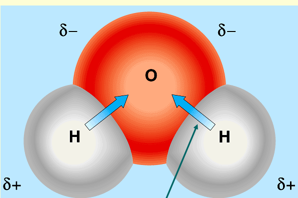
Properties of water

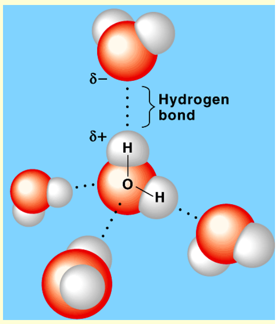
How water interacts with the environment

Lecture outline

- **Chemical and physical properties**
- Viscosity, inertia, and critters
- Water in motion

Why is water so funky?





Unique properties of water

Property	Comparisons with other substances
Density	Max @ 4C (not at freezing point--actually expands)
Melting & boiling points	Very high
Heat capacity	Very high
Heat of vaporization	Very high
Surface tension	High
Absorption of radiation	Minimum in visible region; ↑ red, infrared, & UV
Solvent properties	Excellent for ionic/polar molecules

Thermal buffering

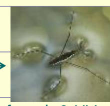
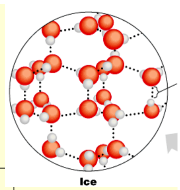


Table 2.1

Density vs. temperature

- Ice
- Stratification



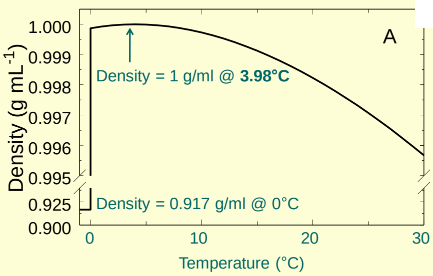


Fig. 2.3ish

Another view

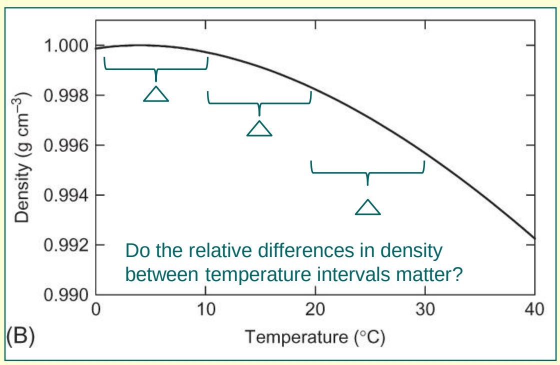


Fig. 2.3b

Lecture outline

- Chemical and physical properties
- **Viscosity, inertia, and critters**
- Water in motion

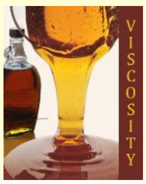
Organism size and water

- How do we describe the fine-scale properties of water that greatly influence organisms?
  - Viscosity
  - Inertia
  - Reynolds number (*Re*)

Osborne Reynolds
1842 - 1912

Viscosity and inertia

- **Viscosity**: resistance of a fluid to change <u>in form</u>; internal friction
- **Inertia**: resistance of a body to a change <u>of motion</u> (i.e., acceleration or deceleration)
- As spatial scale shrinks, viscosity ↑ and inertia ↓
  - In small spaces or with very small organisms the force of *individual* water molecules is very important



Putting viscosity and inertia together

- **Reynolds number**

$$\mathrm{Re} = \frac{F_i}{F_v}$$

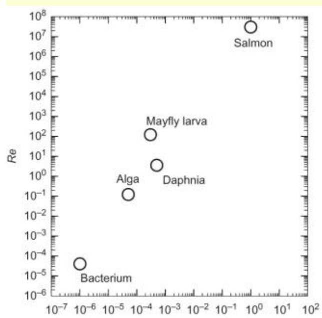


Fig. 2.6a

Thingy	***Re***
Bacterium swimming	0.000001
Pollen grain falling or sperm swimming	0.01
Fruit fly in flight	100
Small bird flying	100,000
Squid fast jetting	1,000,000
Large whale swimming	200,000,000

Vogel (1998)

Implications of *Re* for organisms of different sizes

< 1 mm  vs. 

- Comparing a rotifer to a trout:
  - Who can move easier?
  - Who can collect food easier?
  - Who can get oxygen easier?
  - Who can get rid of wastes easier?

Lecture outline

- Chemical and physical properties
- Viscosity, inertia, and critters
- **Water in motion**

Laminar vs. turbulent flow

- **Laminar flow**: fluid moves primarily in one direction and uniformly, little mixing (diffusion), viscosity dominates
  - In streams: parallel 'layers' sliding past one another
  - Re < 10

Laminar demo

- **Turbulent flow**: fluid moves chaotically with much mixing, eddies forming, viscosity less important
  - Re > 2000

Transition demo

Visualizing more turbulence

Algal thallus

0.5 cm/sec

Increasing velocity

3.5 cm/sec

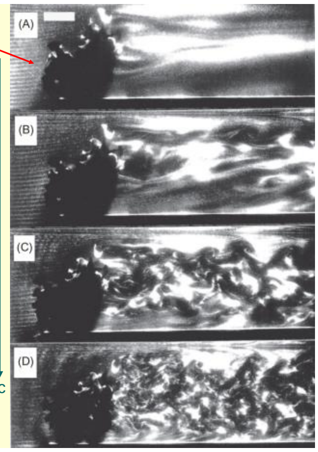


Fig. 2.10

Streamlining and Re

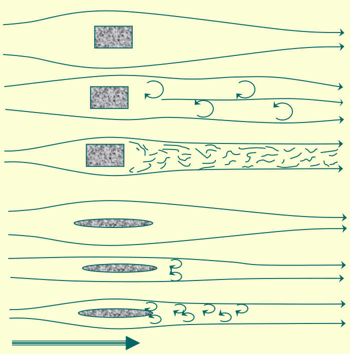


Fig. 2.9

Where do most *stream* organisms live?

- And why?

Flow boundary layer

- Water slows and becomes more laminar as it nears a solid surface due to friction; = '**No-slip condition**'
- The thickness of the **boundary layer** extends to where flow is not influenced by the solid surface (99% of open channel velocity)

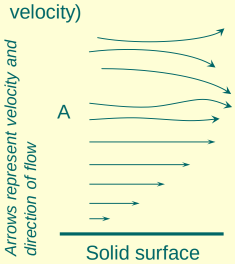
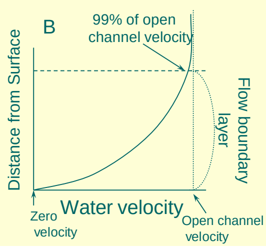


Fig. 2.7



Flow boundary layer (3)

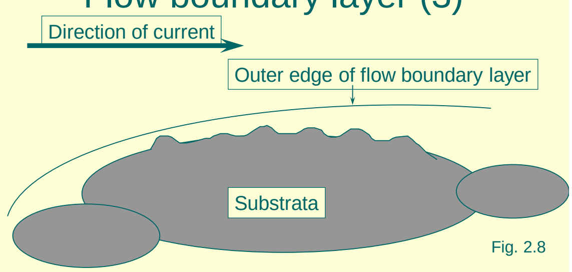
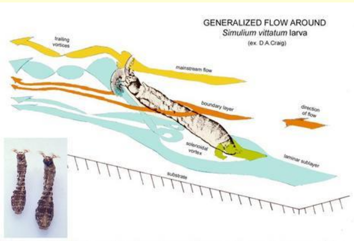


Fig. 2.8

- Vogel (1988) points out that people "retain a fuzzy notion that the boundary layer is a discrete region of nonmoving fluid rather than the discrete notion that the boundary layer is a fuzzy region in which there is a strong velocity gradient"

Interesting ways to feed associated with turbulence (1)



Black flies feeding

Interesting ways to feed associated with turbulence (2)

- Vortex feeding…filtering

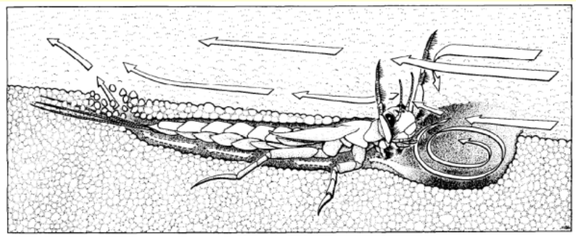


Fig. 2. Diagram of feeding by *Ametropus neavei* larvae. Arrows indicate the direction of flow as observed from dye studies. For clarity, only flow from near the bottom and at the level of the claws (3–5 mm above the bottom) is depicted. Drawing is a composite image based on analysis of videotapes and still photographs.

Soluk & Craig (1988)

Interesting ways to feed associated with turbulence (3)

- Vortex feeding…predation

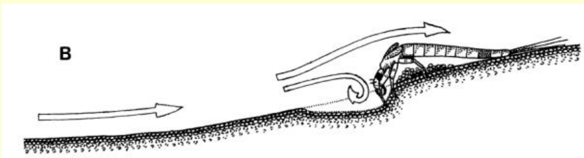


Fig. 3. Diagrammatic representation of feeding behavior of *Pseudiron centralis.* Arrows indicate direction of flow. Larva in arched position creates a solenoidal vortex that spins out laterally on both sides of the head. The vortex rapidly erodes sand from under the mouthparts, forming a pit (A) in which the *Pseudiron* larva probes for the small, interstitial chironomids on which it feeds. Subsequent backward movement of larvae expands the pit (B) temporarily leaving a shallow groove up the face of the dune.

Soluk & Craig (1990)