

ME 498 / ME 599

# Biological Frameworks for Engineers

# Welcome

- Introductions
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- <http://courses.washington.edu/nsniadec/ME498/A11>
- Course Mission and Overview
- Administration and Logistics

ME 498 / ME 599

# 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  $\mu\text{m}$

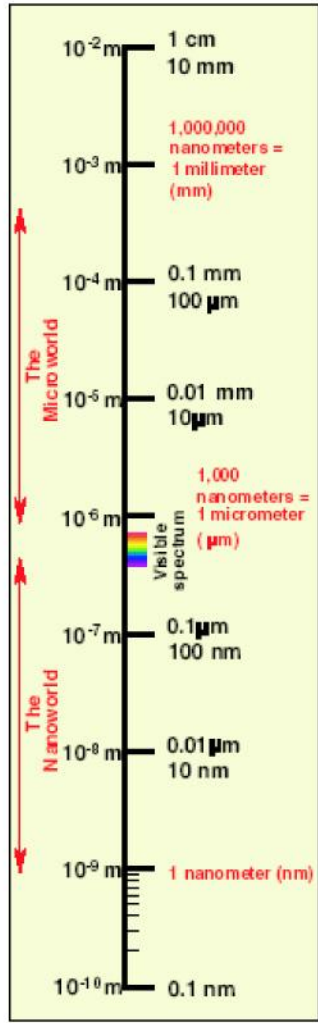
**Ant**  
~5 mm

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

**DNA**  
~2-1.2 nm diameter

**ATP synthase**  
~10 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

**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

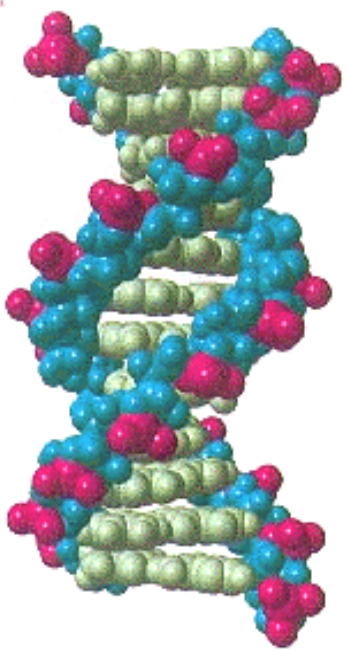
**Carbon nanotube**  
~2 nm diameter

**21st Century Challenge**

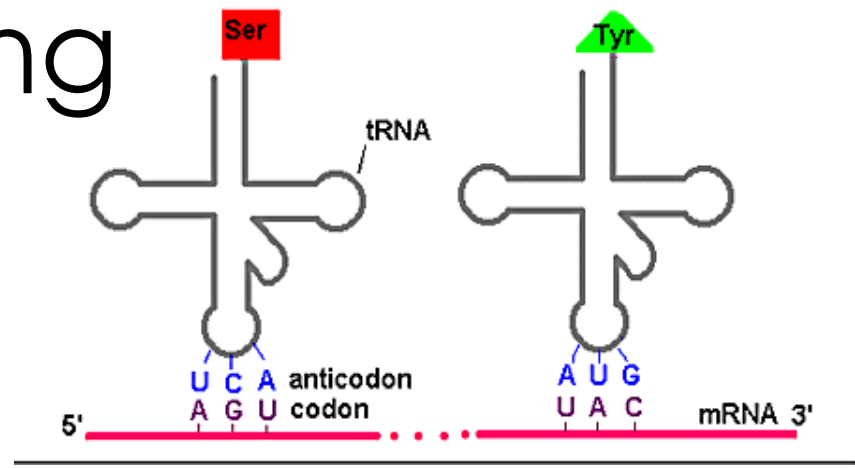
*Assemble nanoscale building blocks to make functional devices, e.g., a photosynthetic reaction center with integral semiconductor storage*

# Motivation...

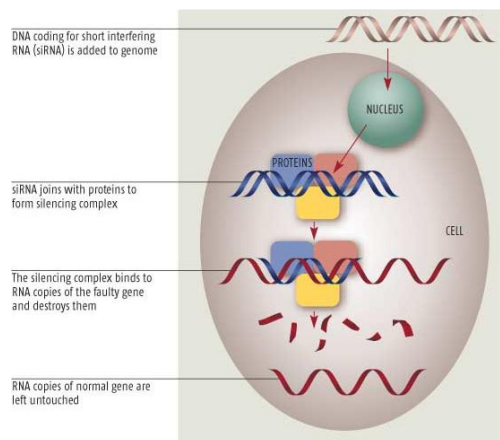
...for working at the interface  
between medicine and  
(mechanical) engineering



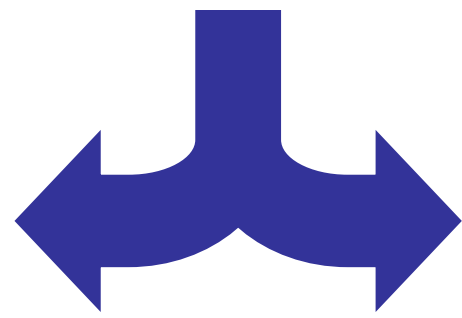
# Coding



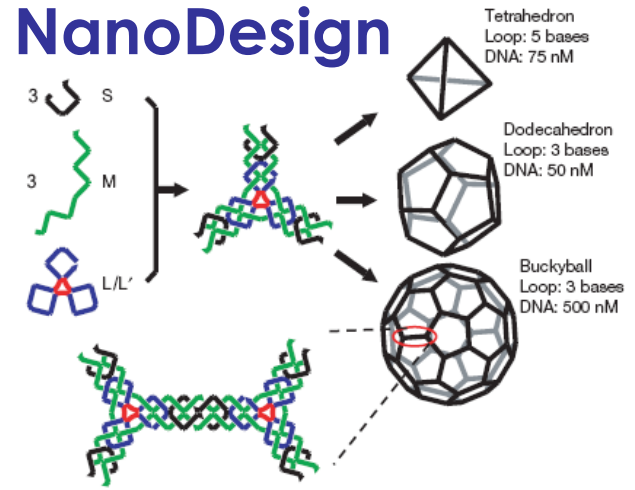
(5')G G A T A G C A T G A A A C C A G C A T A A (3')



# Gene Therapy



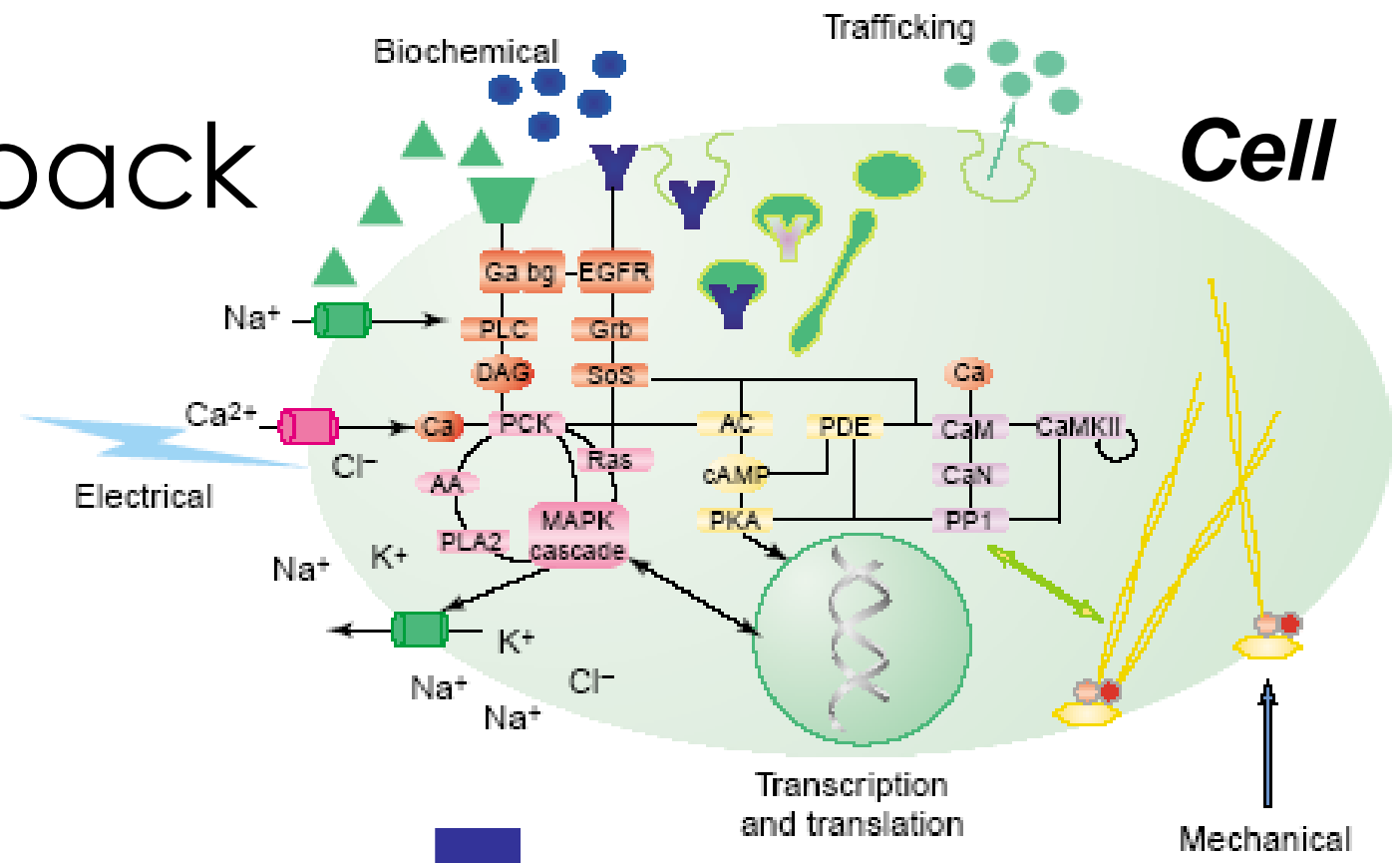
# NanoDesign



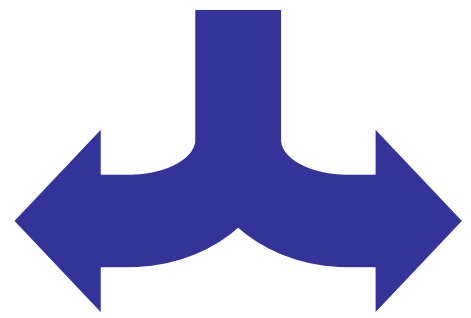
**Figure 1 | Self-assembly of DNA polyhedra.** Three different types of DNA single strands stepwise assemble into symmetric three-point-star motifs (tiles) and then into polyhedra in a one-pot process. There are three single-stranded loops (coloured red) in the centre of the complex. The final structures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



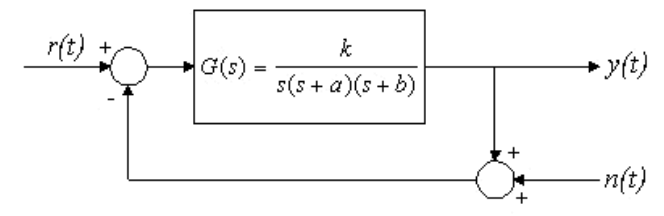
# Feedback



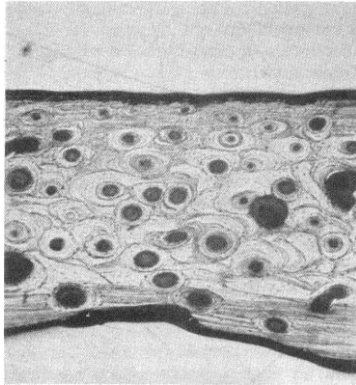
Stem Cell Therapy



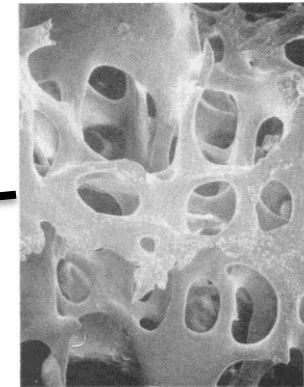
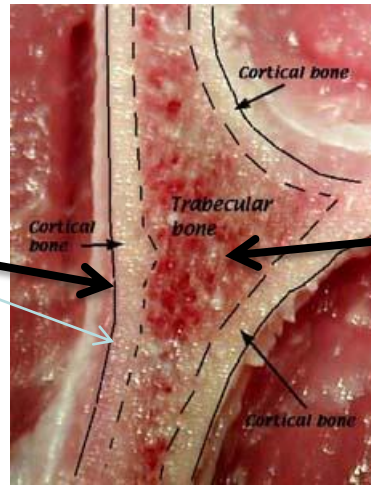
## Control Theory & Systems Biology



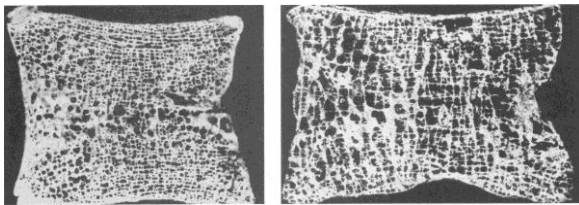
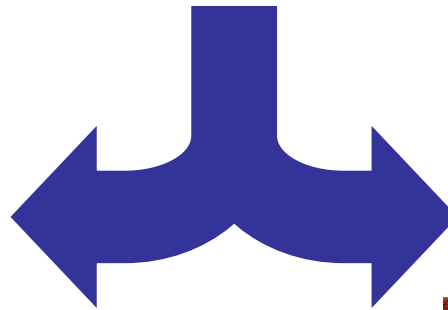
# Integration



Cortical  
(plywood)

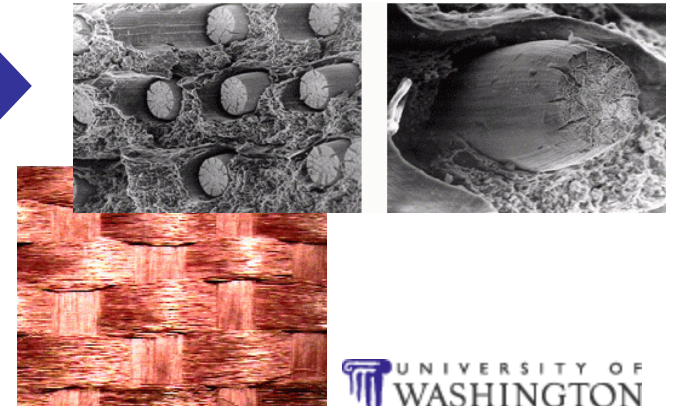


Trabecular  
(foam)



Osteoporosis  
Prevention

## Composite Design





# Functions of Life?


# Environmental Limits to Life?

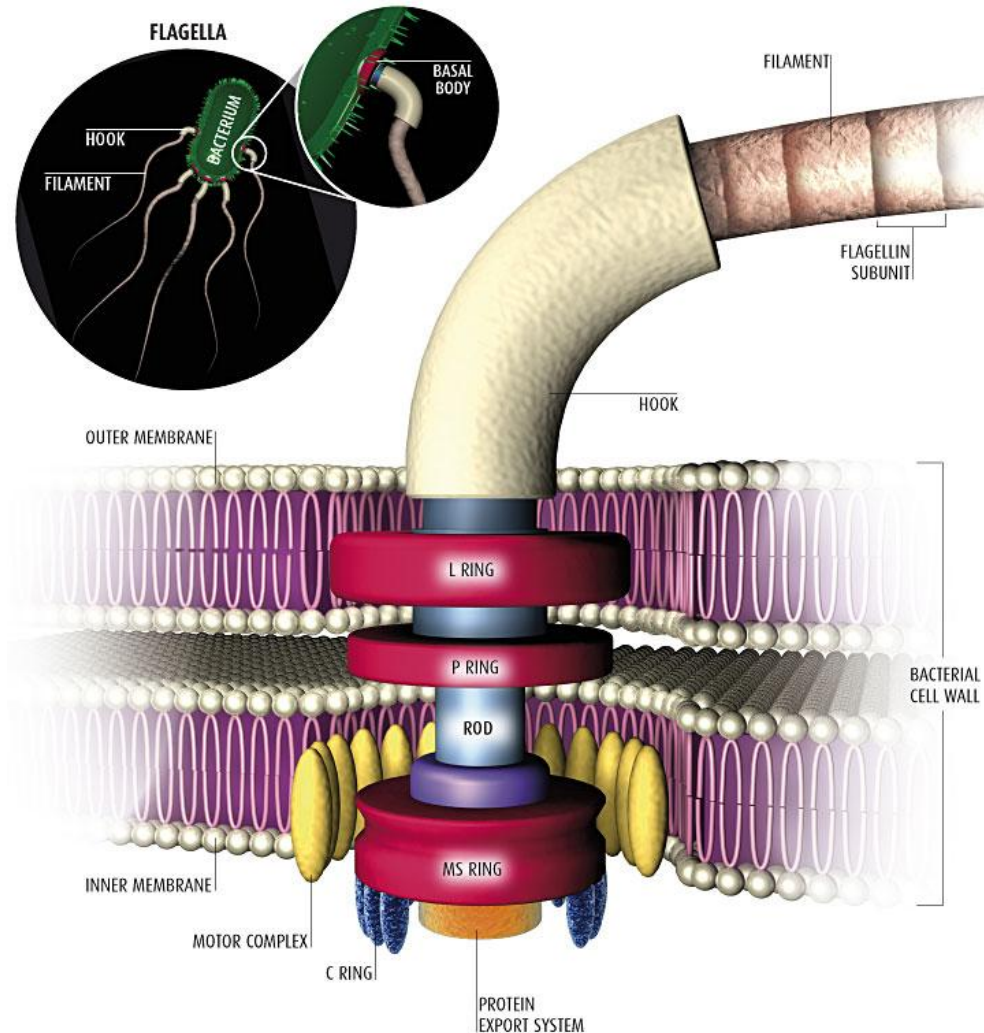

# Fundamental Themes

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

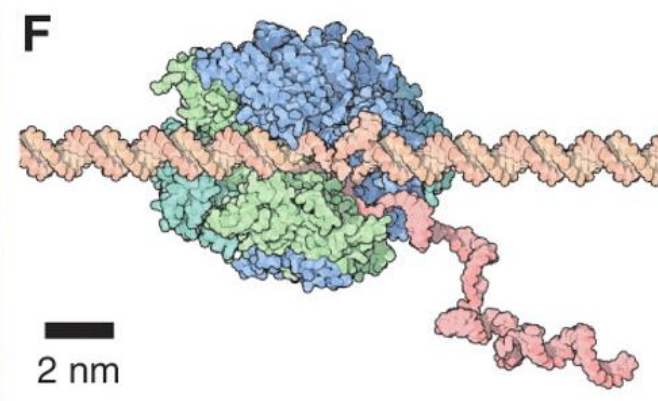
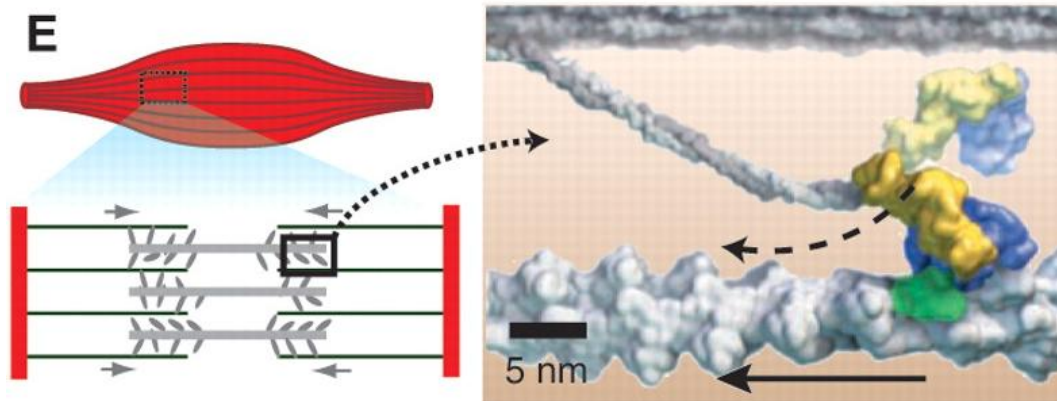
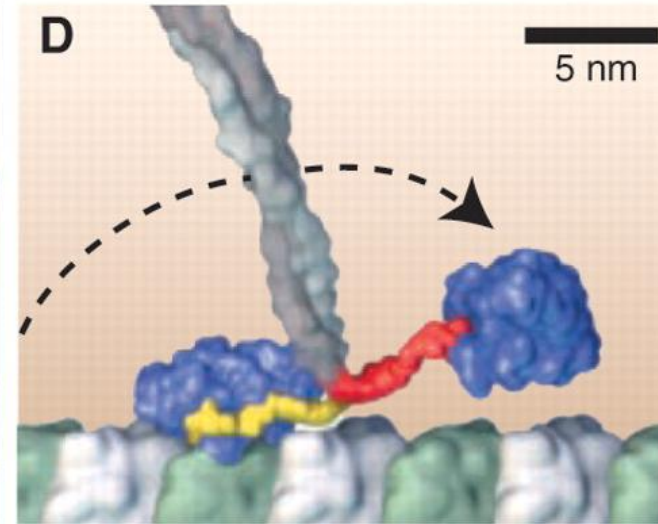
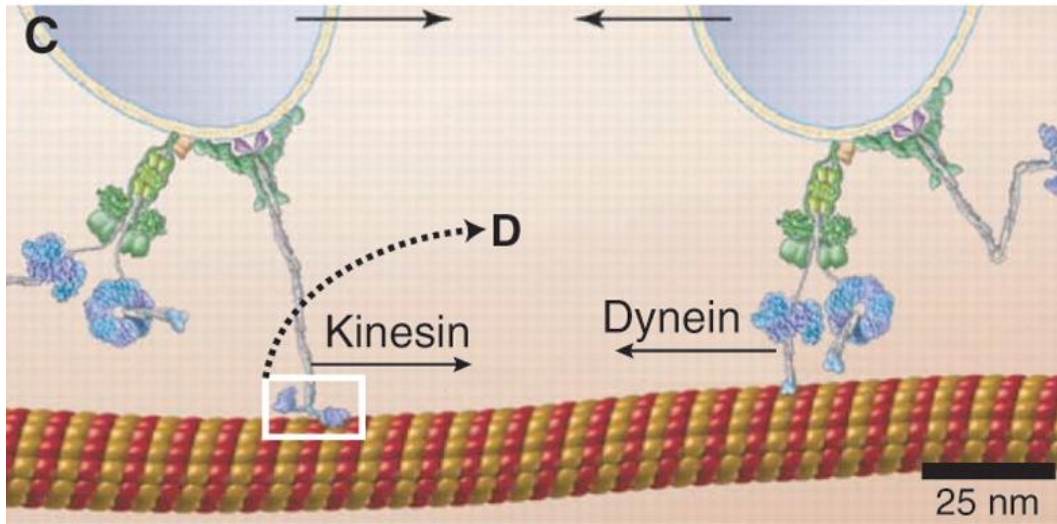
# Molecular Machines

## 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

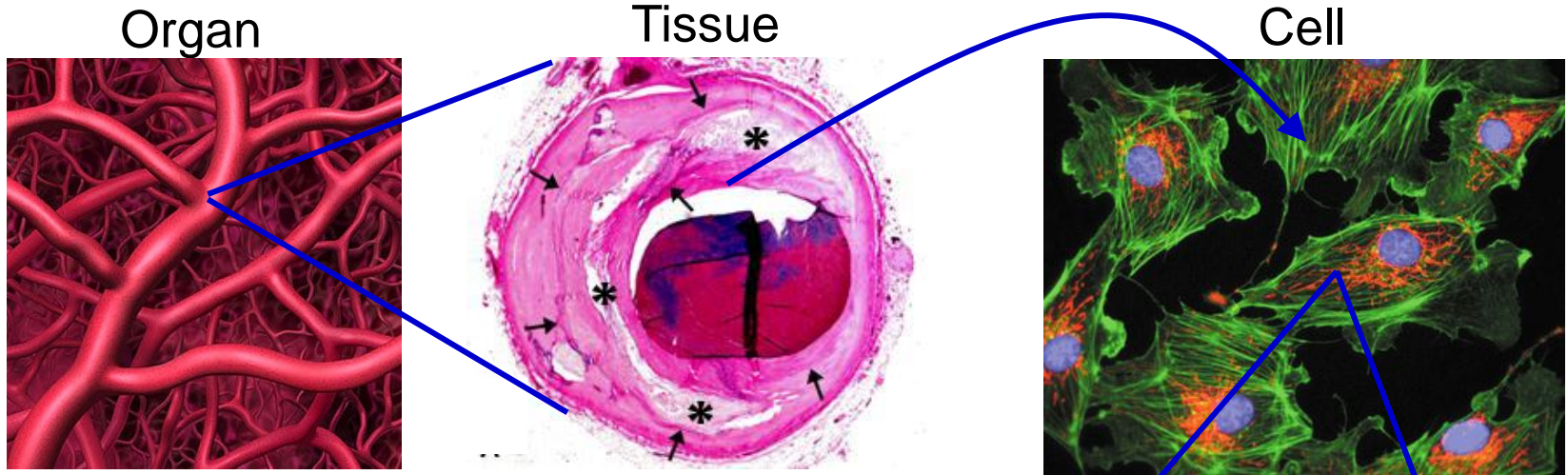


# Molecular Machines



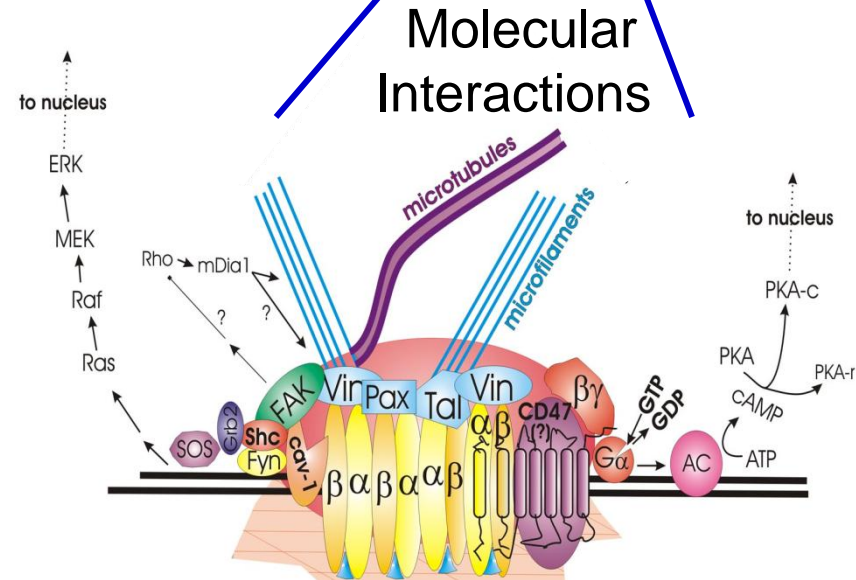


# Integrated Systems



**Biological scale:**  
 Molecular → Cellular → Tissue → Organ → Organism → Ecosystem → Biosphere

**Length Scale:**  
 nm → μm → mm → cm → m → km



# Structure - Function

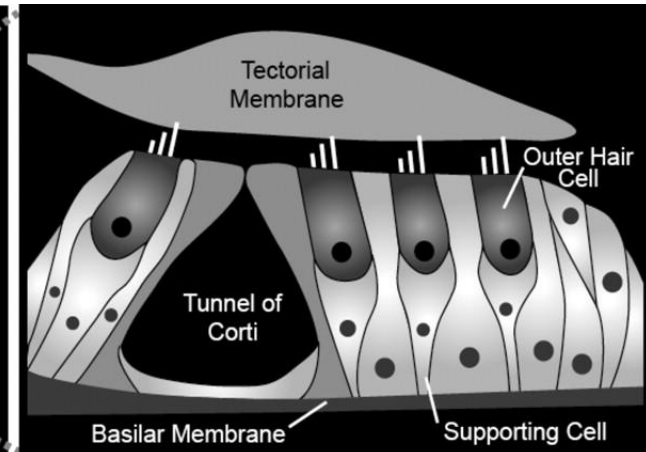
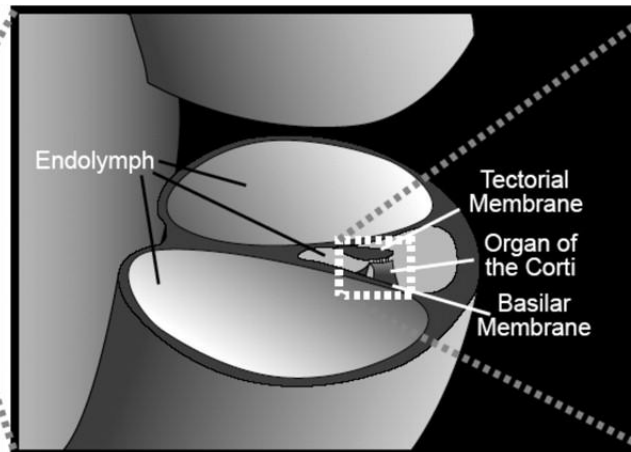
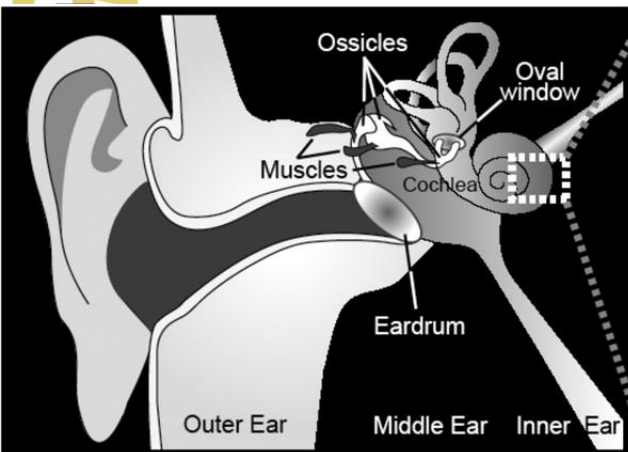
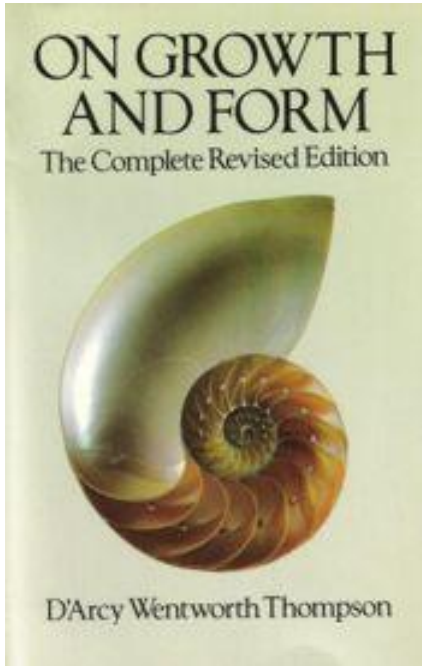
- Form follows function





# Structure - Function

Biological Frameworks for E

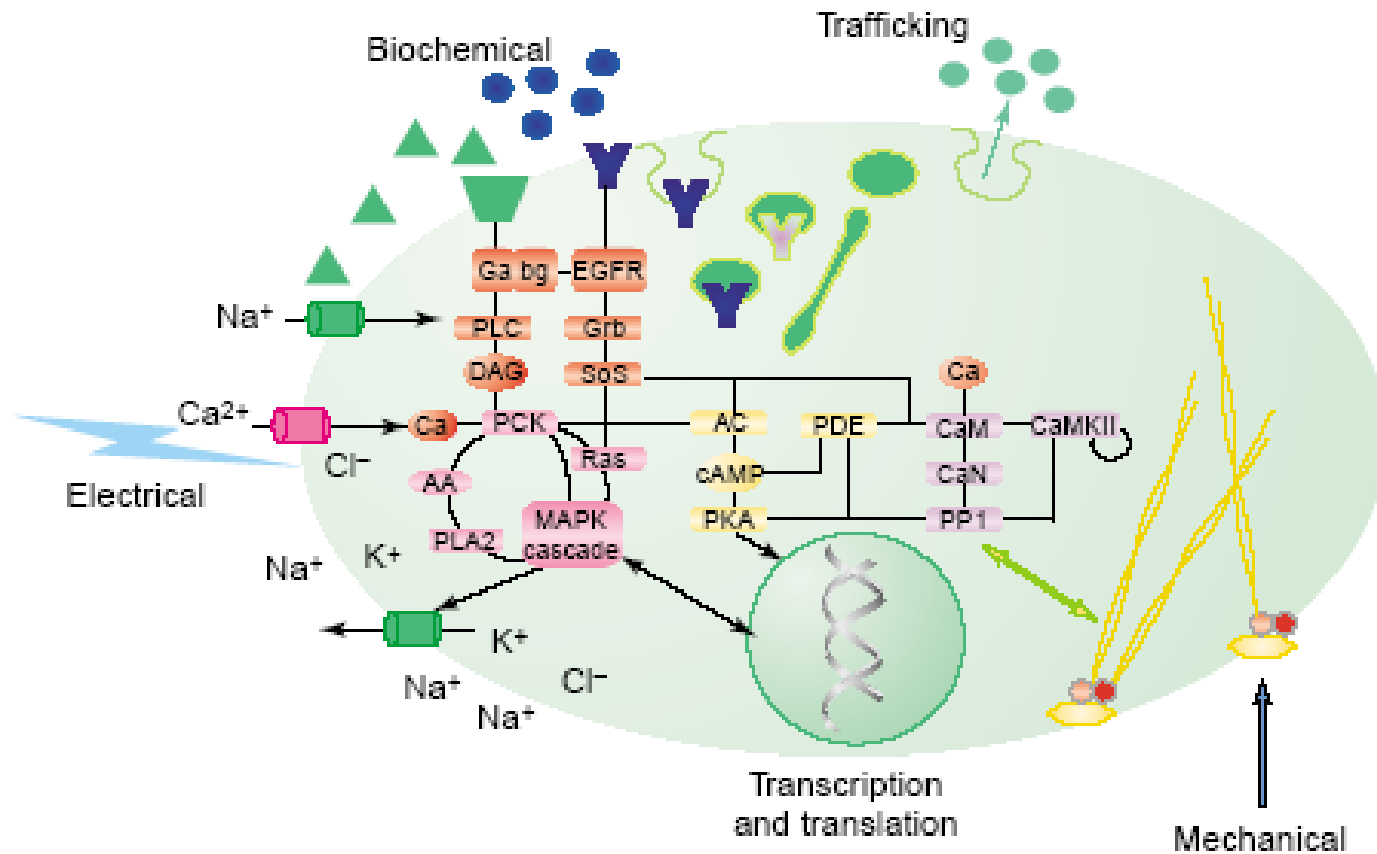


# How to Design Students



# Adaptation

- Short-term



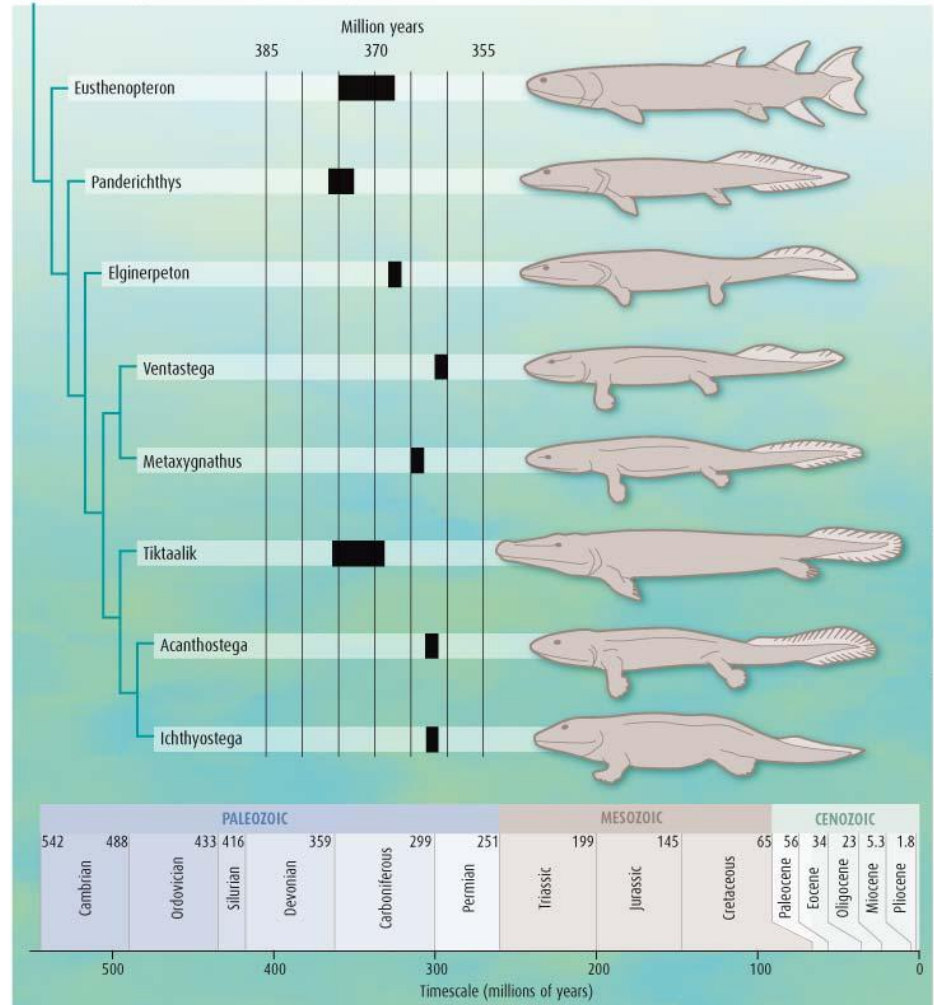


# Adaptation

- Long-term (evolution)

## FROM FISH TO TETRAPOD

The "fishian" 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?

Next class: MEB 231