

ME 411 / ME 511

# Biological Frameworks for Engineers

# Welcome

- Introductions
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- <http://faculty.washington.edu/nsniadec/ME411/A12>
- Course Mission and Overview
- Administration and Logistics

ME 411 / ME 511

# Functions of Life

# Scale of Life

## Things Natural

**Dust mite**  
200  $\mu\text{m}$

**Human hair**  
~10-50  $\mu\text{m}$  wide

**Red blood cells with white cell**  
~2-5  $\mu\text{m}$

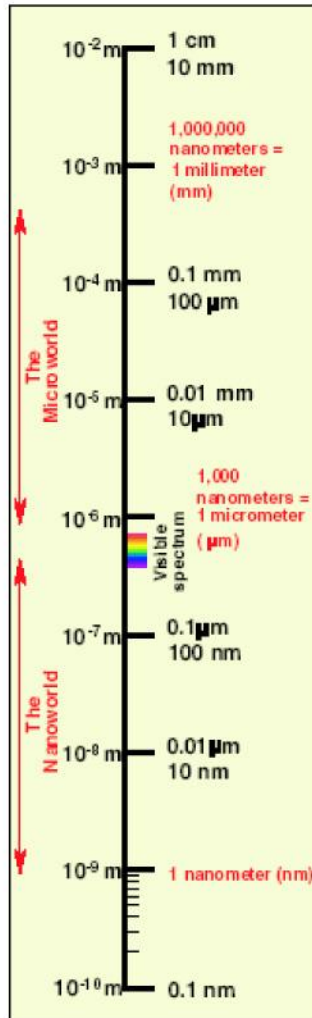
**Ant**  
~5 mm

**Fly ash**  
~10-20  $\mu\text{m}$

**ATP synthase**  
~10 nm diameter

**DNA**  
~2-1.2 nm diameter

**Atoms of silicon**  
spacing ~ tenths of nm



## Things Man-made

**Head of a pin**  
1-2 mm

**Microelectromechanical devices**  
10-100  $\mu\text{m}$  wide

**Red blood cells**  
**Pollen grain**

**Nanotube electrode**

**Nanotube transistor**

**Quantum corral of 48 iron atoms on copper surface**  
positioned one at a time with an STM tip  
Corral diameter 14 nm

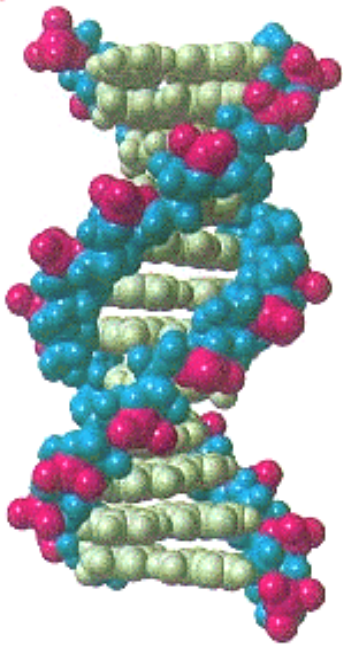
**Carbon nanotube**  
~2 nm diameter

**21st Century Challenge**

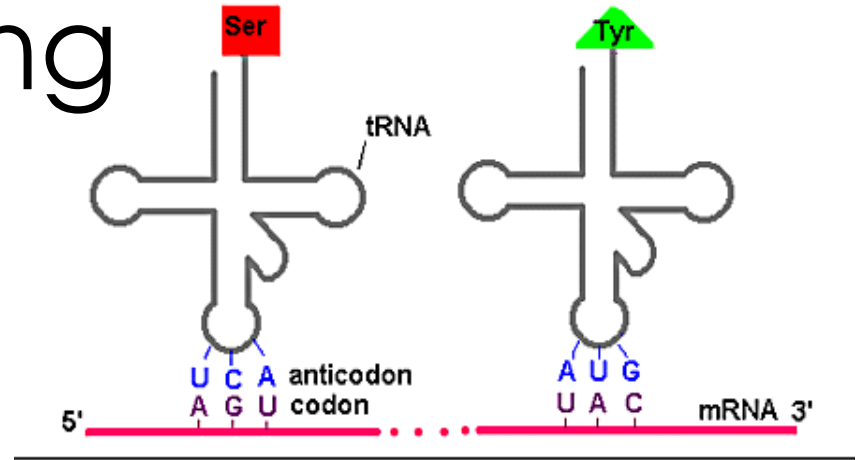
*Assemble nanoscale building blocks to make functional devices, e.g., a photosynthetic reaction center with integral semiconductor storage*

# Motivation...

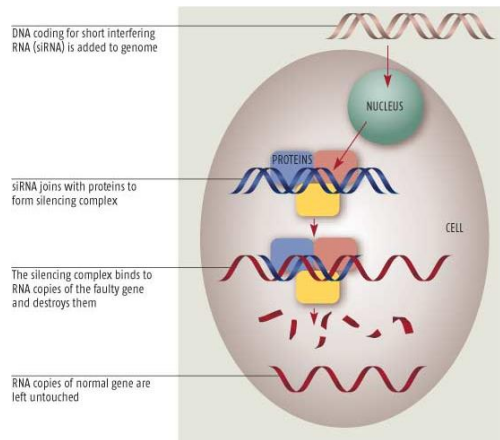
... to empower you to work at the interface between medicine and (mechanical) engineering



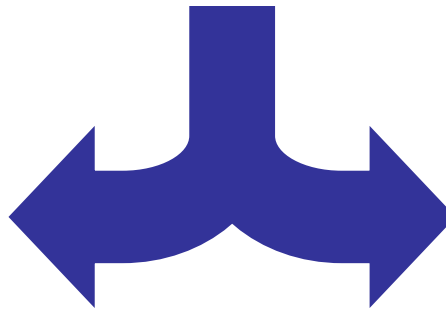
# Coding



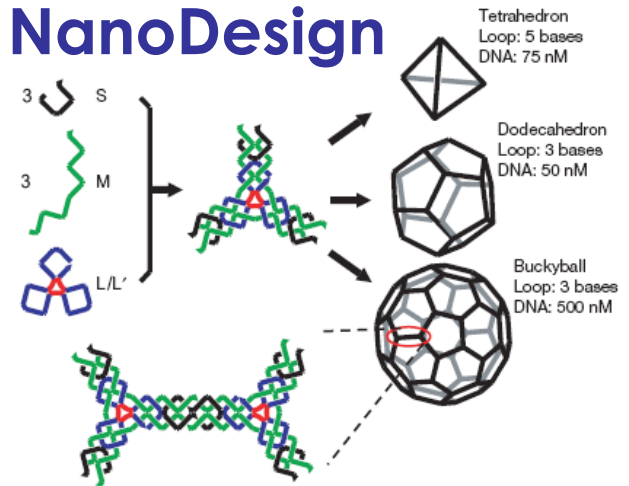
(5')G G A T A G C A T G A A A C C A G C A T A A (3')



# Gene Therapy

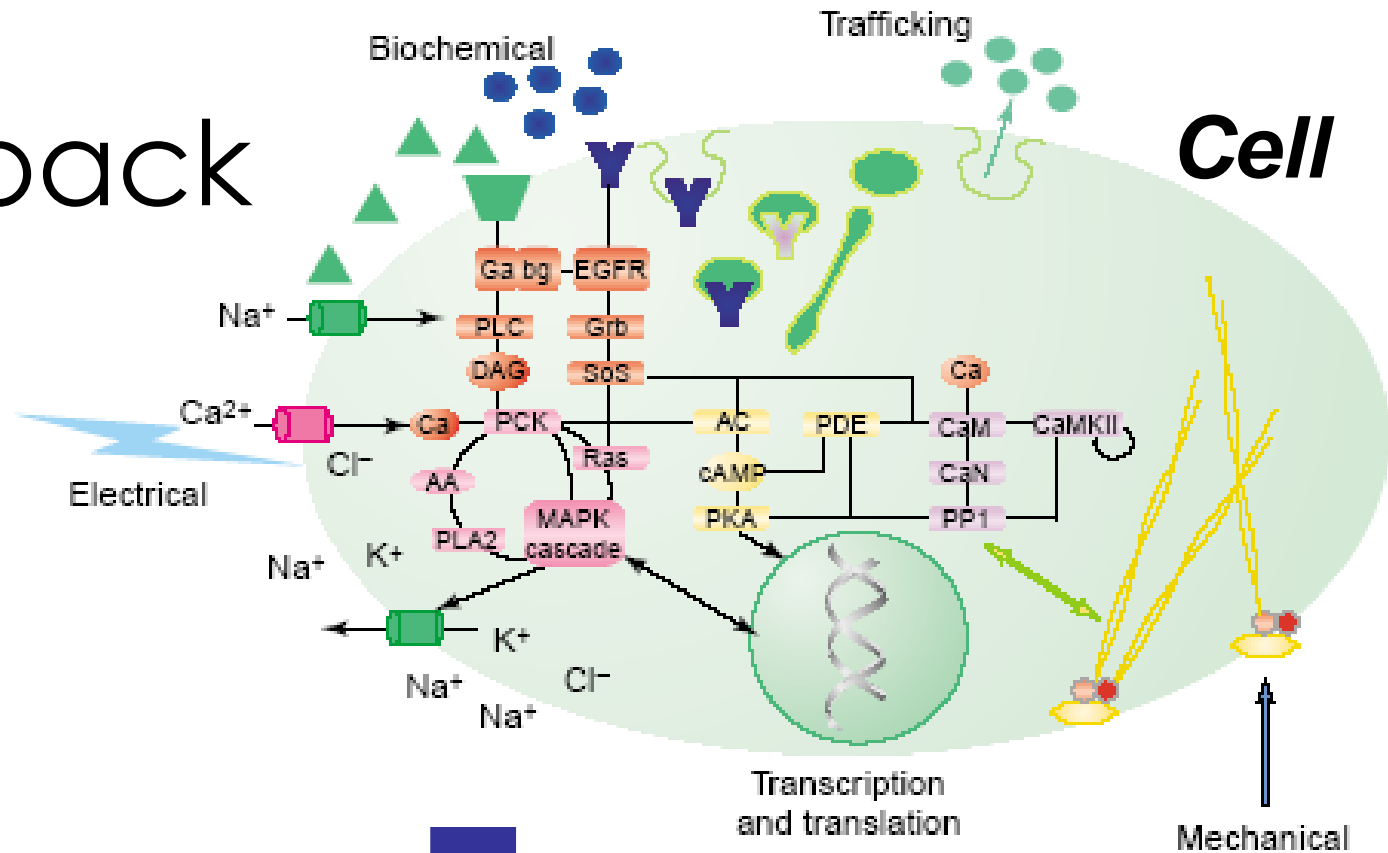


# NanoDesign

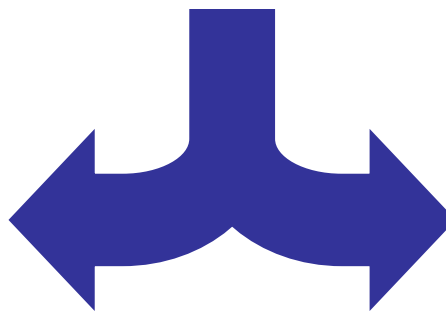


**Figure 1 | Self-assembly of DNA polyhedra.** Three different types of DNA single strands stepwise assemble into symmetric three-point-star motifs (tiles) and then into polyhedra in a one-pot process. There are three single-stranded loops (coloured red) in the centre of the complex. The final structures (polyhedra) are determined by the loop length (3 or 5 bases long) and the DNA concentration.

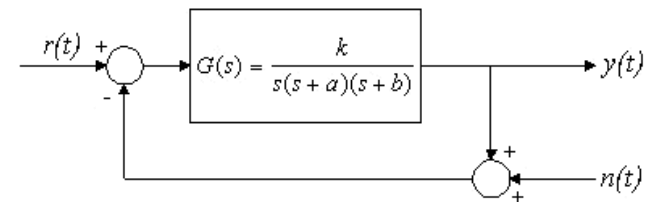
# Feedback



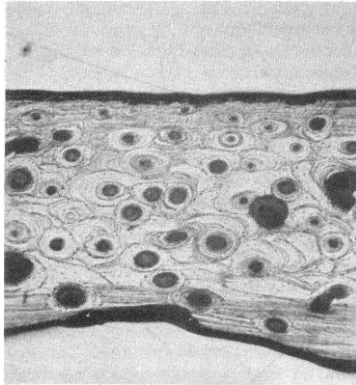
Stem Cell Therapy



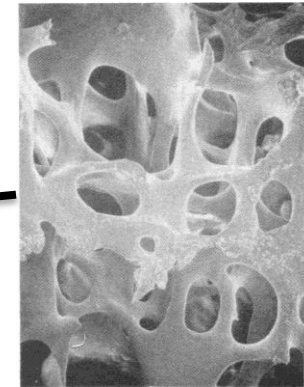
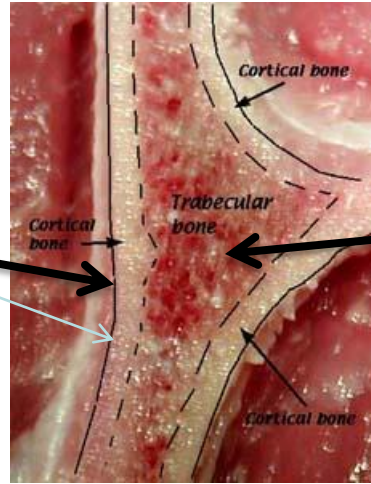
## Control Theory & Systems Biology



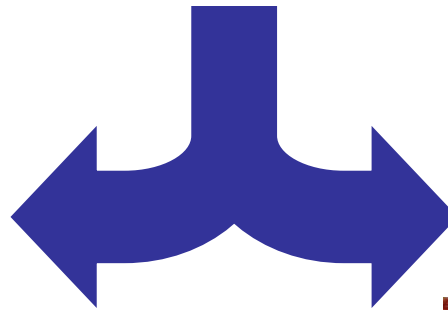
# Integration



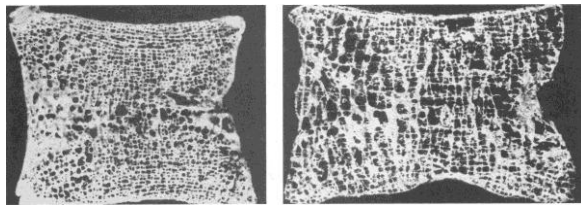
Cortical  
(plywood)



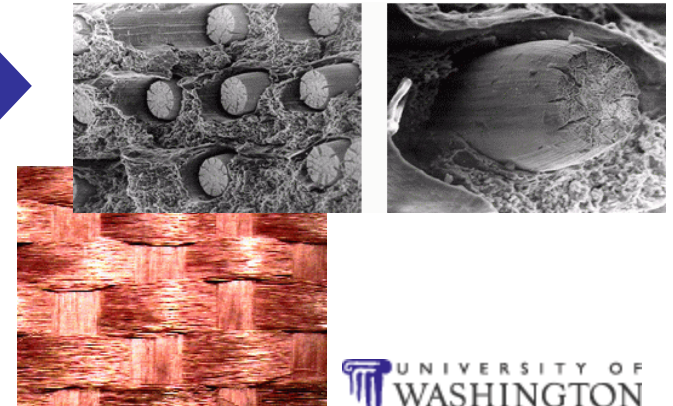
Trabecular  
(foam)



## Composite Design



Osteoporosis  
Prevention





# Functions of Life?

# Environmental Limits to Life?

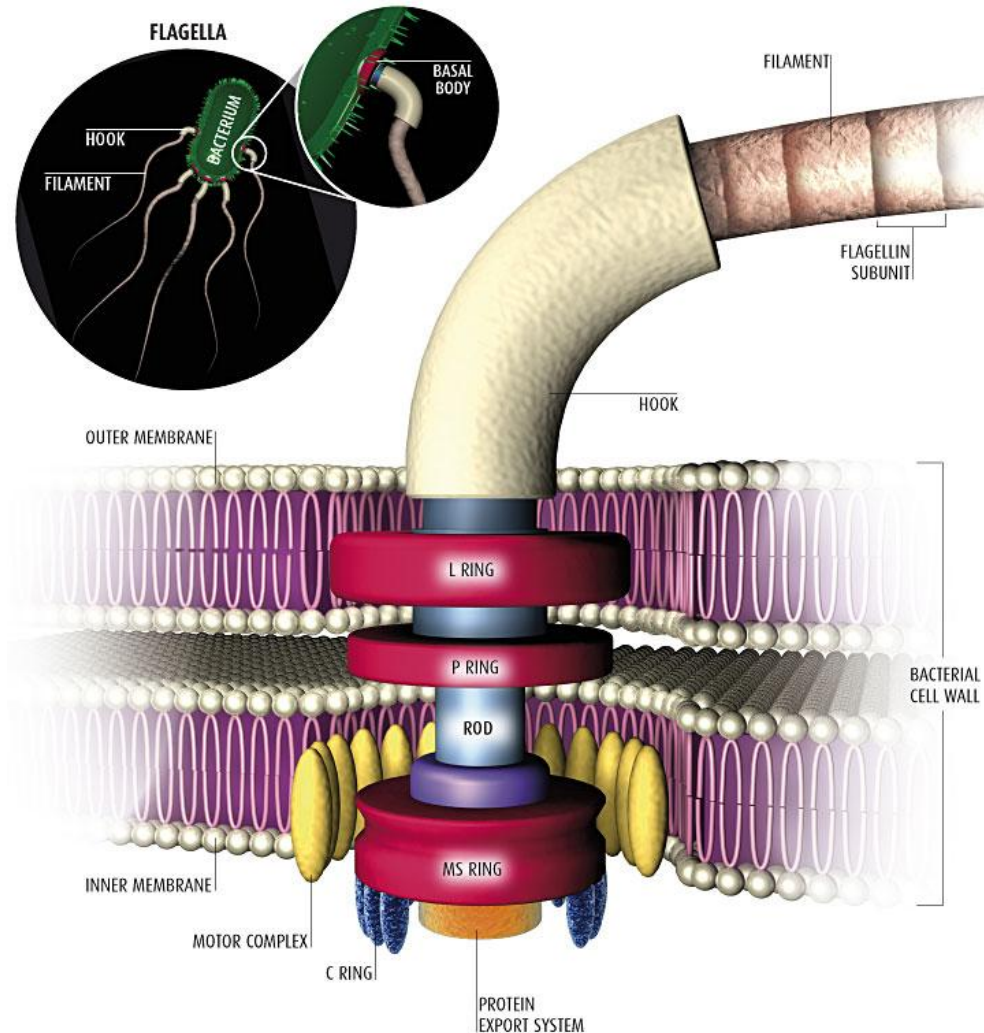
# Fundamental Themes

- Molecular Machines
- Integrated Systems
- Structure - Function
- Adaptation

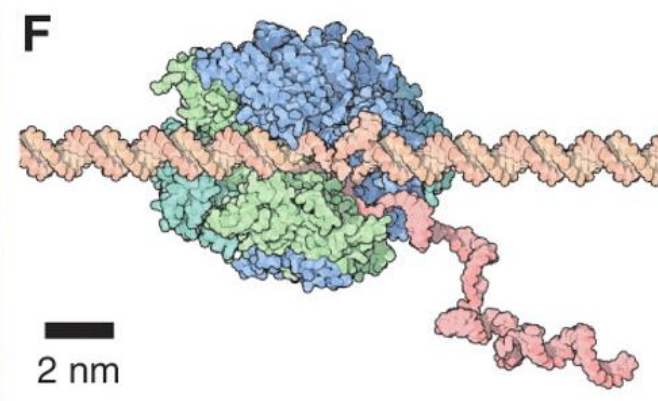
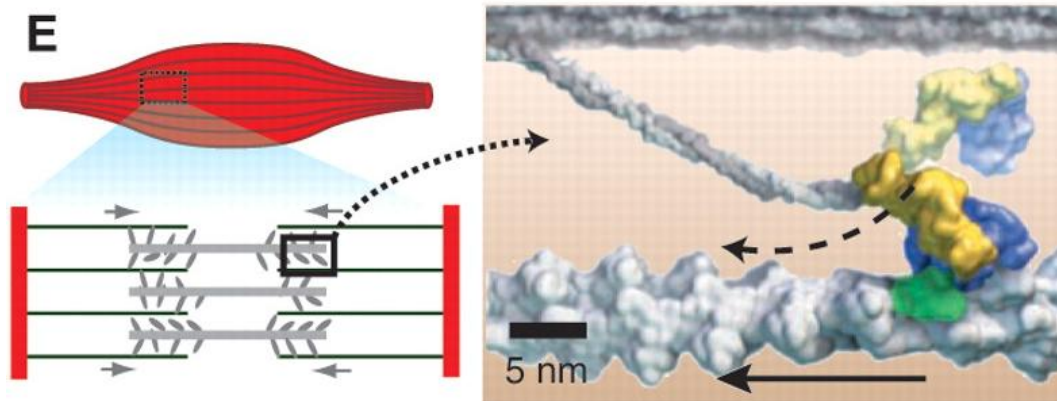
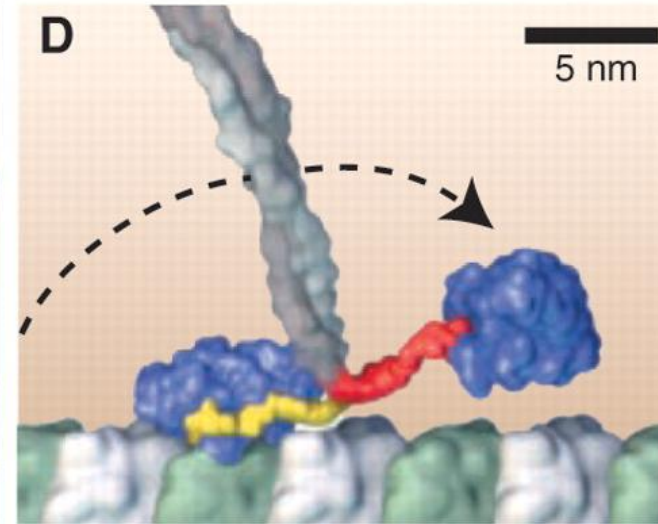
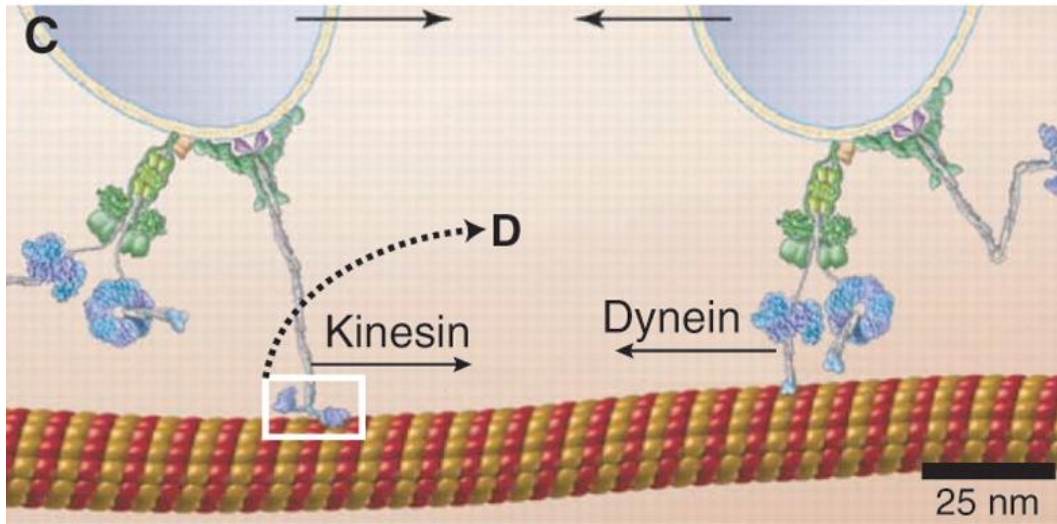
# Molecular Machines

## NATURE'S OUTBOARD MOTOR

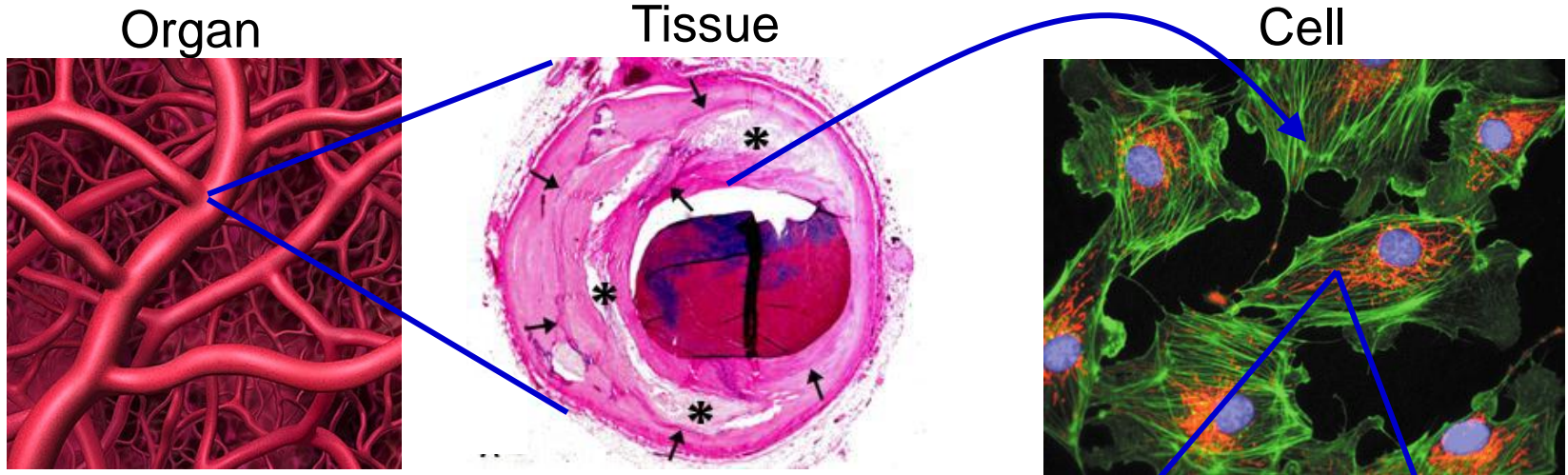
Despite the intricacies of the bacterial flagellum, biologists are unravelling its workings and making great headway in understanding how the nanoscale appendage evolved



# Molecular Machines



# Integrated Systems

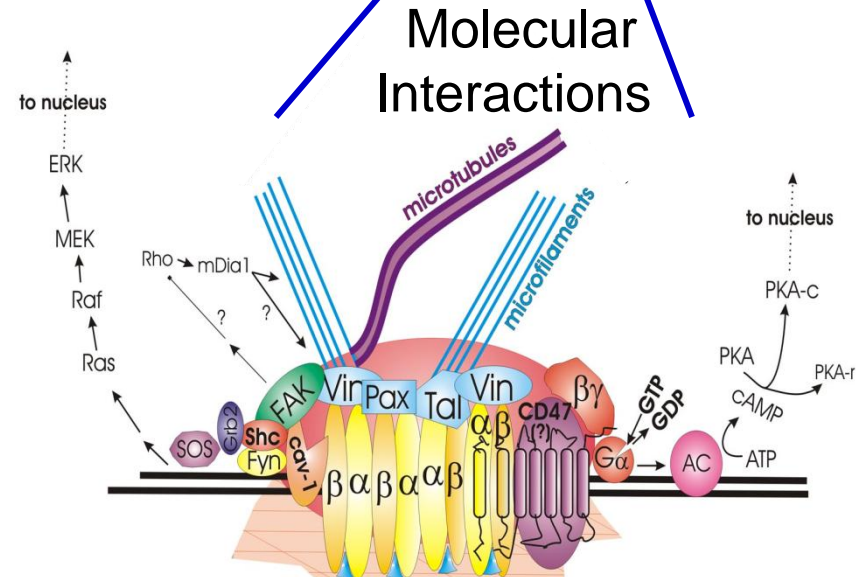


## Biological scale:

Molecular → Cellular → Tissue → Organ → Organism → Ecosystem → Biosphere

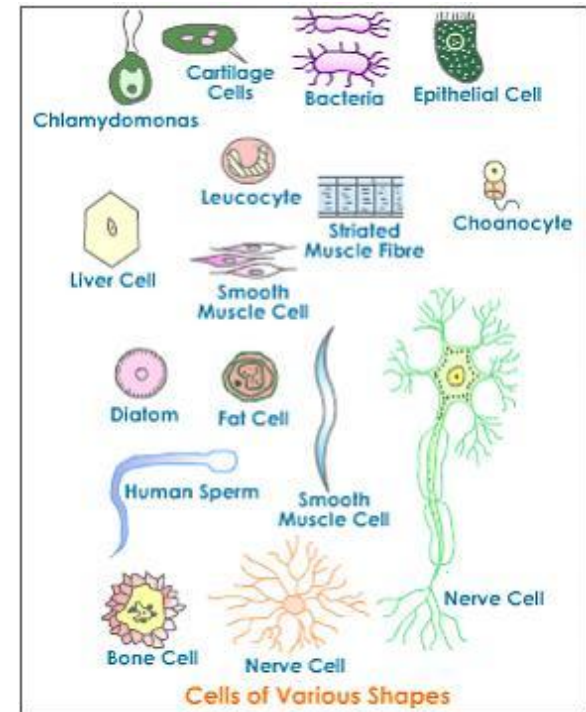
## Length Scale:

nm → μm → mm → cm → m → km



# Structure - Function

- Form follows function



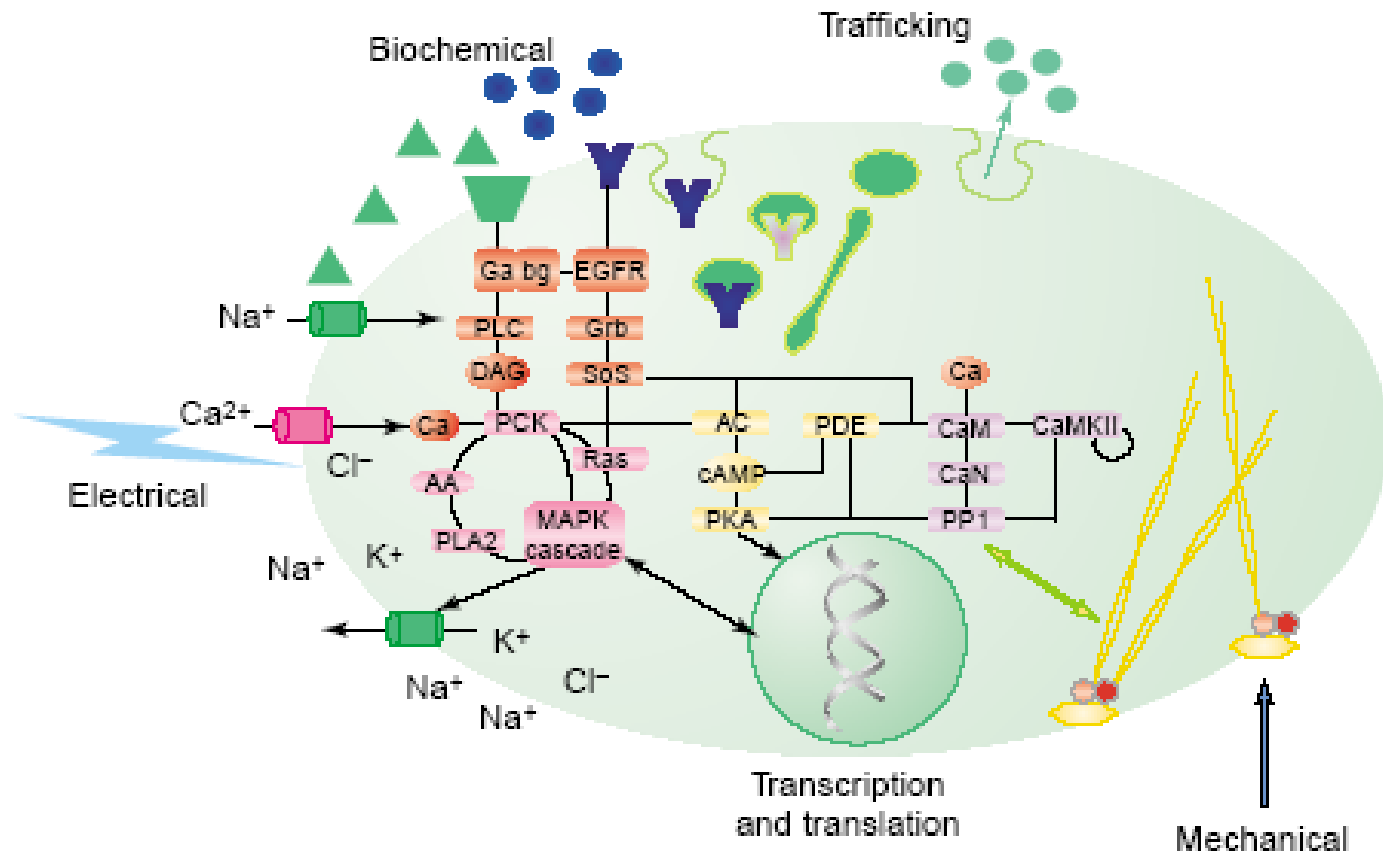
# How to Design Students





# Adaptation

- Short-term

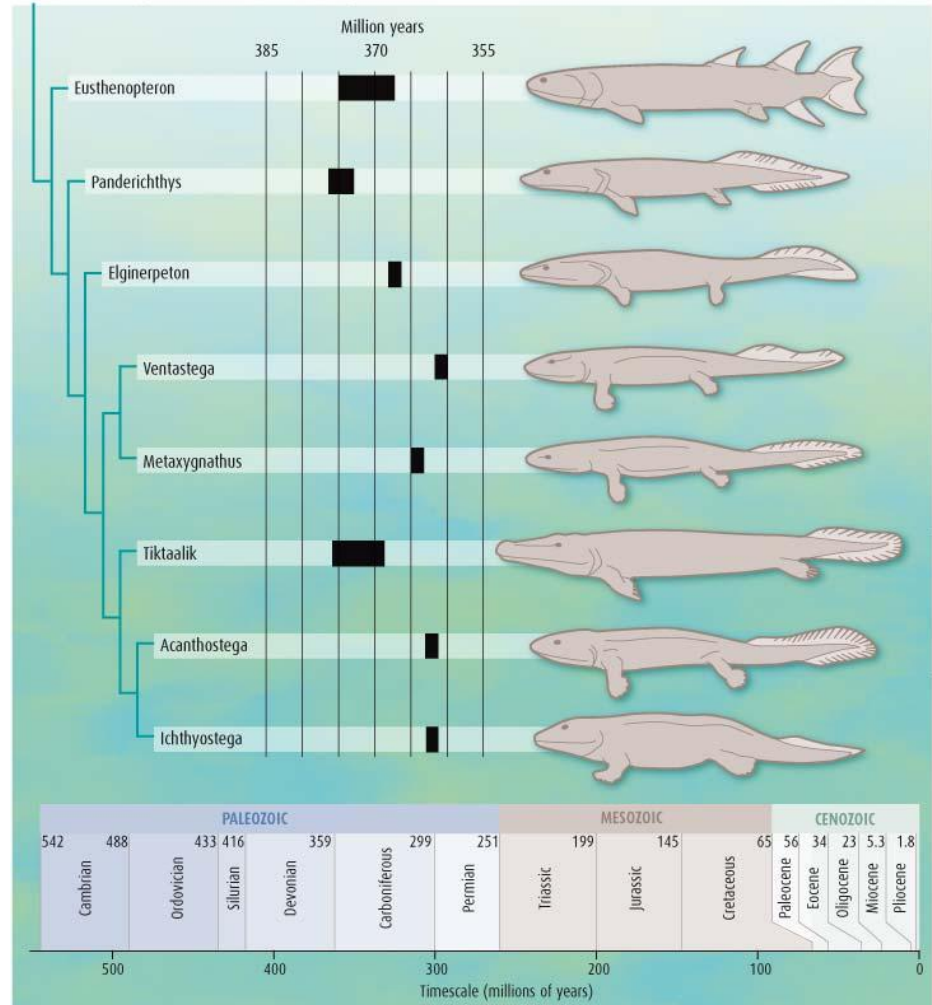


# Adaptation

- Long-term (evolution)

## FROM FISH TO TETRAPOD

The "fishbian" sequence is one of the most complete in the fossil record



SOURCE: EVOLUTION: WHAT THE FOSSILS SAY AND WHY IT MATTERS (COLUMBIA UNIVERSITY PRESS)

# Questions?

Bring your laptop...