Biology 337 **College of Charleston**
Biology of Invertebrates **Dr. Bob Podolsky**

20. Physical biology--fluid forces on life at small and large scales

"What a drag it is getting cold." --Fuiman and Batty (1997)

MAJOR THEMES
- Sex and the single cell
- Inertial and viscous forces
- The Reynolds number
- Appendages useful at small scales
- Biological effects of temperature
- Measures of performance
- Cilia and flagella
- Life in wave-swept environments
- Drag, lift, and the acceleration reaction

Recap: Sexual reproduction; metamorphic transitions from larva to adult

OUTLINE

1) Sex and the single cell: sexual life cycles pass through a (small) single-cell stage
2) The Reynolds number: forces acting on animals as they move through fluids (water, air)
3) An unexpected biological consequence of temperature at small scales
4) Probabilities of urchin dislodgment in wave-swept environments

GOALS

After studying from lecture notes and the associated reading, you should be able to:

- Explain why sexual reproduction creates an important constraint for a life cycle
- Describe differences in physical realities experienced by large and small organisms
- Explain why "Re" is a useful measure of forces created by movement through a fluid
- Give some examples of Reynolds numbers for relevant organisms or body parts
- Explain why cilia and flagella are effective appendages at low Reynolds numbers
- Explain why the function of bristled appendages at small scales can violate our intuitions
- Explain why there are two potentially confounding effects of temperature at low Re
- Explain the experimental design used by Podolsky to distinguish these effects
- Explain why small-scale effects may also be relevant for much larger organisms
- Explain why the shingle urchin (*Colobocentrotus*) was originally thought to have a morphology better suited for its particular habitat
- Explain the basis of three different forces that could dislodge an organism from a wave-swept marine environment, and how Denny and Gaylord measured these forces
- Explain why the results of these measurements were surprising in light of their predictions
- Explain how they used their results to make predictions about the probability of dislodgment

REFERENCES

Denny, M. and B. Gaylord (1996). Why the urchin lost its spines: hydrodynamic forces and survivorship in three echinoids. Journal of Experimental Biology 199: 717-729.

Emlet RB (1991) Functional constraints on the evolution of larval forms of marine invertebrates: experimental and comparative evidence. American Zoologist 31: 707-725.

Podolsky RD, Emlet RB (1993) Separating the effects of temperature and viscosity on swimming and water movement by sand dollar larvae (Dendraster excentricus). Journal of Experimental Biology 176: 207-221.

Podolsky, RD (1994). Temperature and water viscosity: physiological versus mechanical effects on suspension feeding. Science 265:100-103.

Strathmann, RR (1990). Why life histories evolve differently in the sea. American Zoologist 30:197-207.

Vogel, S (1978). Organisms that Capture Currents. Scientific American 239:128-139.