2013-12-10

Arteries

Bernoulli

large – 1 mm – few cm

viscosity

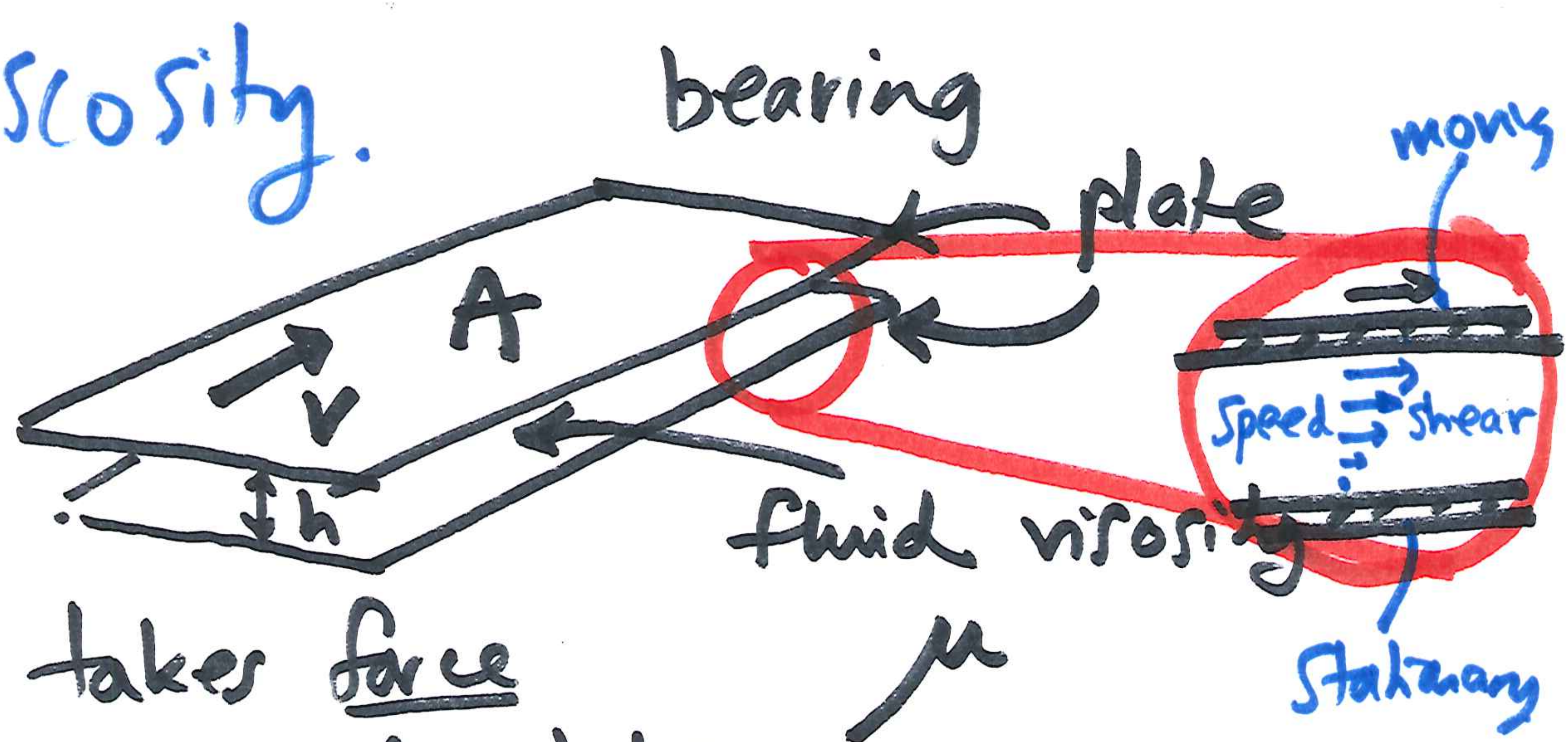
arterioles – 0.1 mm

$\Big\}$ blood pressure from heart.

Capillaries – 3 μm) diffusion

"random"

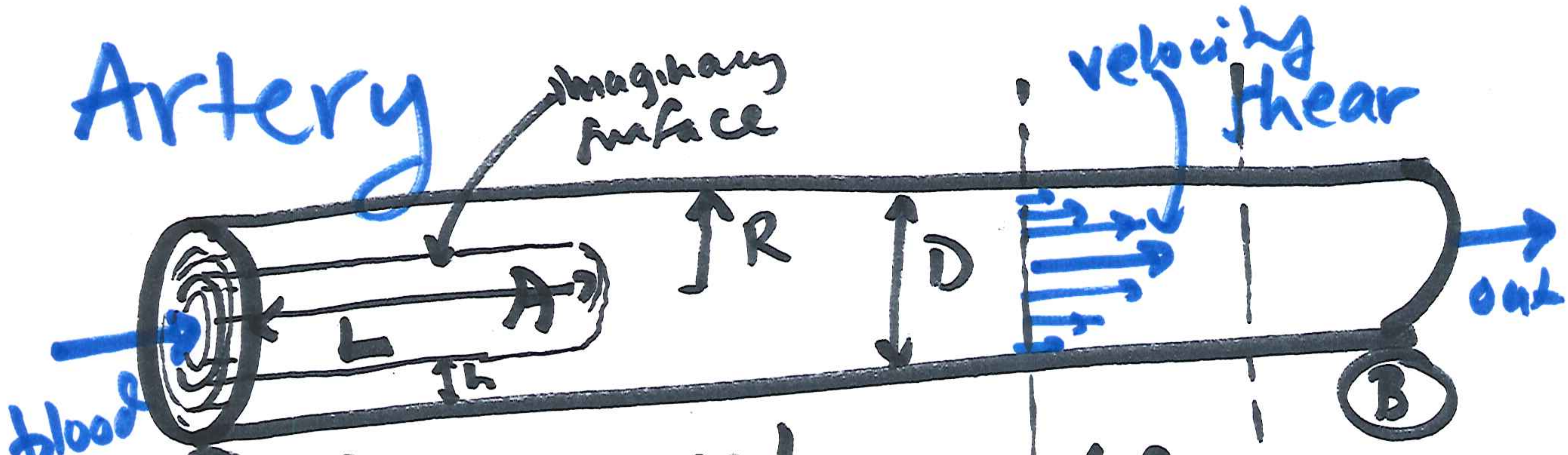
Viscosity.



it takes force to move the plate:

$$\boxed{F = \mu \cdot A \cdot \frac{v}{h}}$$

definition of viscosity



flow: $Q = \frac{\text{volume}}{\text{time}} =$

mean $V = \frac{Q}{\pi R^2}$

$$F = \cancel{\mu A \frac{V}{h}} \approx \overbrace{\mu \frac{L\, 2\pi \cancel{R}\, v}{\cancel{R}}}^{\text{good enough.}}$$

$$\Delta P_{AB} \text{ pressure difference} = \frac{F}{A} = \mu \frac{L\, 2\cancel{\pi}\, v}{\cancel{\pi} R^2}$$

Viscosity

$$\boxed{\mu \text{ or } \eta \quad \text{units} \quad Pa \cdot s = \frac{N \cdot s}{m^2}}$$

(kinematic viscosity ν

$$\nu = \frac{\mu}{\rho} = \frac{\cancel{kg}\, m}{s^{\cancel{2}}} \frac{\cancel{s}}{\cancel{m^2}} \cdot \frac{m^{\cancel{3}}}{\cancel{kg}}$$

$$= \frac{m^2}{s})$$

- density of blood: $1000 \frac{kg}{m^3}$

- viscosity of blood $\mu = 4 \times 10^{-3}\ Pa \cdot s$

Blood flow in artery:

$$V = \frac{Q}{\pi R^2}$$

Q — volumetric rate $\frac{m^3}{s}$

πR^2 — x-sectional area

$$\Delta P \approx \mu \frac{2LV}{R^2}$$

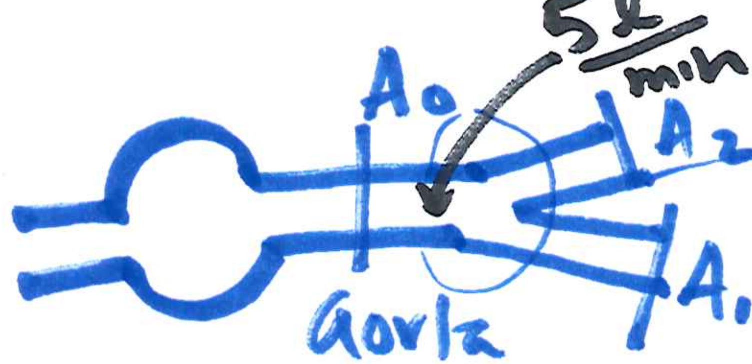
ΔP — pressure difference from end to end

L — length of artery

R — radius of artery.

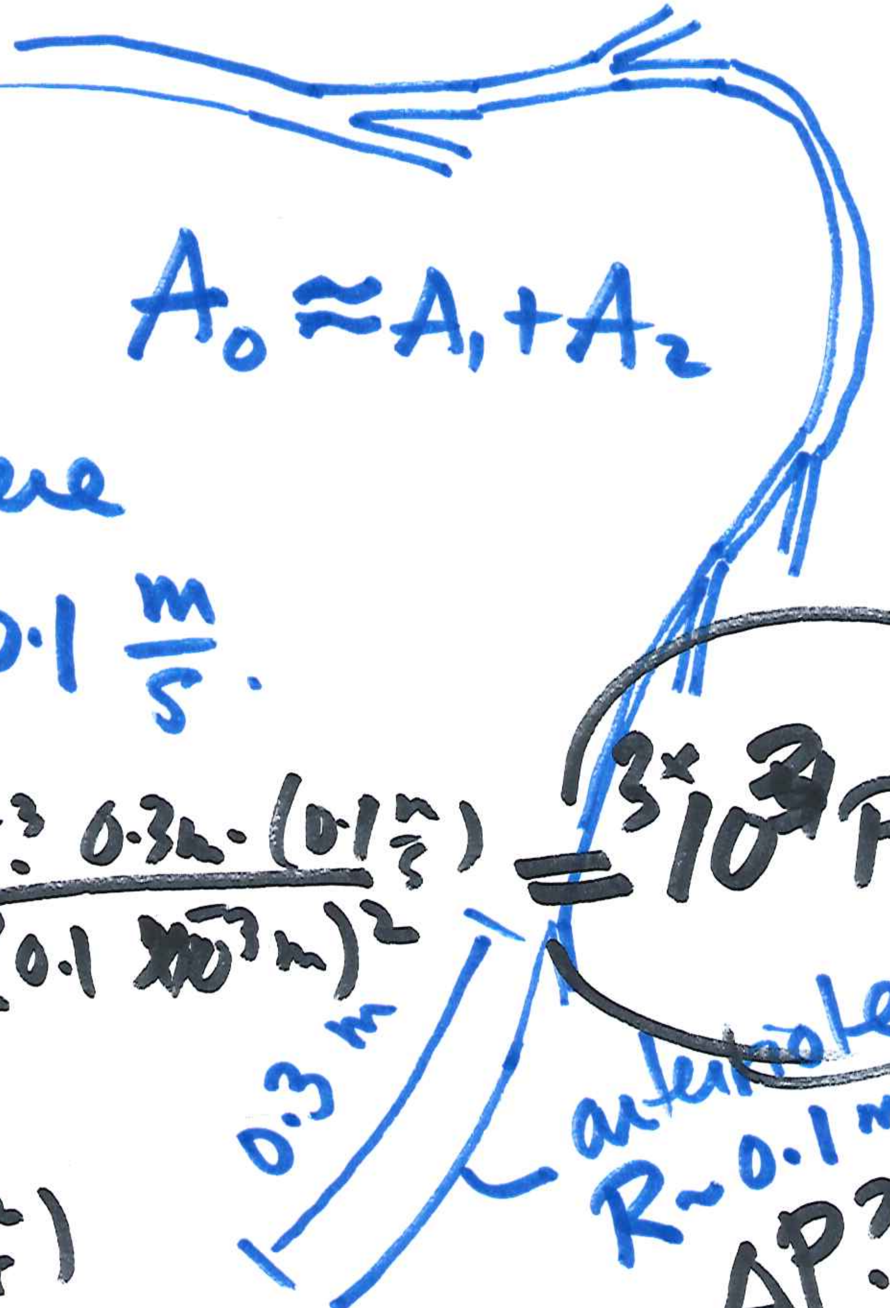
$$\Delta P \approx \mu \frac{2LQ}{\pi R^4}$$

$2 = 8$!



$A_0 \approx A_1 + A_2$

V everywhere is $\sim 0.1 \frac{m}{s}$.



$$\Delta P \sim \mu \cdot \frac{2LV}{R^2} = \frac{8\times 10^{-3} \cdot 0.3\,m \cdot (0.1\frac{m}{s})}{(0.1\times 10^{-3}\,m)^2} = 3\times 10^{3}\,Pa$$

$$Q \sim \pi R^2 V$$

$$3(0.1\times 10^{-3}\,m)^2 \cdot (0.1\,\frac{m}{s})$$

$$= 3\times 10^{-9}\,\frac{m^3}{s}\ \ \mu l/s$$