

Monday, December 14, 2009

Heart of the Beat (the Flagellar Beat, that is)

The **Biophysical Journal** highlights important topics by featuring them in a "New and Notable" commentary, where a leading expert will discuss one of the papers published in a particular issue. In the December 2009 issue, Prof. **Charles Lindemann**, of the **Department of Biological Sciences**, was asked to comment on a paper by **Charles Brokaw** of the **California Institute of Technology**. Lindemann's commentary, titled "**Heart of the Beat (the Flagellar Beat that is)**" (*Biophys. J.*, Volume 97, Pages 2865-2866), begins "The mechanism that makes **aeukaryotic flagellum** or **cilium** beat is one of **cell biology**'s most enduring puzzles." Lindemann describes his motivation for research on cilia and flagella on his **website**

"Cilia and flagella are whip-like appendages of many living cells that are used to move fluid or to propel the cells. Cilia beat with an oar-like motion and flagella have a snake-like motion.... The cilia in your lungs keep dirt and dust from clogging your breathing tubes (the bronchi) by moving a layer of sticky mucous along to clean out the airways. Sperm cells use a flagellum as a propeller to move the cell through the fluid of the oviduct to reach the egg. Thousands of animals and plants use cilia and flagella for swimming (example: paramecium), or feeding (example: clams and mussels) or mating (example: green algae). It is a curious fact that all of these cilia and flagella have a very similar internal arrangement of tubes (the outer doublets) and protein connectors (the nexin links and dynein arms) that suggest that there is something very special about this particular way of building a cell propeller.... Nature tends to keep designs that work well. Possibly if we can understand why this particular design works so well we might be able to design miniature devices that use the same principles of operation!

His commentary then reviews much of the work on flagellar beating, including his own work on the "geometric clutch" hypothesis. His website describes the hypothesis

"The Geometric Clutch model of ciliary and flagellar beating is a hypothesis that attempts to explain the way that cilia and flagella work. A computer model based on this hypothesis can do a fairly believable imitation of a cilium or a flagellum. The basic underlying idea of the Geometric Clutch hypothesis is rather simple to understand. When the molecular motors...that power the beat of the cilium or flagellum are activated they pull and push on the outer doublets and induce a strain on the structure that causes the cilium to bend. This part of the story of how cilia beat is agreed upon by all of the scientists that study cilia and flagella. The Geometric Clutch idea is that when the motors push and pull on the outer doublets the strain on each doublet creates a sideways force that is transverse to the doublet. This transverse force (or t-force) pushes some of the doublets closer together and others are pushed apart. The motors on the doublets that are pushed closer together go into action and generate force; the motors on doublets that are pulled apart are forced to stop pulling. In the Geometric Clutch model this is the working principle. The t-force controls the motors and acts like a "clutch", much as the clutch that engages or disengages the motor of your car."

Lindemann has published extensively on this topic for decades, and for much of this time his research has been funded by the **National Science Foundation**. Many Oakland University students have participated in this research.

SUMMARY

Professor Charles Lindemann publishes a commentary in the *Biophysical Journal* about how a flagellum or cilium beats.

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