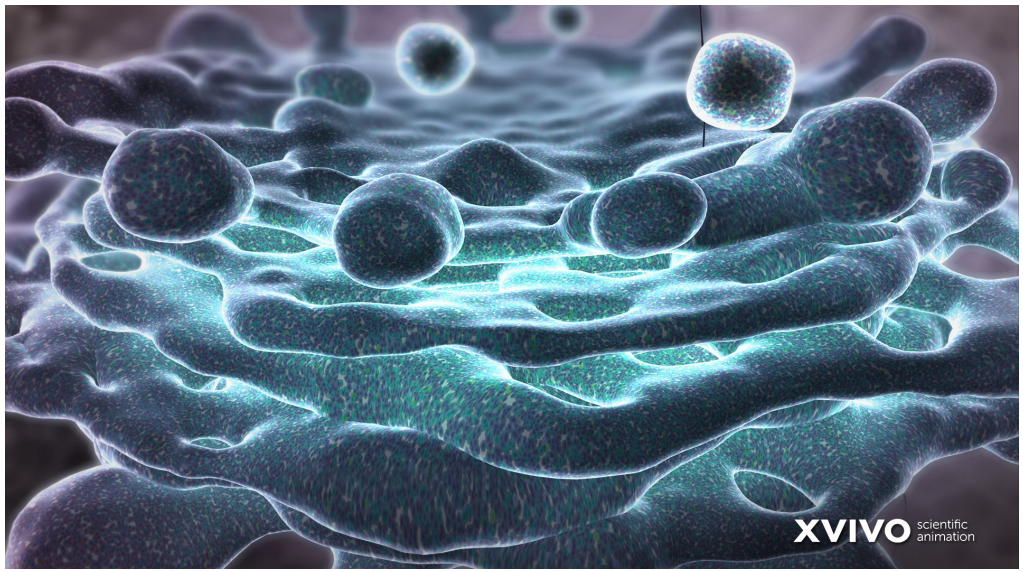
Teachers' Day: Making Physics Real

Exploring Fluids

Elena Koslover, UCSD Physics



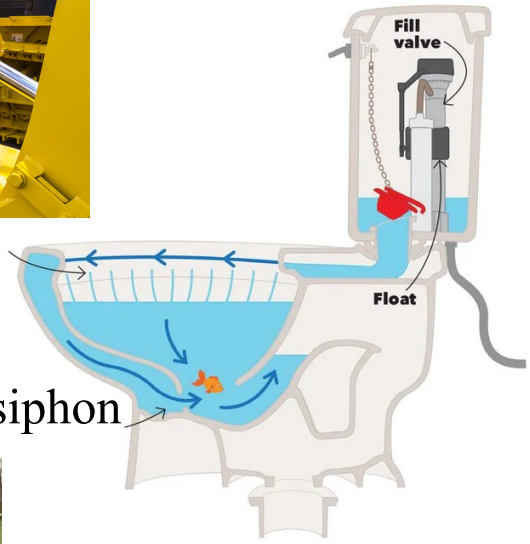
March 15, 2026

Introduction: Physics of Fluids

- **Hydrostatics:** fluids at rest (pressure, depth)
- **Hydrodynamics:** flowing fluids (viscosity, flow rate)

Fluids in technology

hydraulics

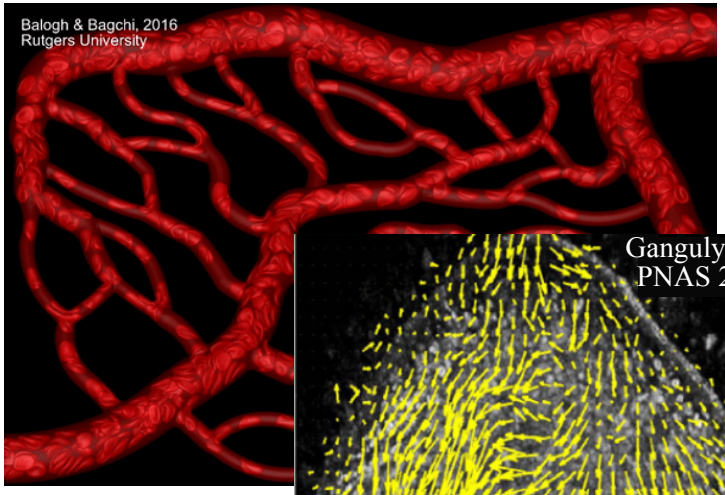


siphon

pump

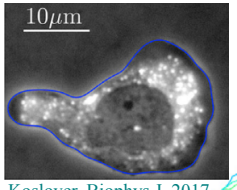
IV drip

Fluids in living systems

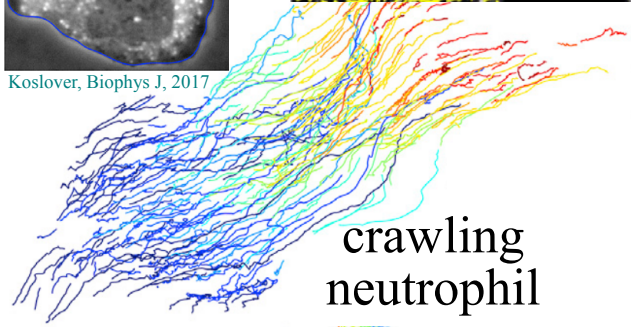


blood flow

fly oocyte



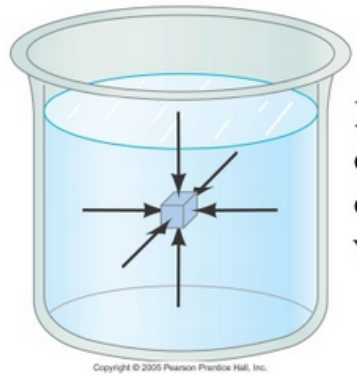
Koslover, Biophys J, 2017

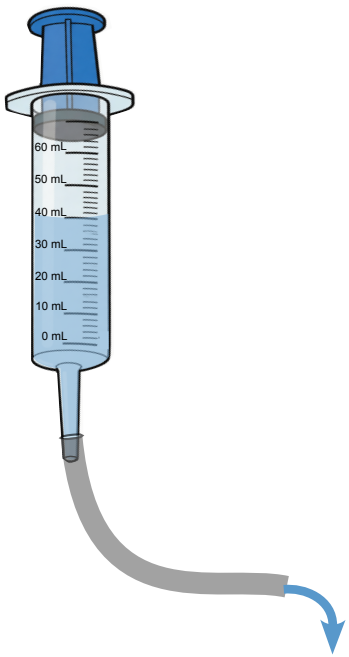


crawling neutrophil

Key Concept: Fluid Pressure

- In fluid at rest, pressure is the same on all sides





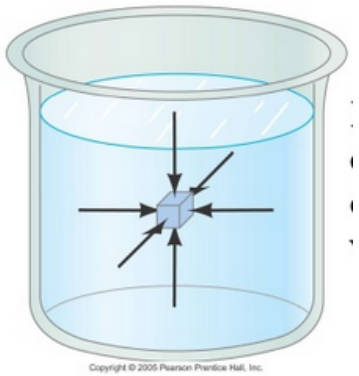
Key Concept: Fluid Pressure

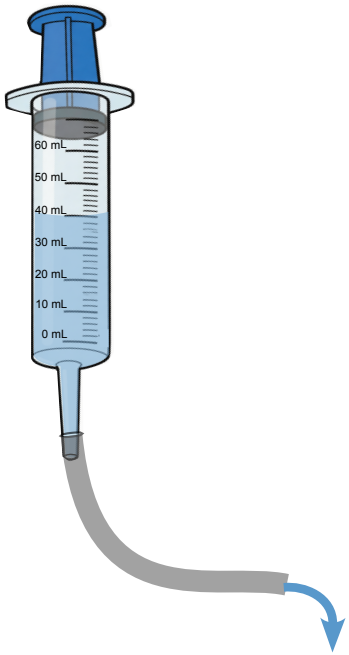
- In fluid at rest, pressure is the same on all sides
- Each chunk of fluid must support weight of water above it

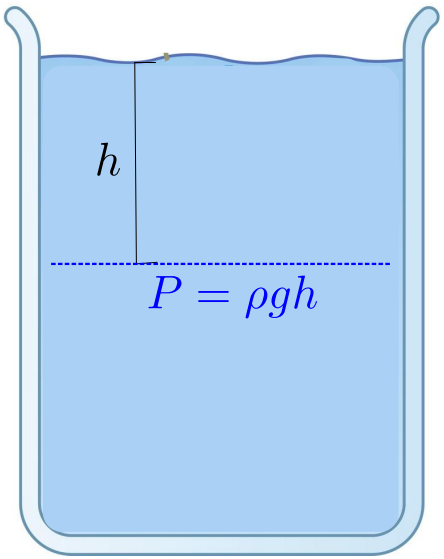
Pressure increases with depth:

$$P = \rho\, g\, h$$

force / area ← P; ρ: density; g: gravity; h: depth below open surface







(bottle demo)

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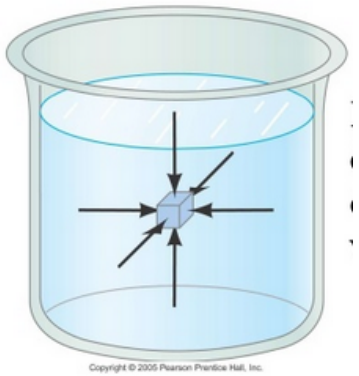
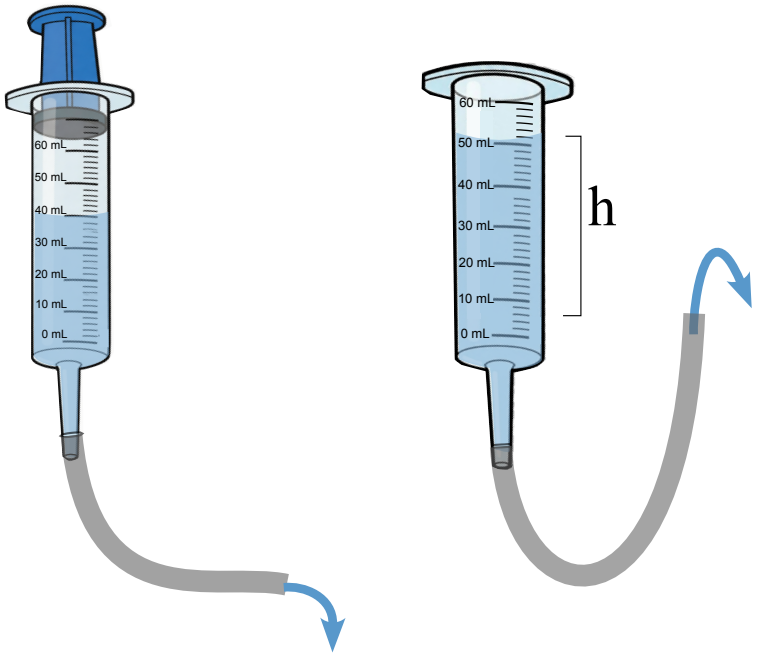
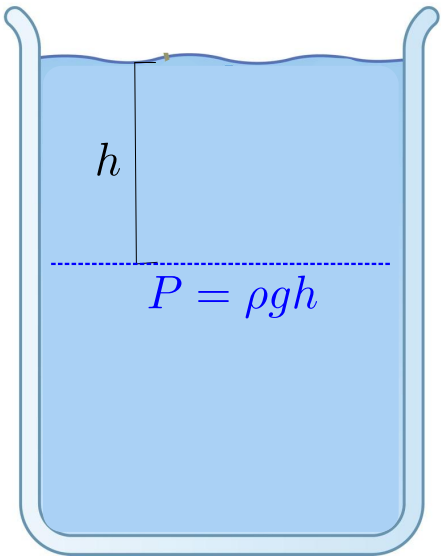






(bottle demo)

Concept Check: Pascal's Barrel

Barrel A is filled to the brim with water. Barrel B is filled and closed off, a very thin very tall straw is put in, and the straw is filled to the top.

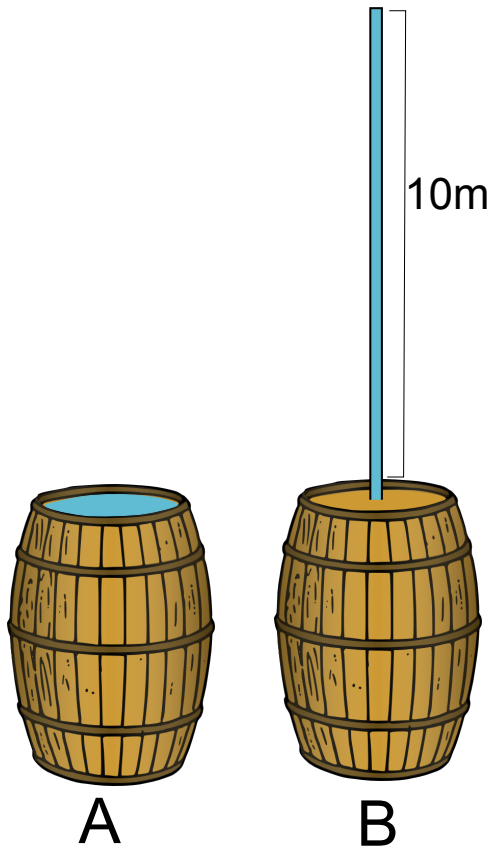
Clicker question!

(a) The pressure on the sides of Barrel A and Barrel B are approximately the same

(b) The pressure on the sides of Barrel B is much greater than Barrel A.

(c) The pressure on the sides of Barrel B is much less than Barrel A.

(d) There is not enough information given to decide which pressure is greater.



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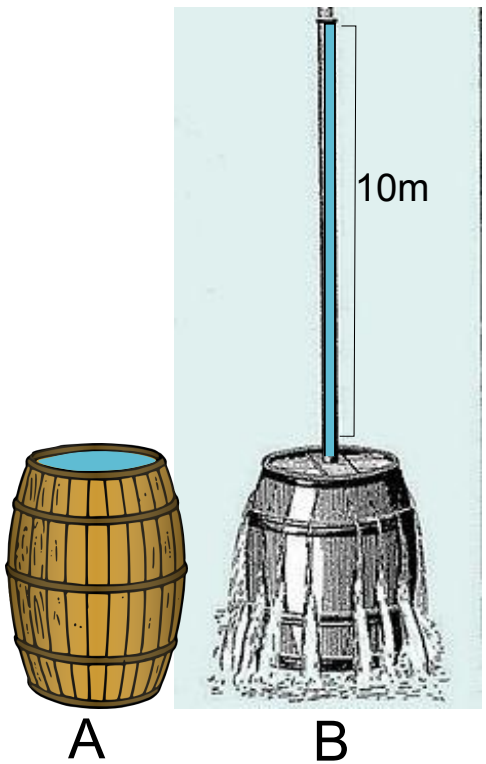

Pascal's Vases

When will the water stop flowing?

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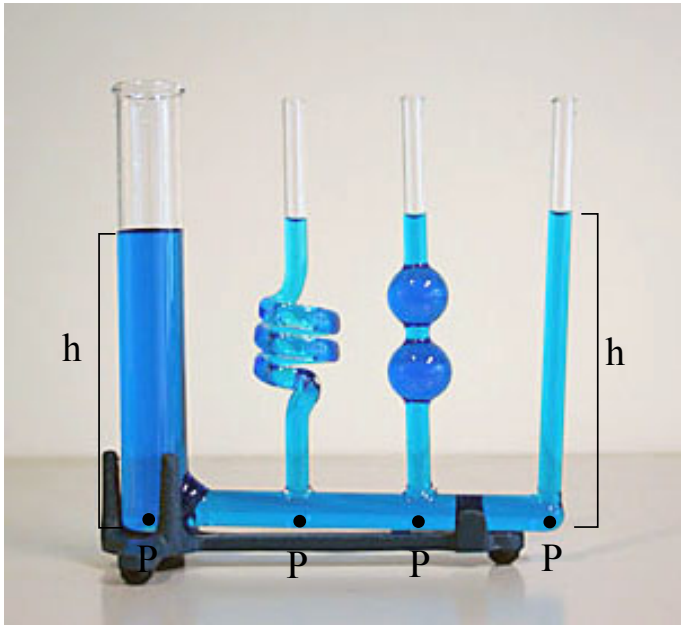
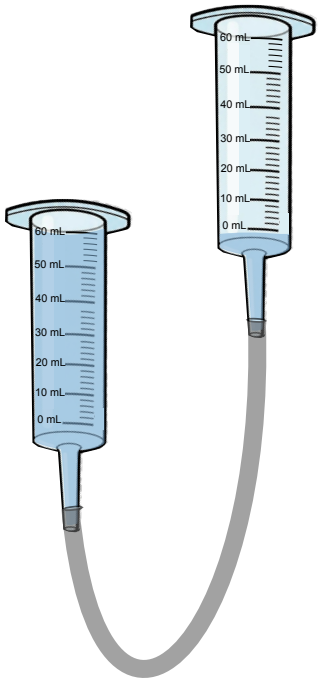


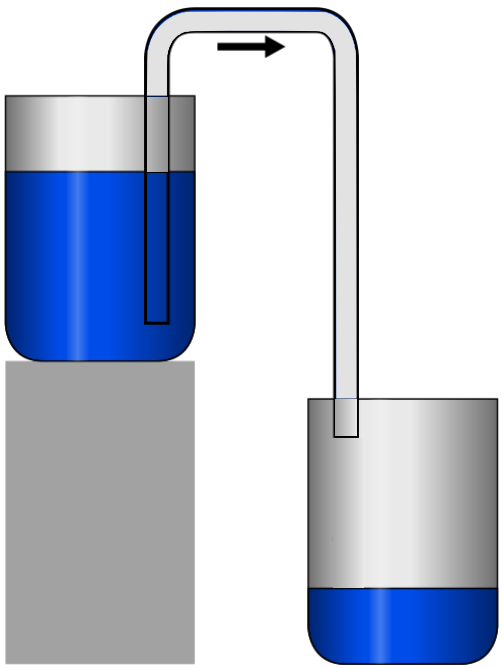


General principle: "Water seeks its own level"

- Fluids flow from high to low pressure
- Will keep flowing until all open surfaces are at the same height

Key Concept: Siphons

- A **siphon** (when filled with fluid) allows water to flow over a hill



no flow

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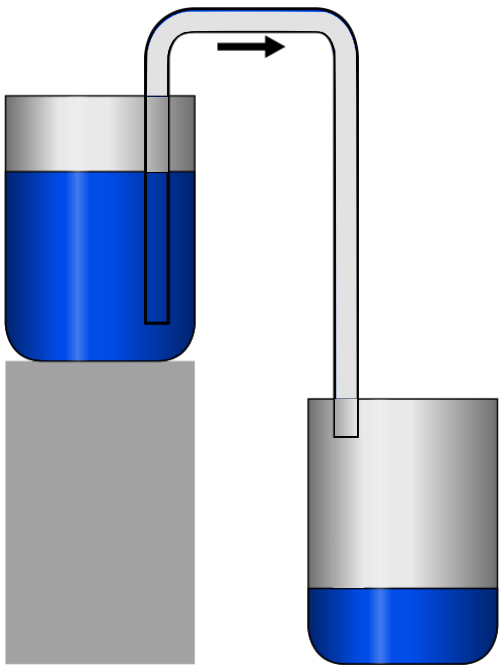

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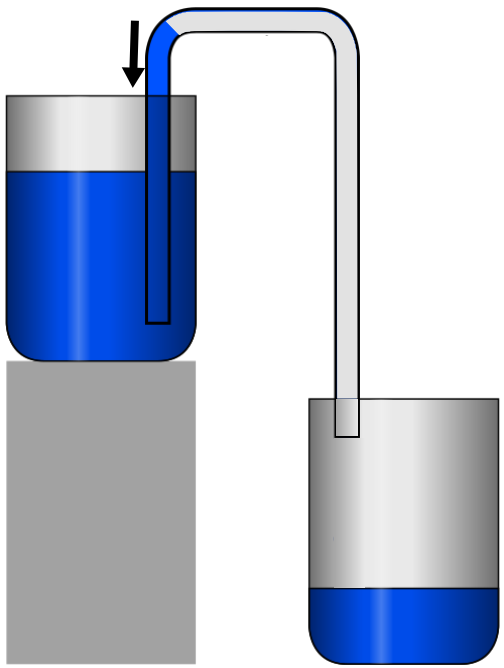
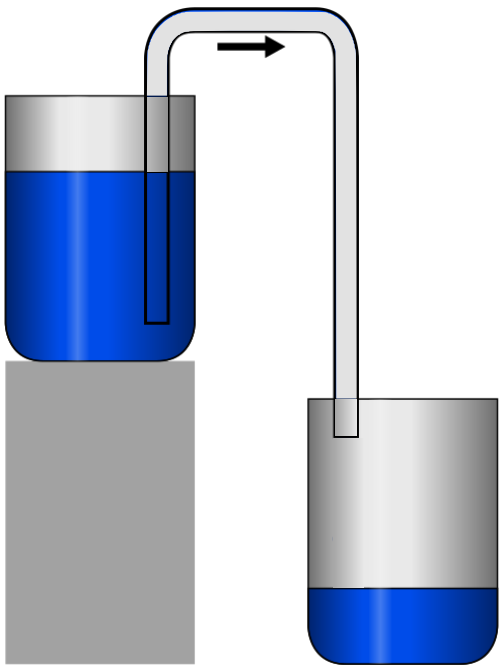


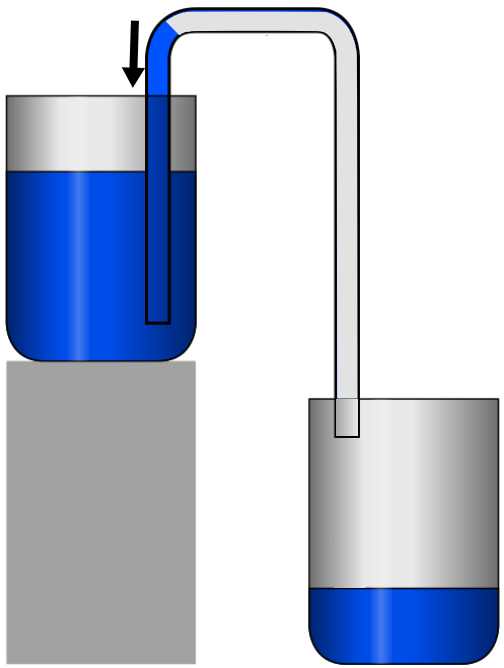
back flow

Key Concept: Siphons

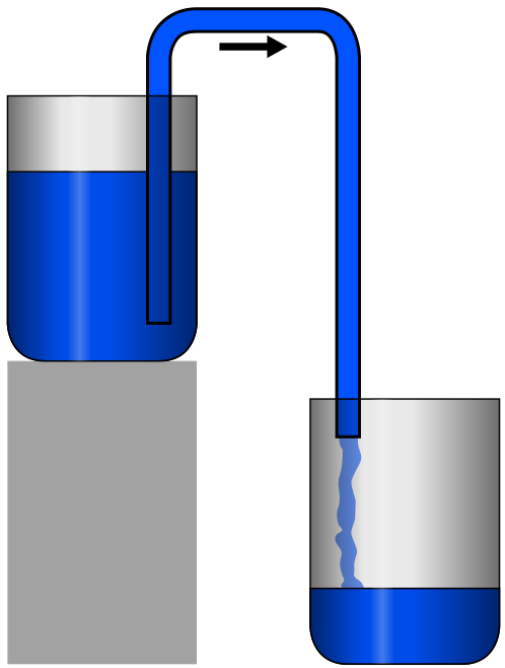
- A **siphon** (when filled with fluid) allows water to flow over a hill
- Will keep flowing until surfaces reach same height (or upper container empties)



no flow



back flow

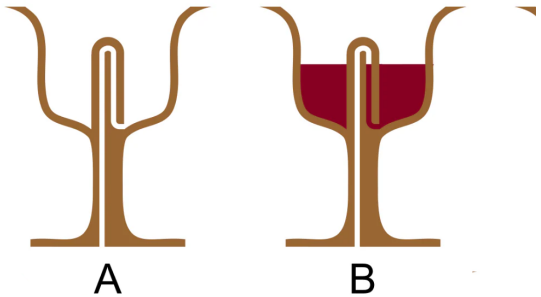


flow

Application of Siphons: Flushing

Pythagoras's "Greedy Cup"

- Works fine when filled moderately



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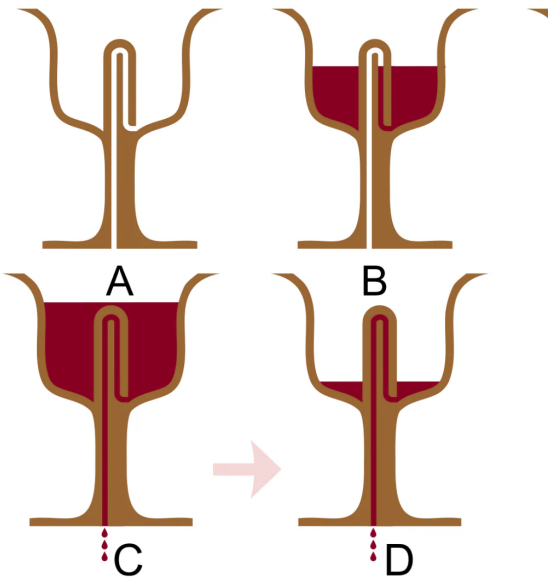

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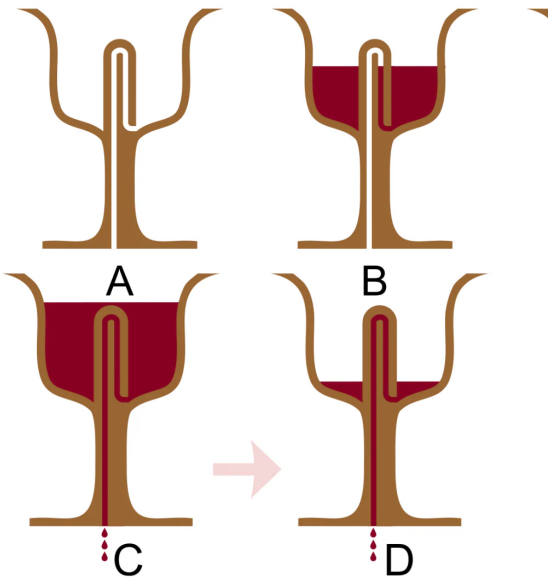

Siphonic toilets

- Flow through siphon draws out waste

Rate of Fluid Flow

What determines rate of fluid flow?

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viscosity, pressure difference, pipe thickness and length

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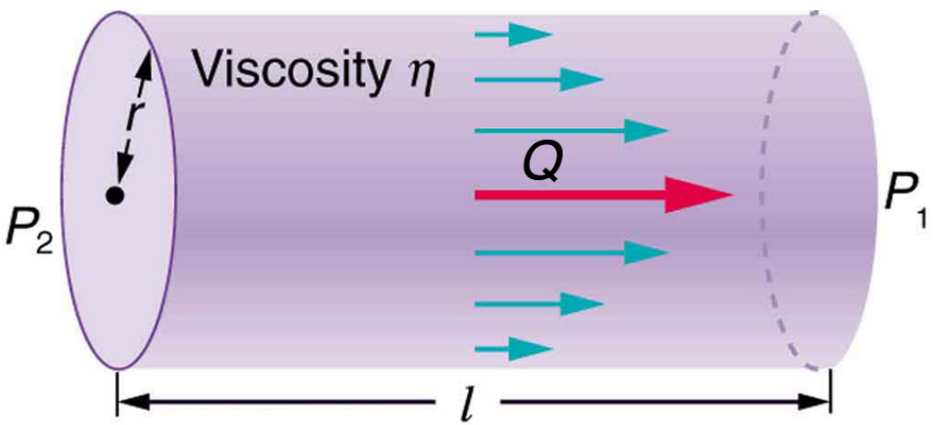
viscosity, pressure difference, pipe thickness and length

Simplest system:
viscous fluid flowing
through a pipe



Poiseuille's Law

$$\text{flow rate: } Q = \frac{P_2 - P_1}{\mathcal{R}}$$

$$\text{flow resistance: } \mathcal{R} = \frac{8\eta\ell}{\pi r^4}$$

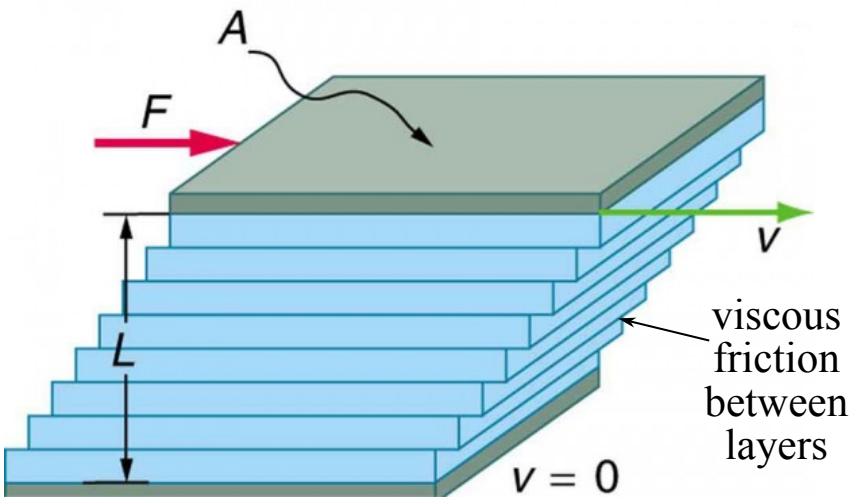
(viscosity)

(junctions can provide parallel pipes, but also add extra resistance)

Total flow rate = cross-sectional area $\times$ speed

Key Concept: Viscous Friction Sets Flow Speed

Viscosity: how much friction between layers of flowing fluid



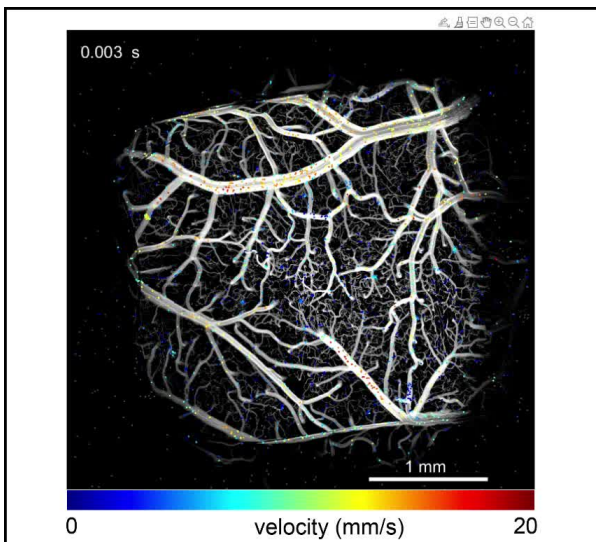
Viscosity η relates shear stress (force per area) and strain rate (velocity per height):

$$\frac{F}{A} = \eta \frac{v}{L}$$

Flow Through Tubes in Living Systems

- Biological systems adjust tube width, length, pressure, connectivity to control fluid flow through networks

Blood flow in brain
(tube width:
$\sim 100\mu$m)



(Glück, PNAS, 2024)

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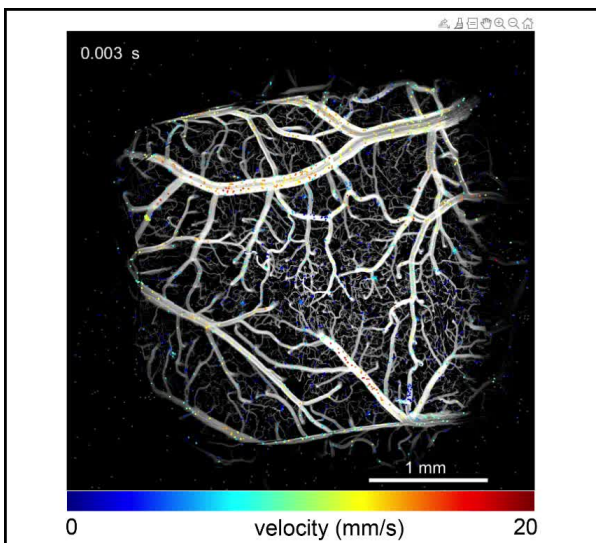

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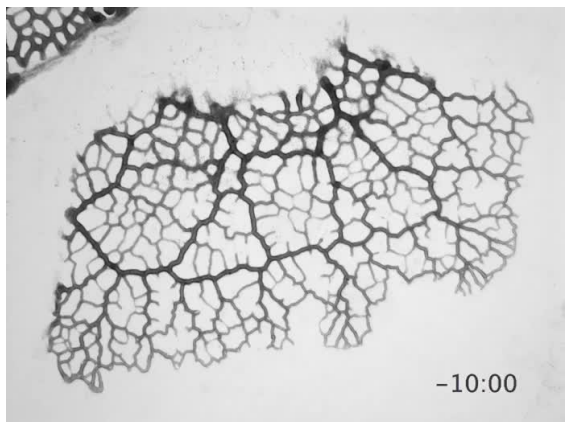
Slime mold (tube width: 50μm)



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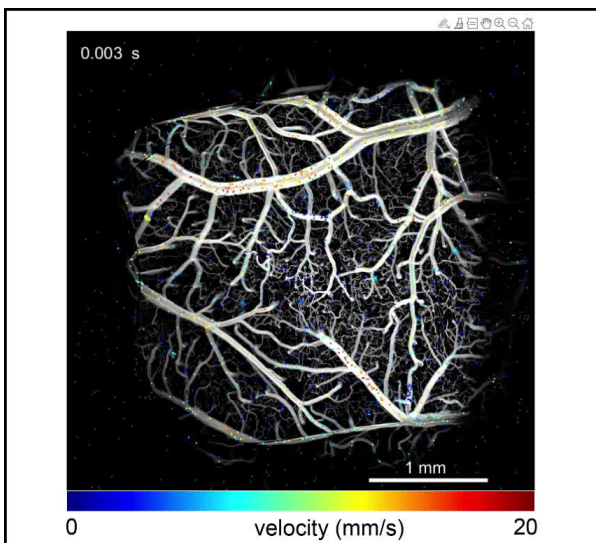

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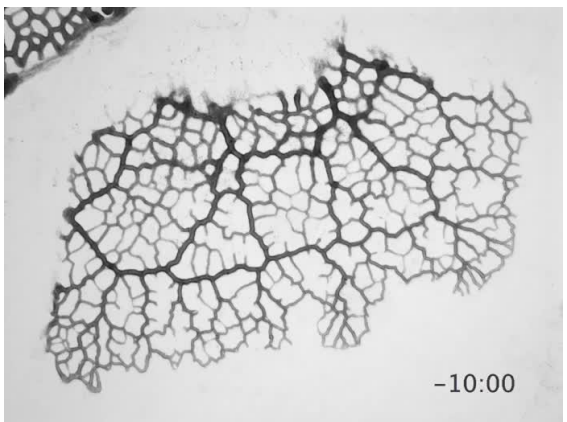

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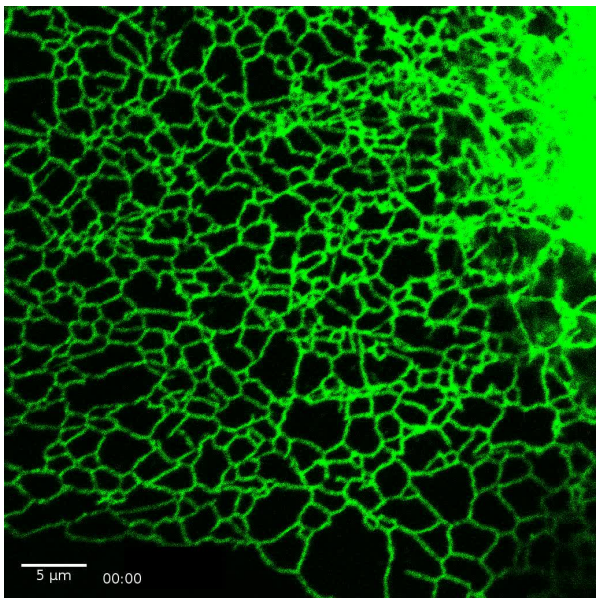
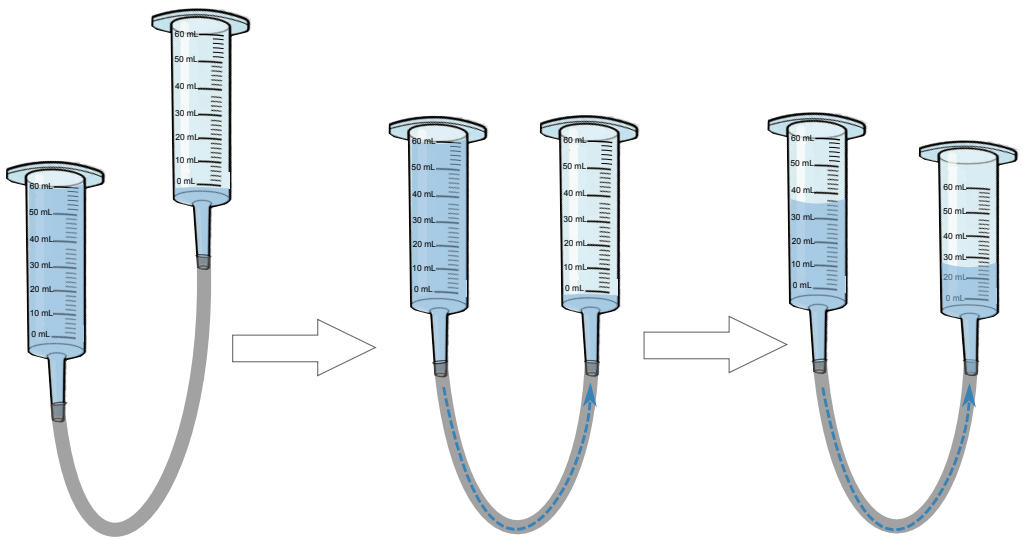
endoplasmic reticulum (tube width: 100nm)



Your Turn

Try out the activity, following the worksheet provided



Want to see these slides / worksheet / other activities?

Go to: `https://koslover.ucsd.edu/YSC.html`