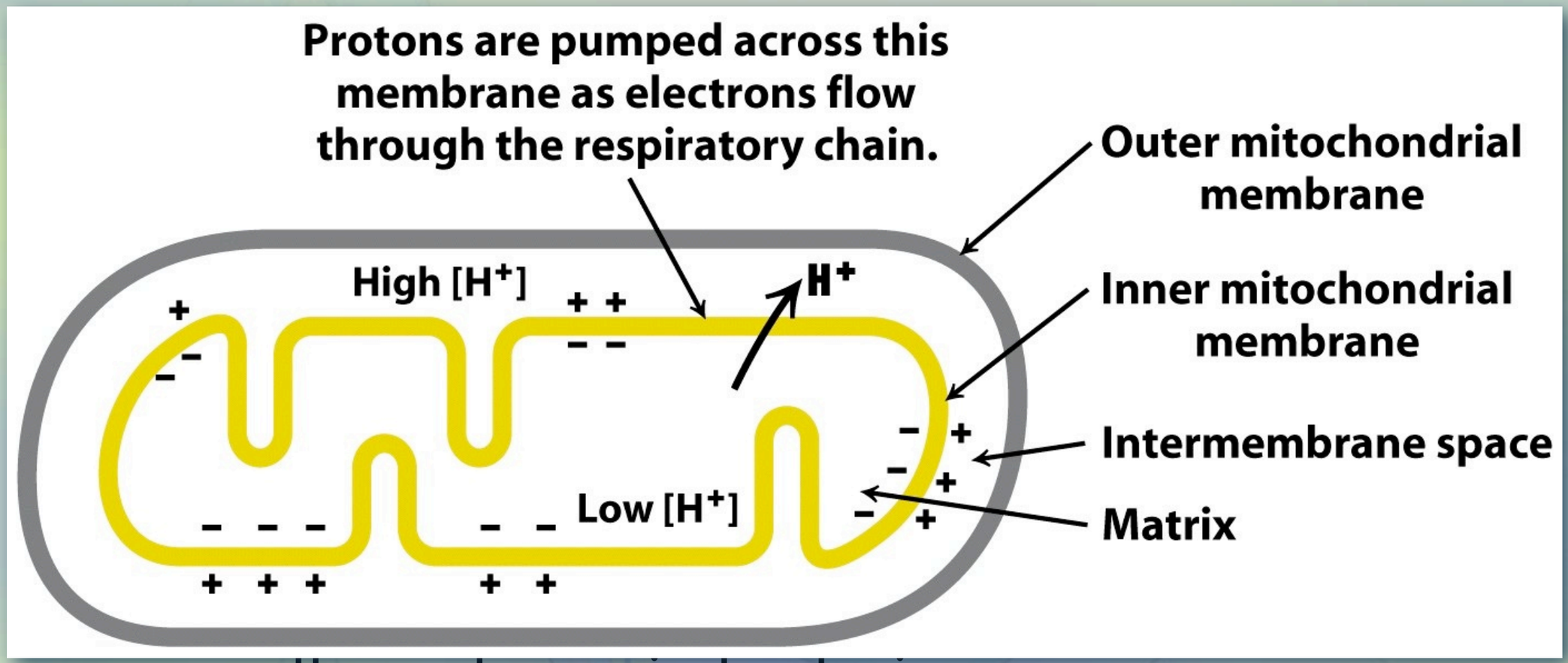

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ATP Synthase

- ATP S… and
  anima…
  - ATP…
  - The …m
    phot… …l
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  - This …n
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    - ce…
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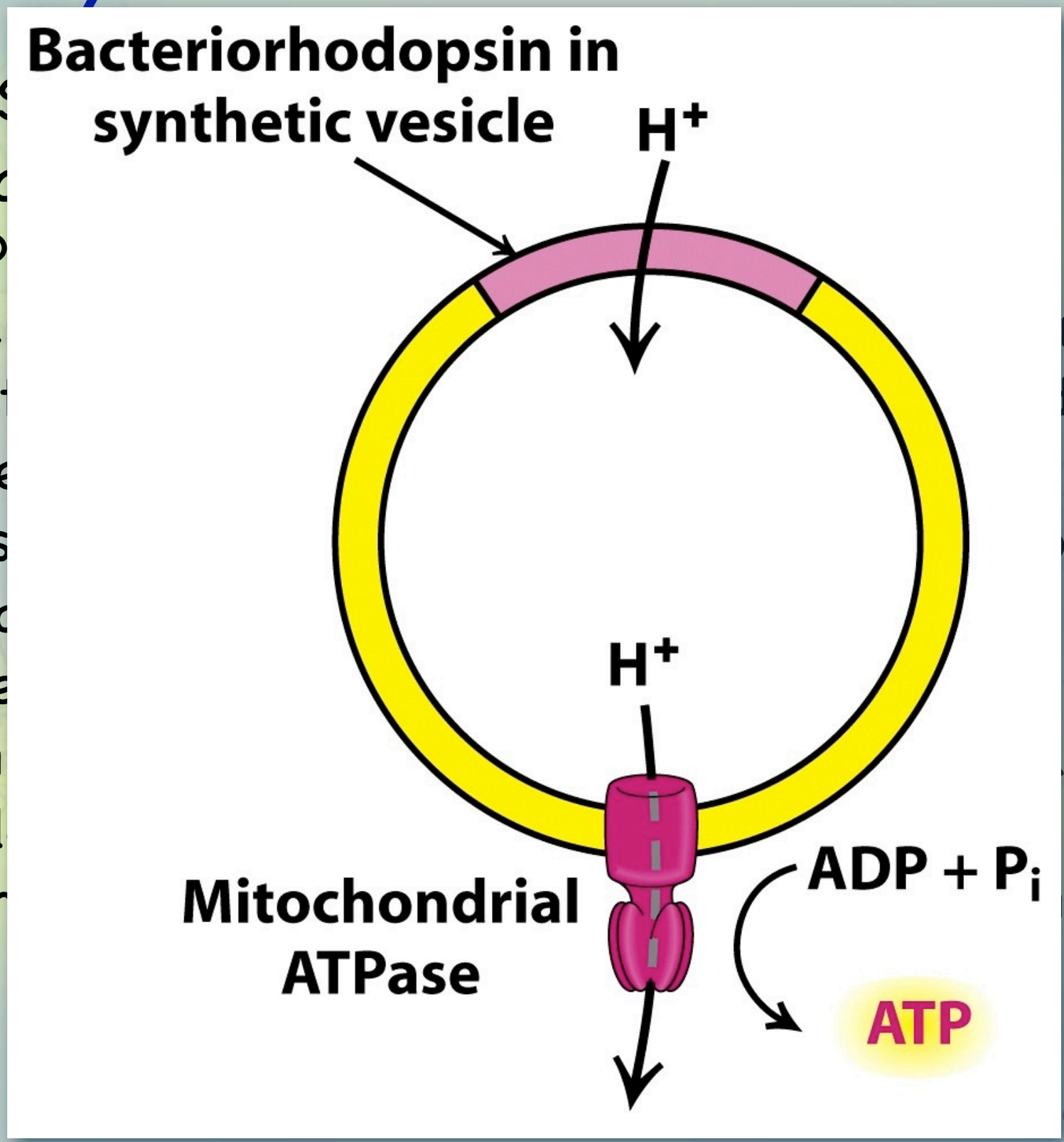
      pl…
    - th… …ts



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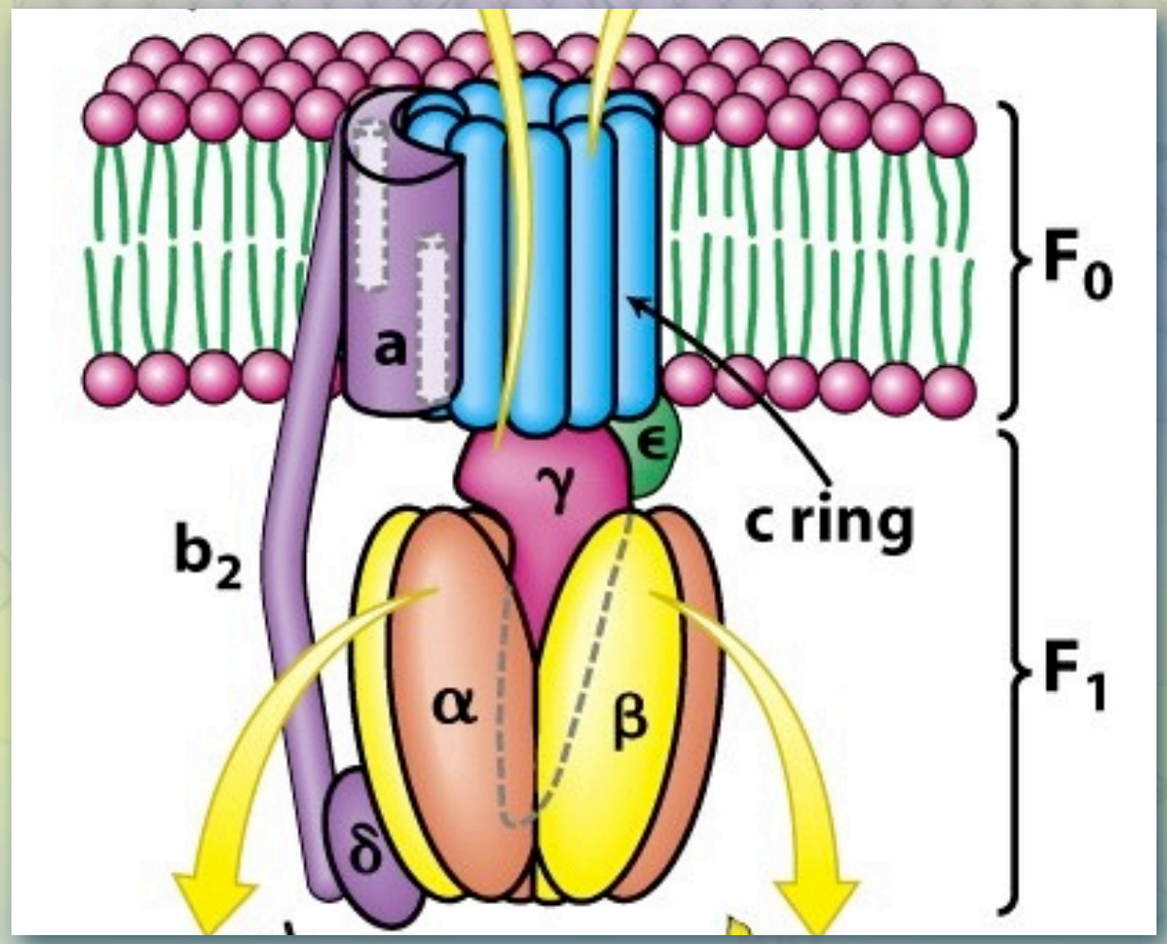
ATP Synthase

- ATP Synthase couple the flow of H^+ back down the concentration gradient to the synthesis of ATP.



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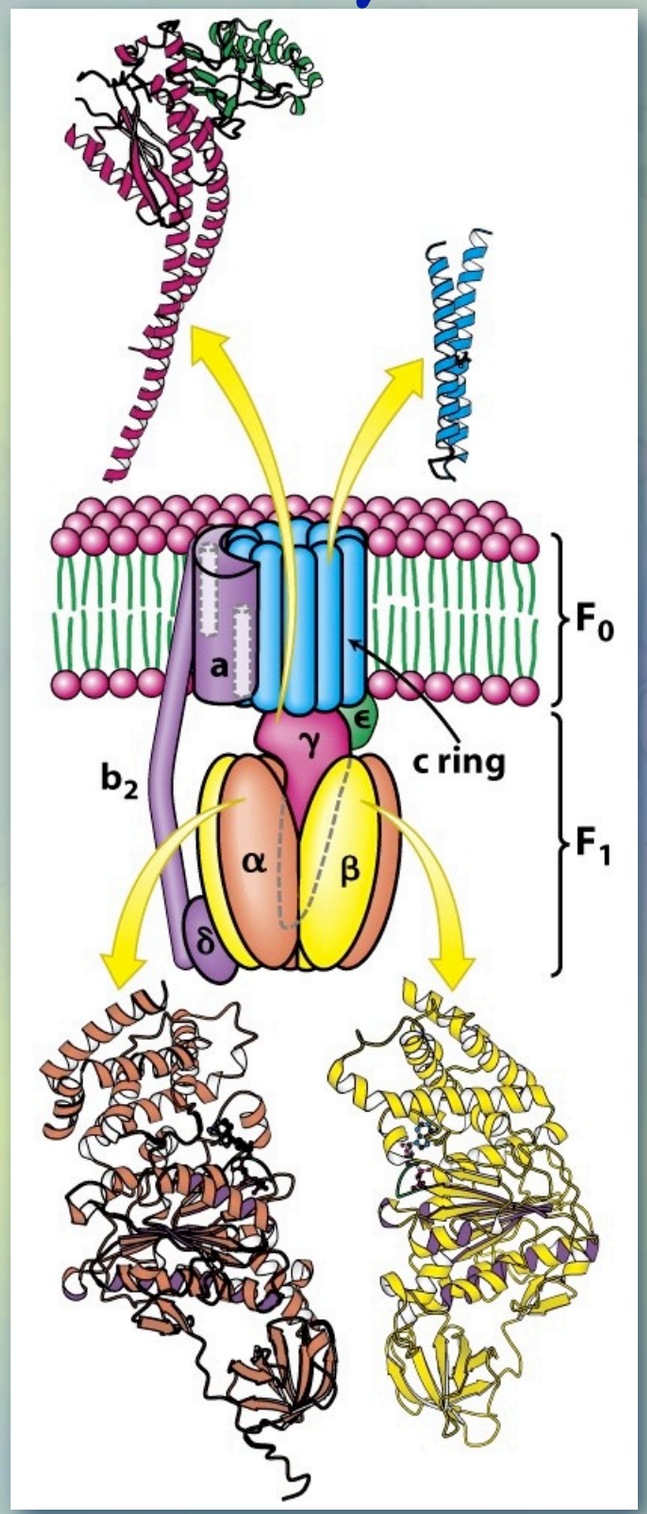

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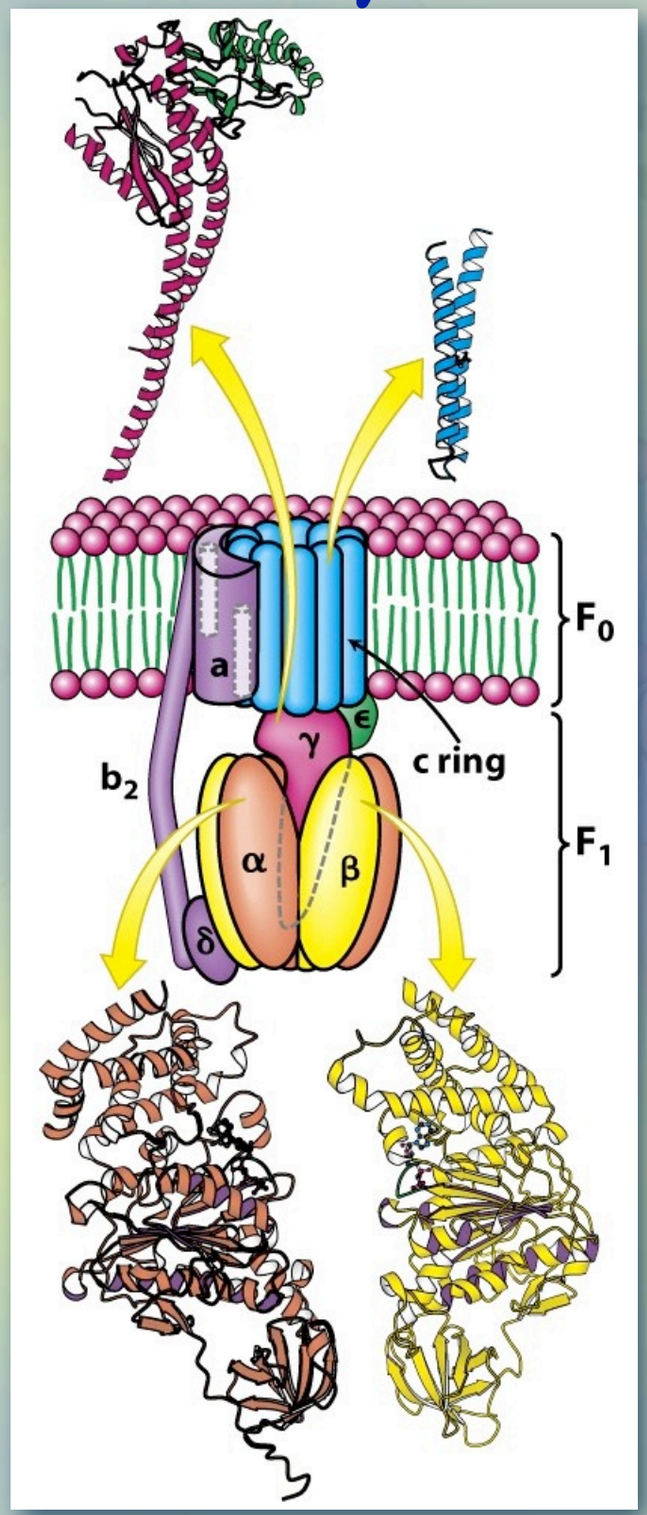

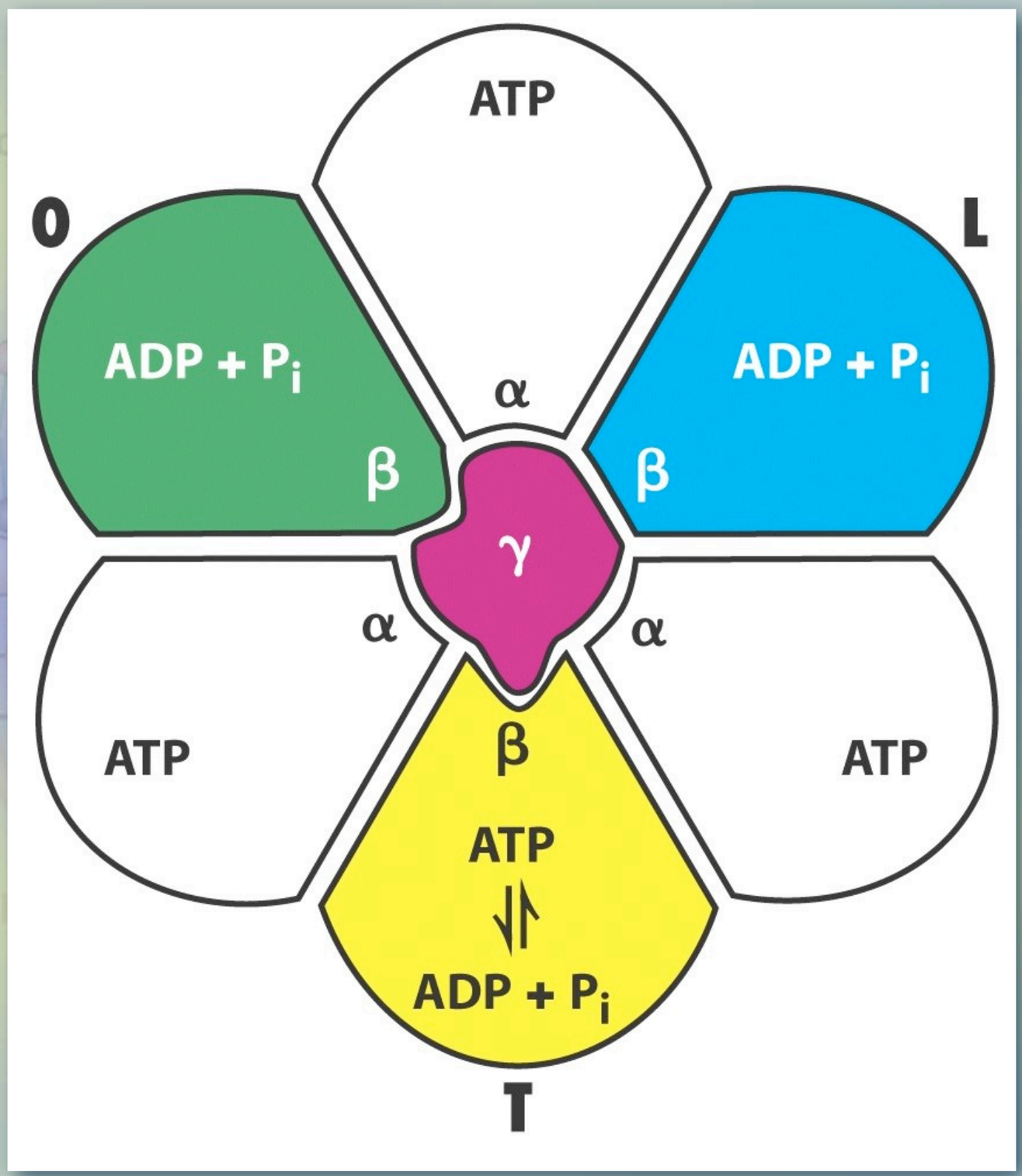

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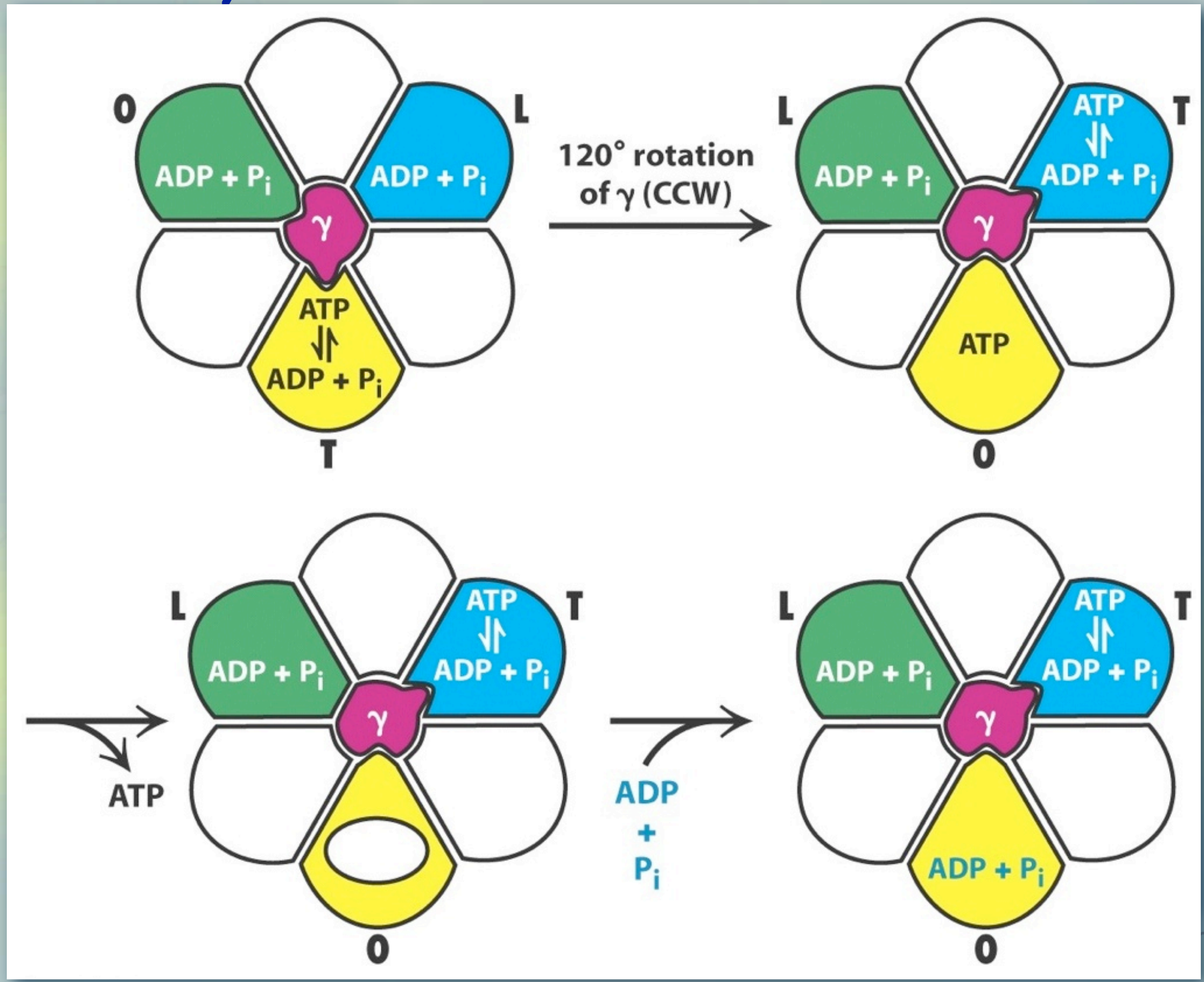

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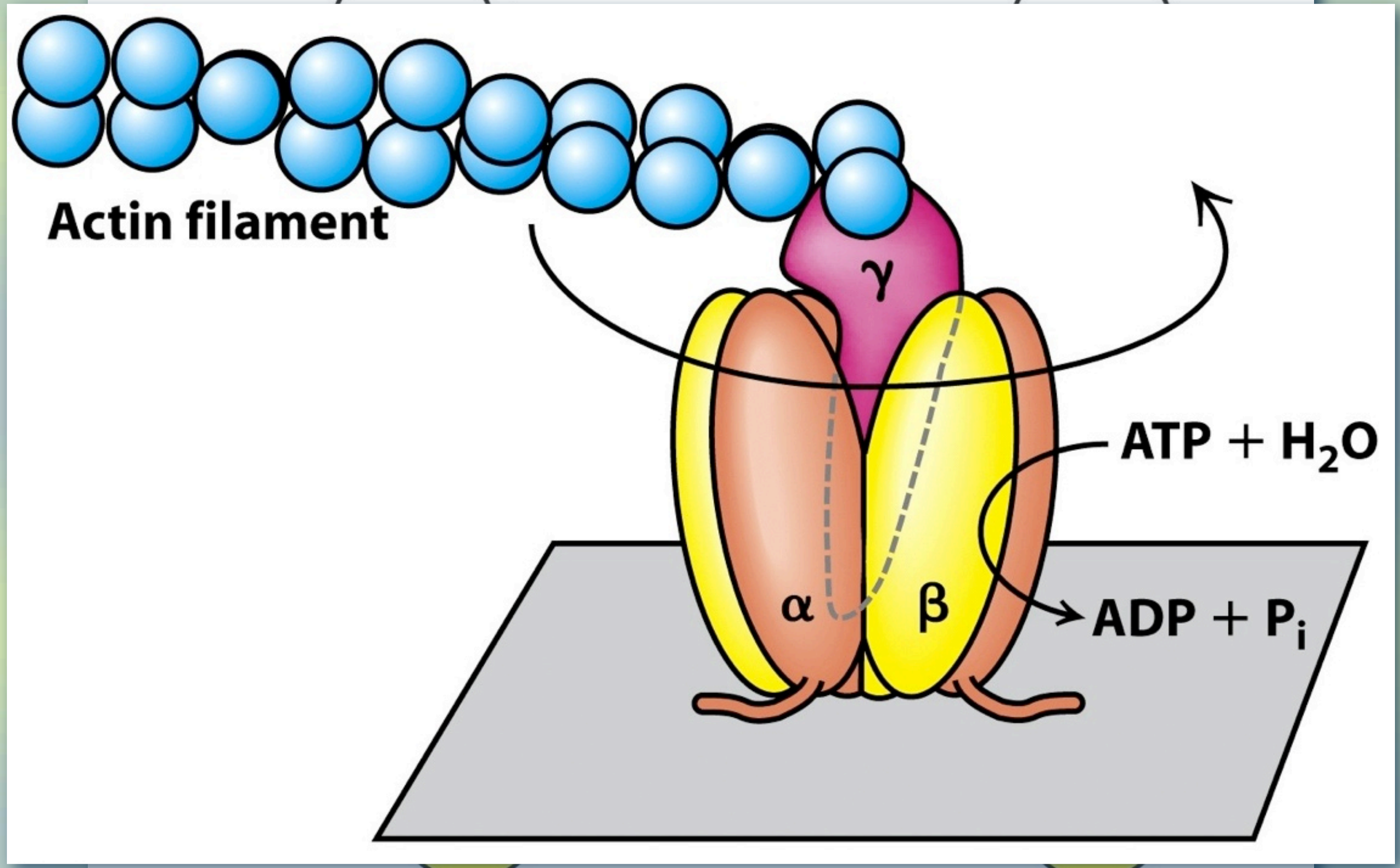

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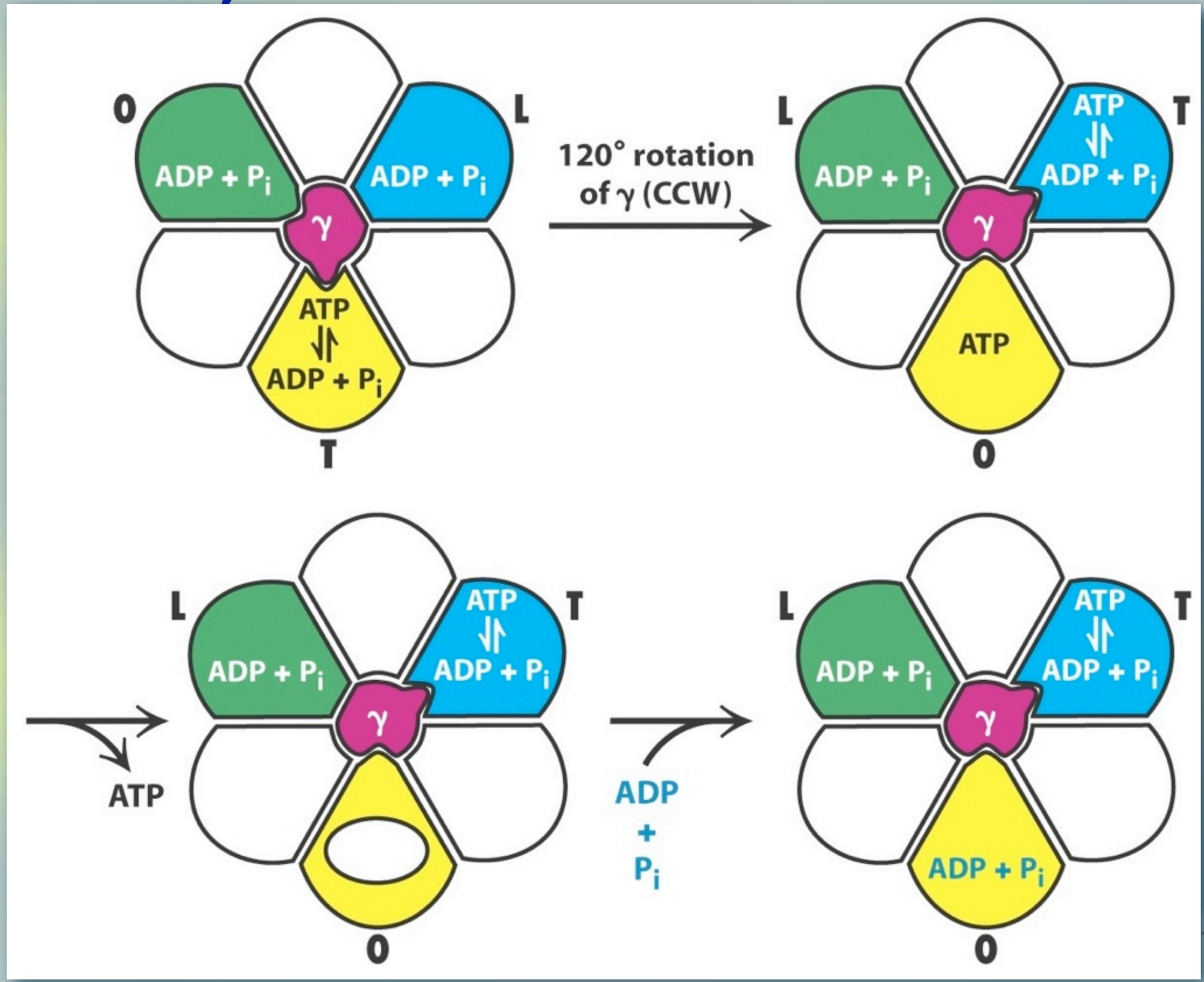
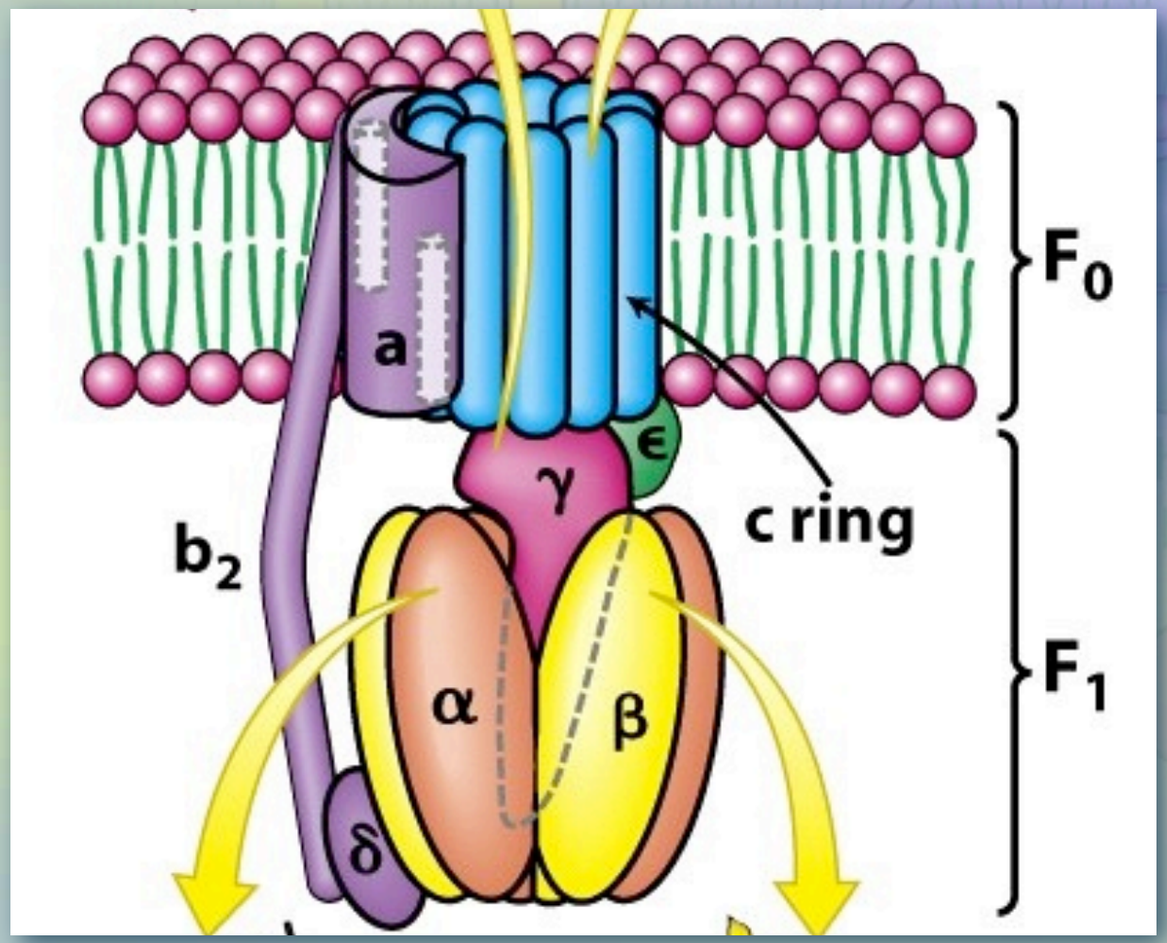
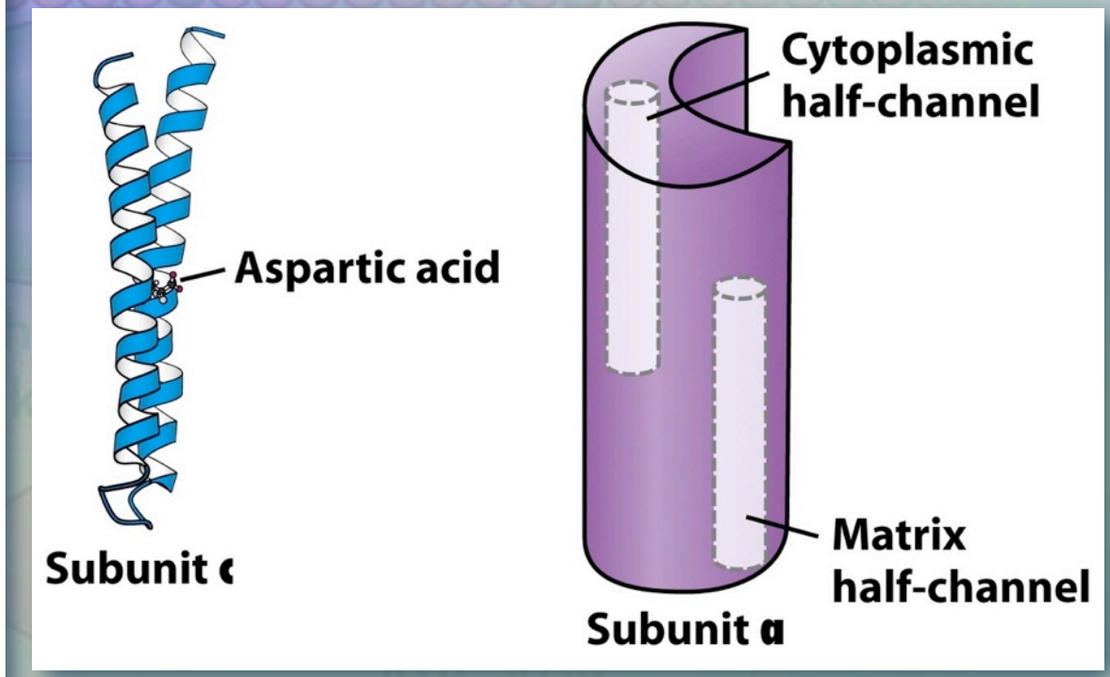


ATP Synthase

- The flow of H^+ across the membrane occurs in the a subunits and involves 2 half-channels.
  - Subunit c shuttles the H^+ from one half-channel to the other.





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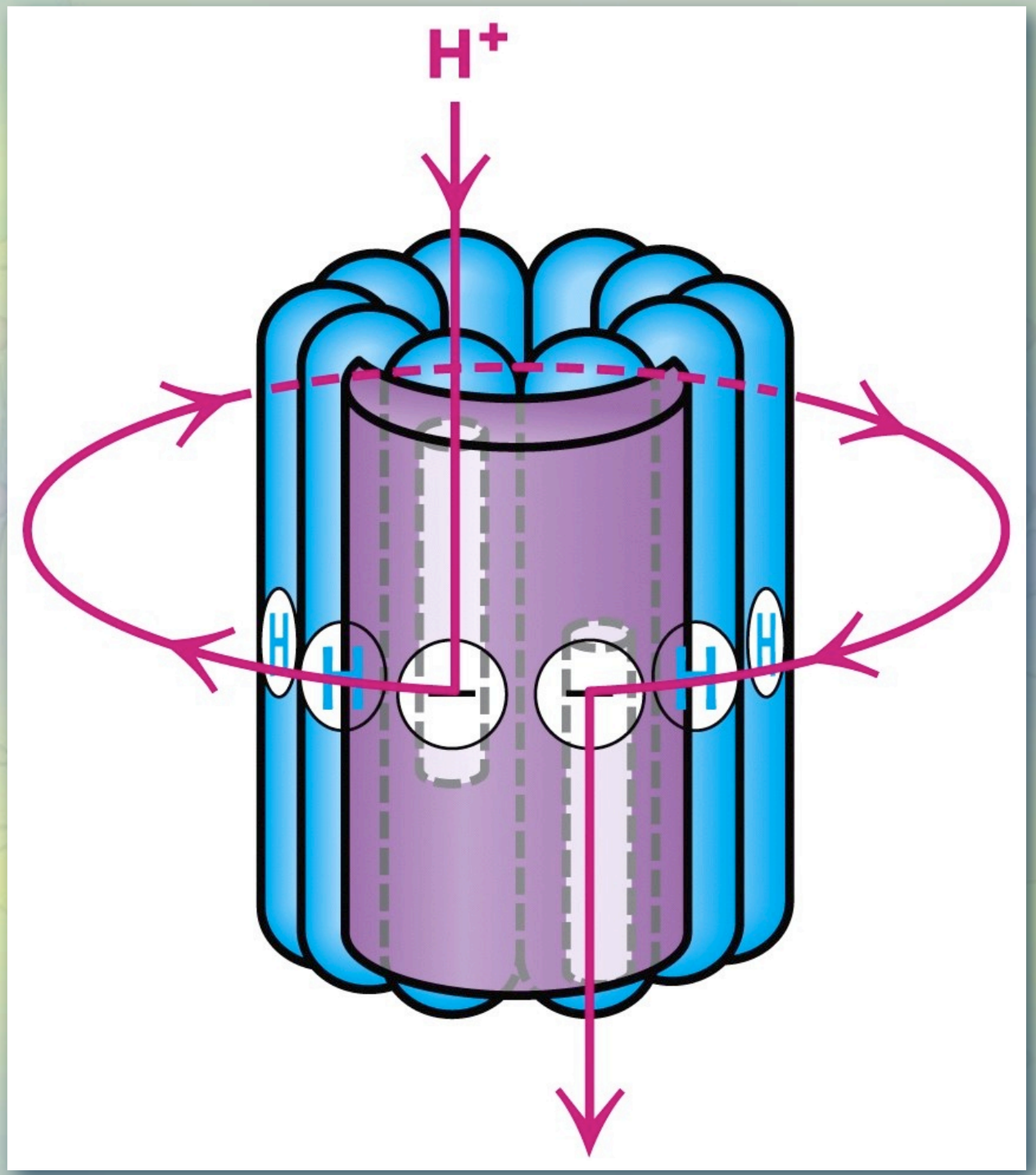

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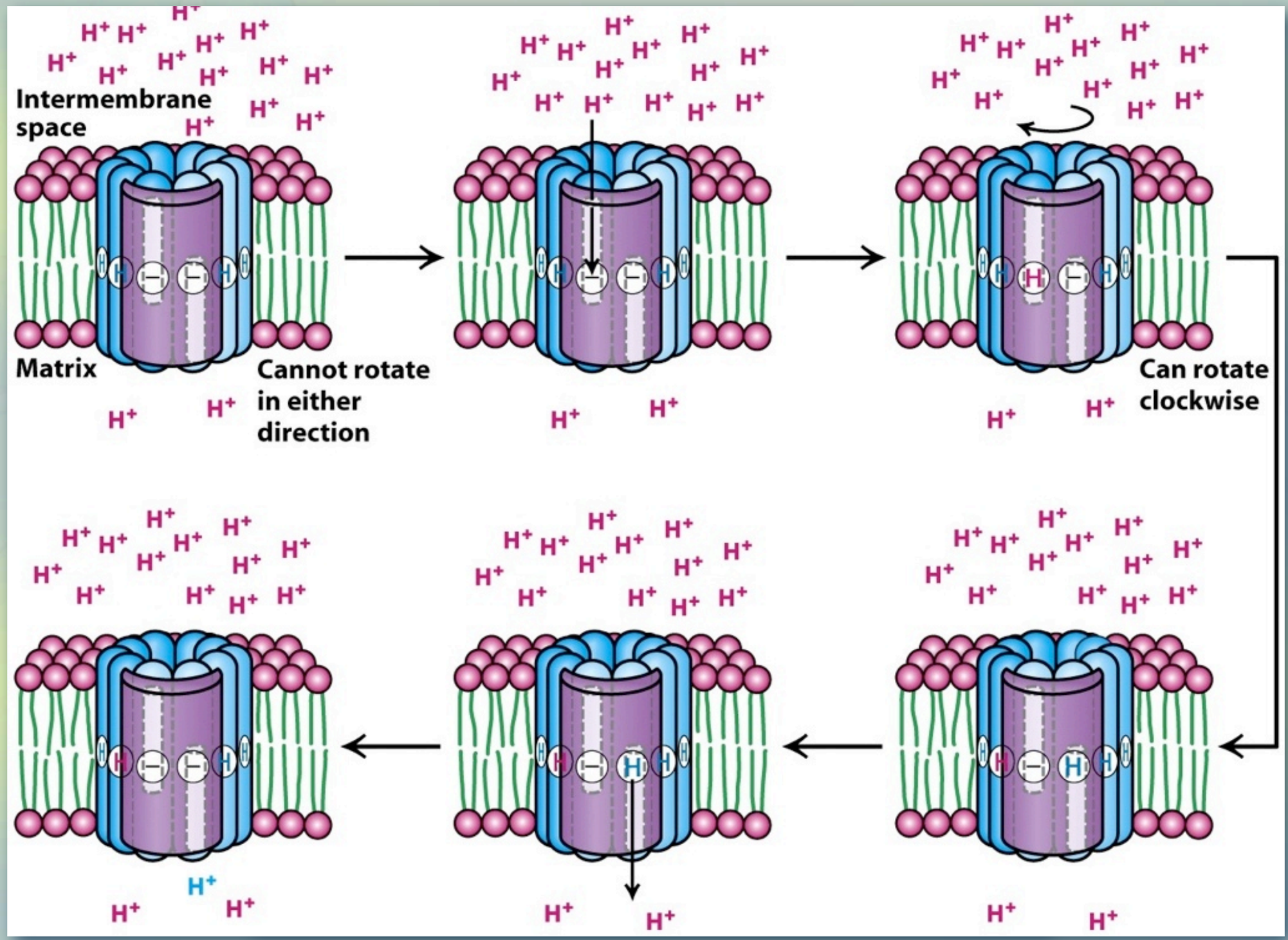
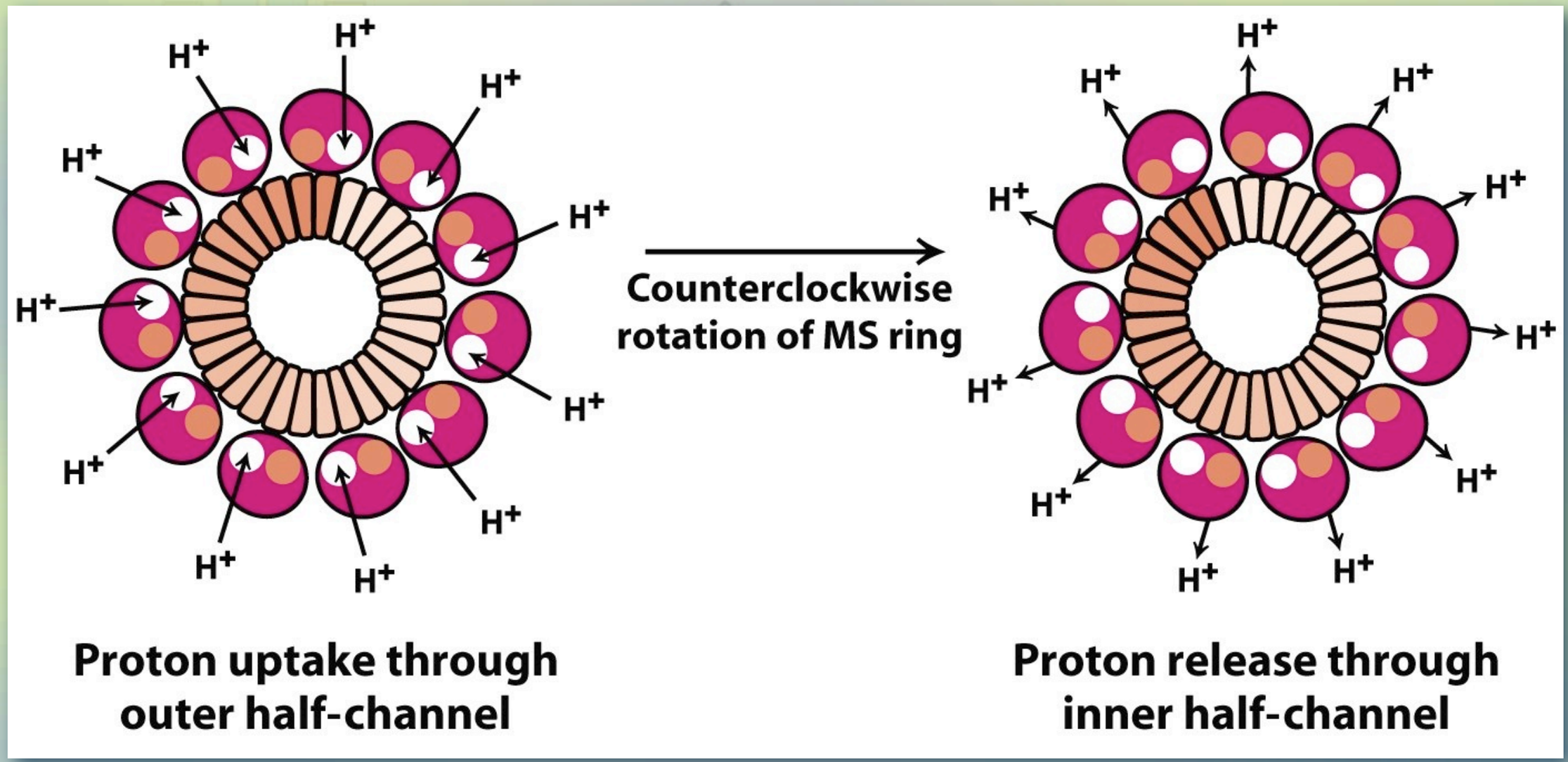


Bacterial Flagella

- Bacterial flagella are believed to also have two half-channels.

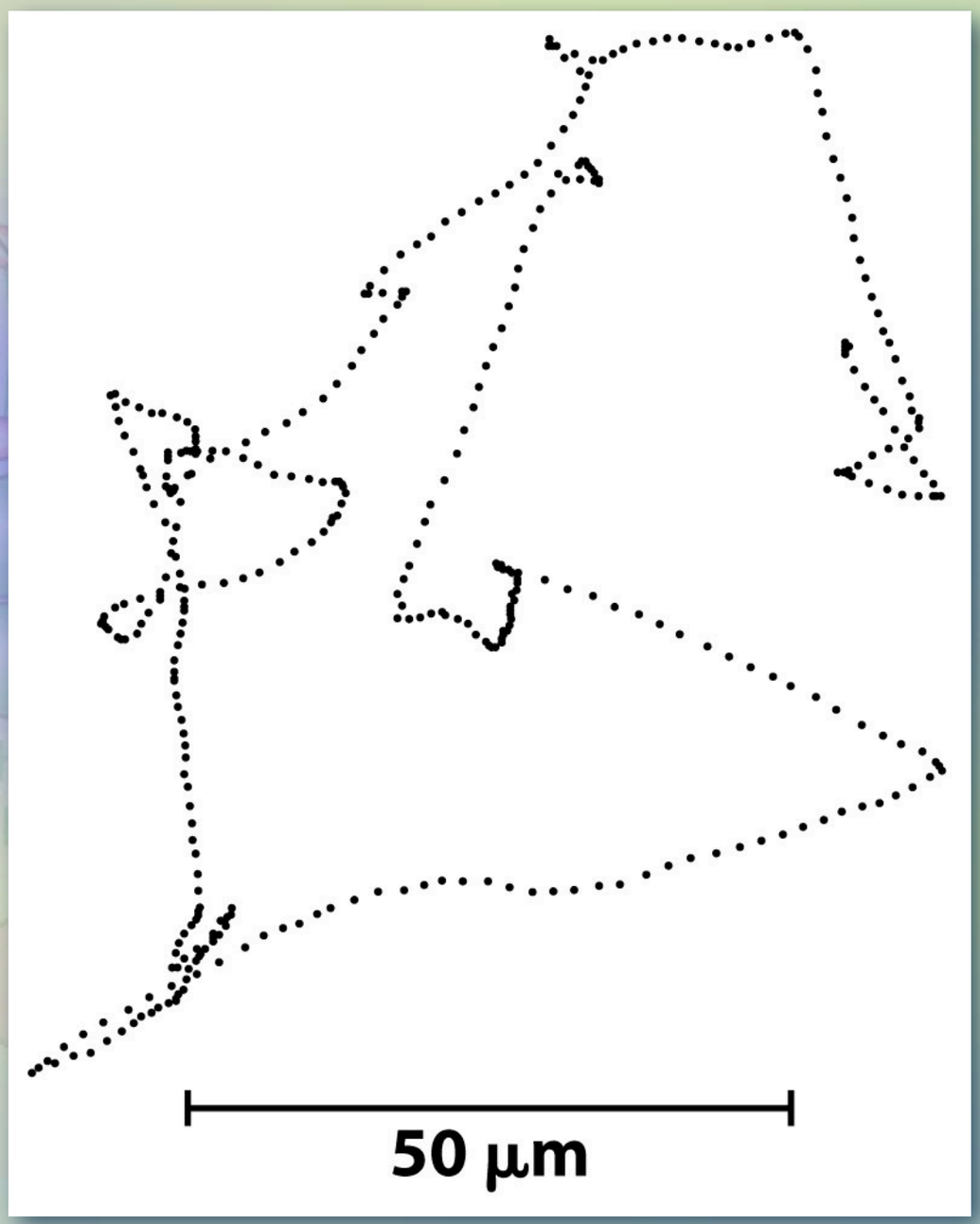


Bacterial Flagella

- Like secondary active transporters, they are driven not by the hydrolysis of ATP, but by ion gradients across the cell membrane.

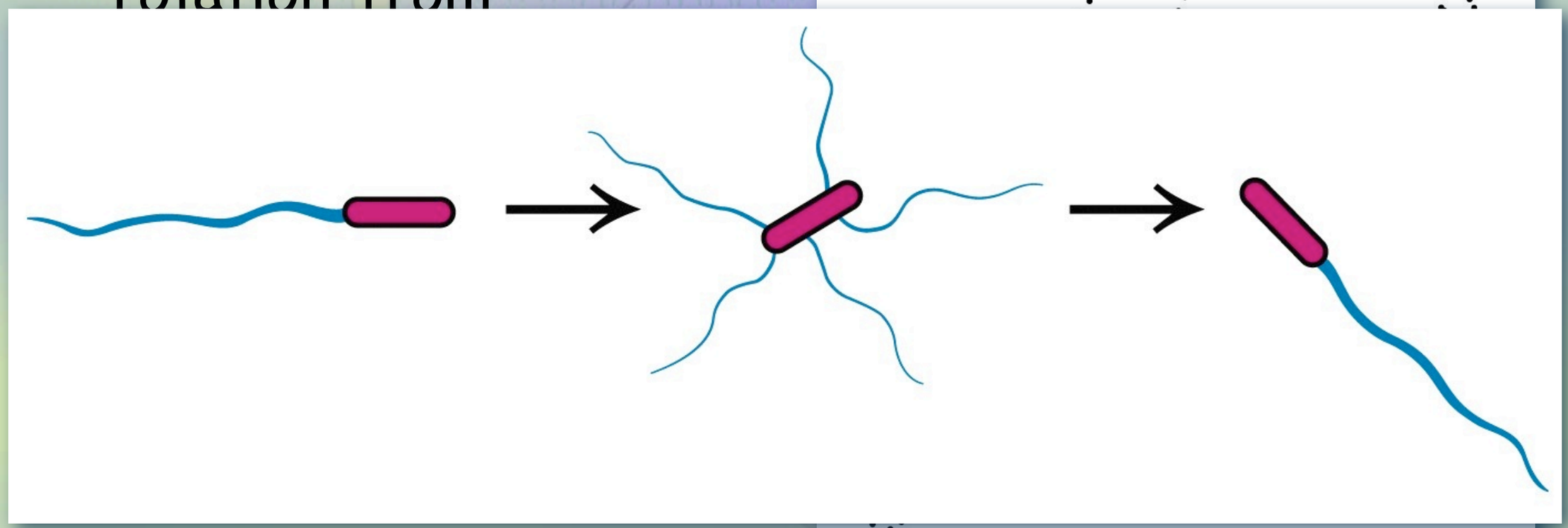
Bacterial Flagella

- Bacteria move in a random walk.
- Reversing the direction of flagellar rotation from counterclockwise to counter clockwise causes them to change direction.



Bacterial Flagella

- Bacteria move in a random walk.
- Reversing the direction of flagellar rotation from



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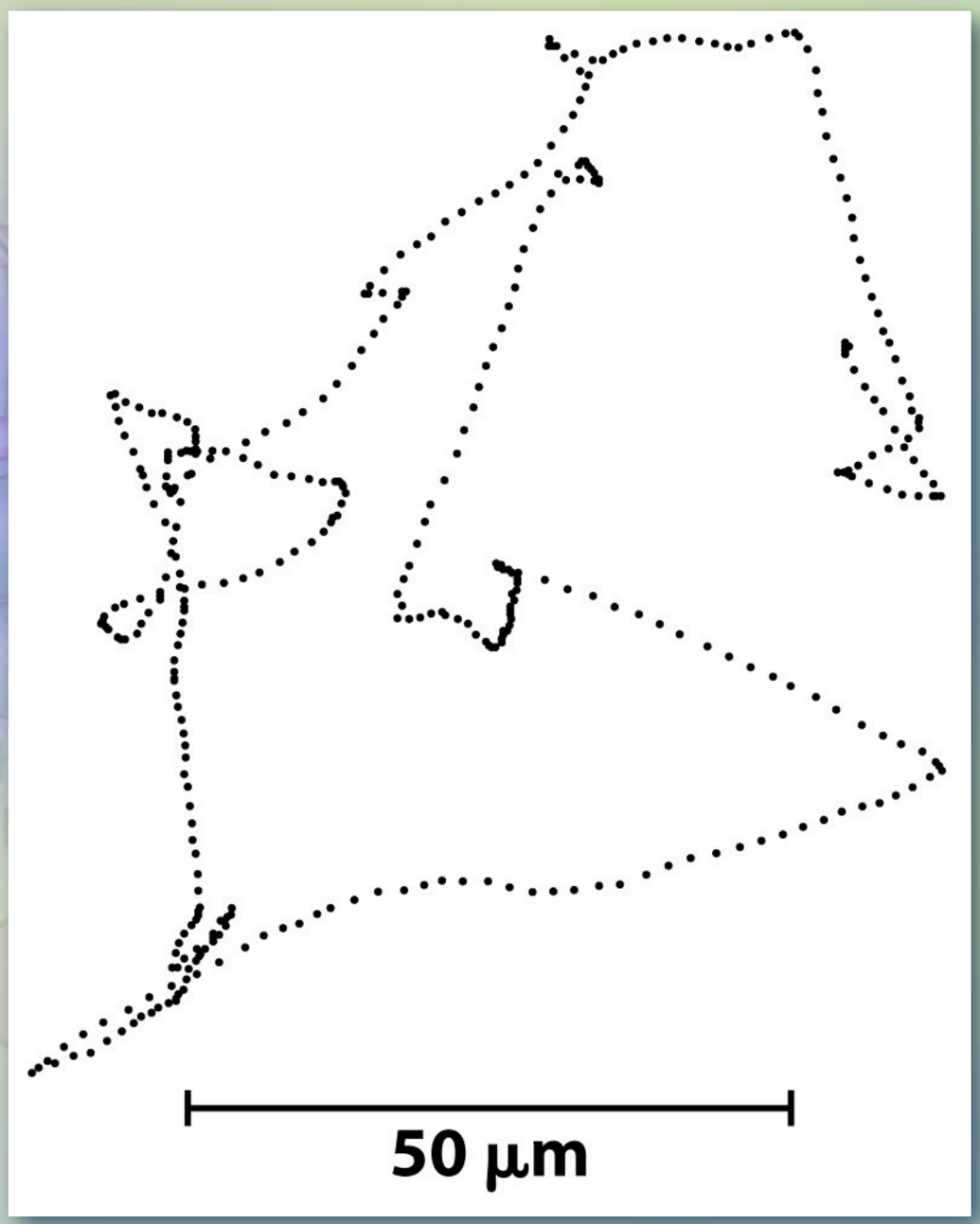
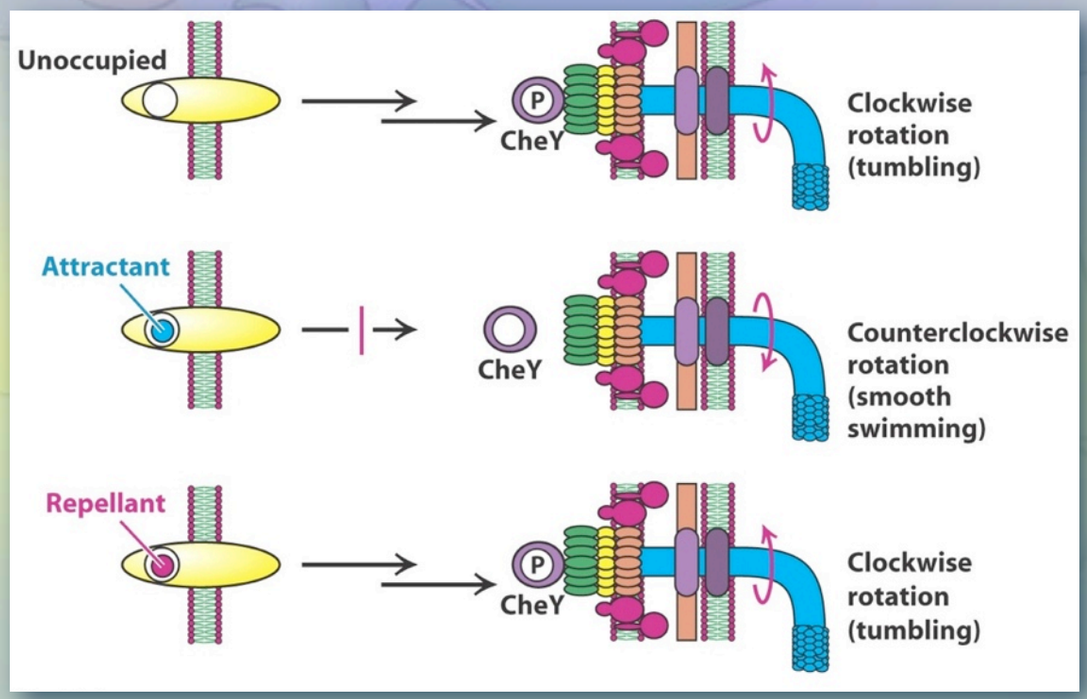


Bacterial Flagella

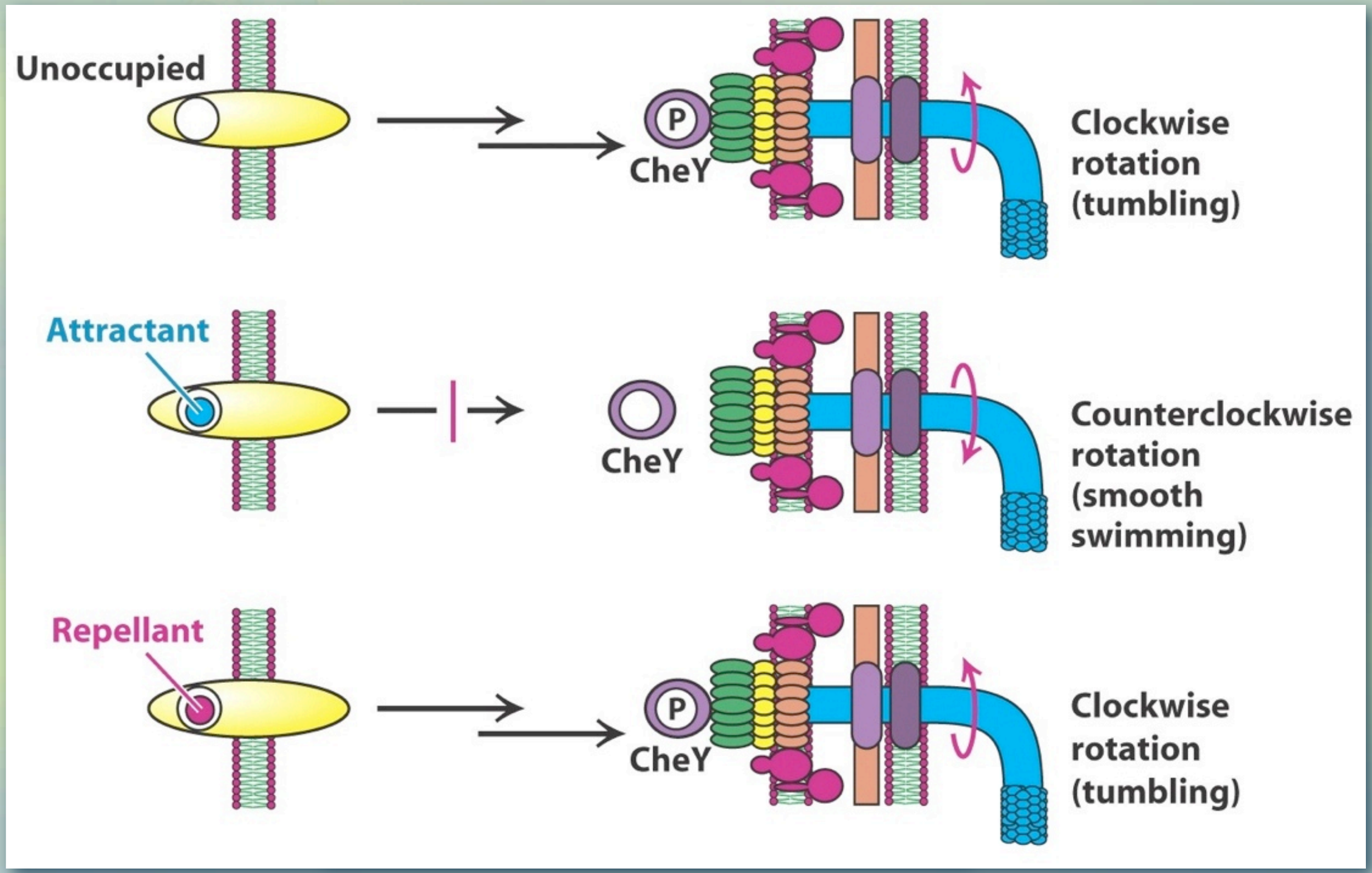
- The random walk can be biased by **chemotaxis**.
- Bacteria to more likely to swim towards a **chemoattractant**.
  - Such as a food source, like glucose
- Bacteria are also more likely to swim away from a **chemorepellant**.
  - Such as a toxic chemical, like phenol

Bacterial Flagella

- Chemotaxis is facilitated by the Che proteins.
  - When the CheY protein is phosphorylated it associates with the flagellar motor, which promotes clockwise rotation (tumbling).
  - When the CheY protein is dephosphorylated it dissociates from the flagellar motor, which promotes counterclockwise rotation (swimming).



Bacterial Flagella



Next up

- Exam IV on Unit V (Lectures 9, 10 & 11)
  - Friday, Dec 9.

- Final exam on Units (I through V)
  - Wednesday, Dec 21 at 8:00am in Schneider 100