Fig. 4.1: Pressure and stress

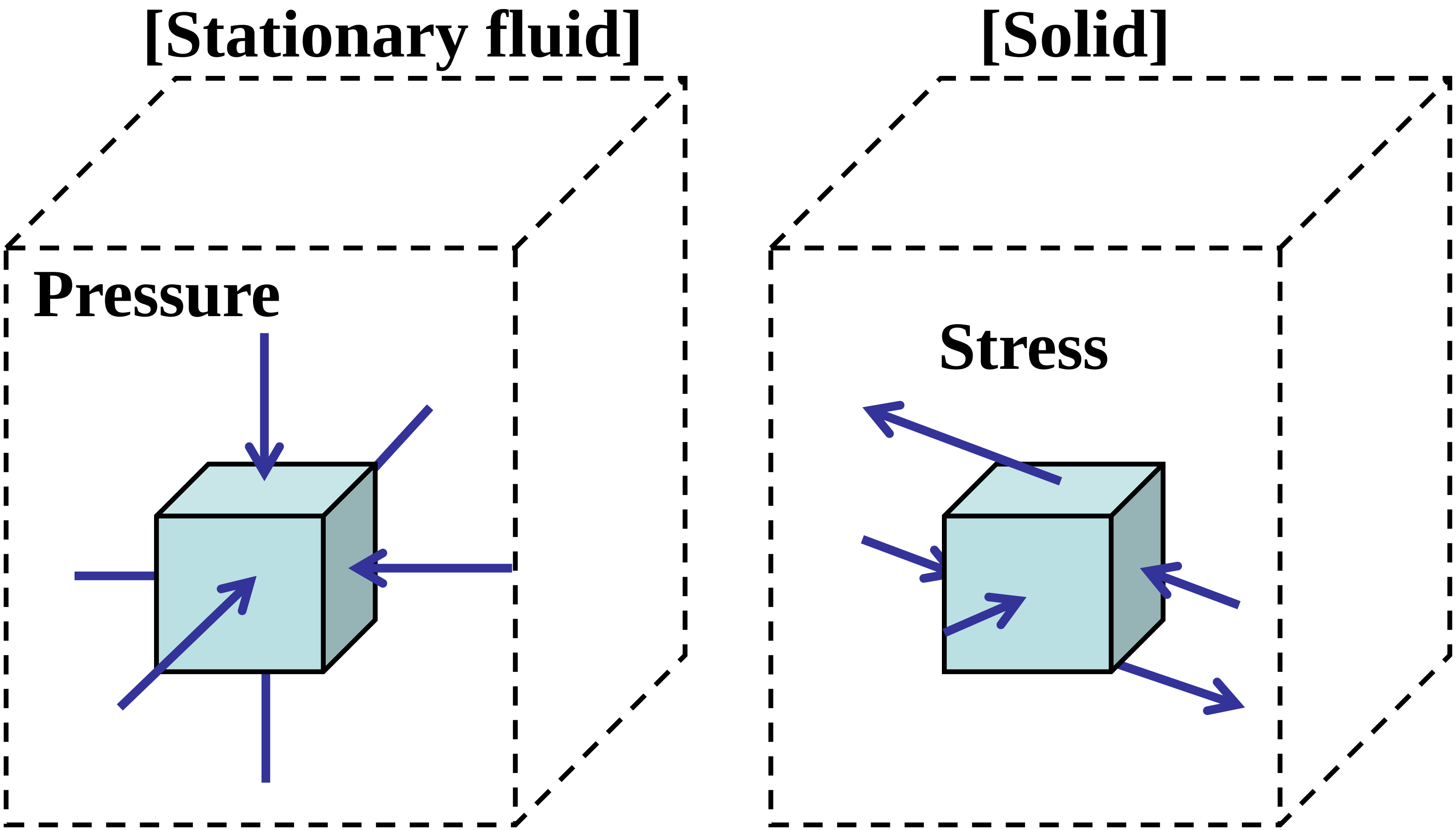


Fig. 4.2: Telemetry of pressure by the communicating tube

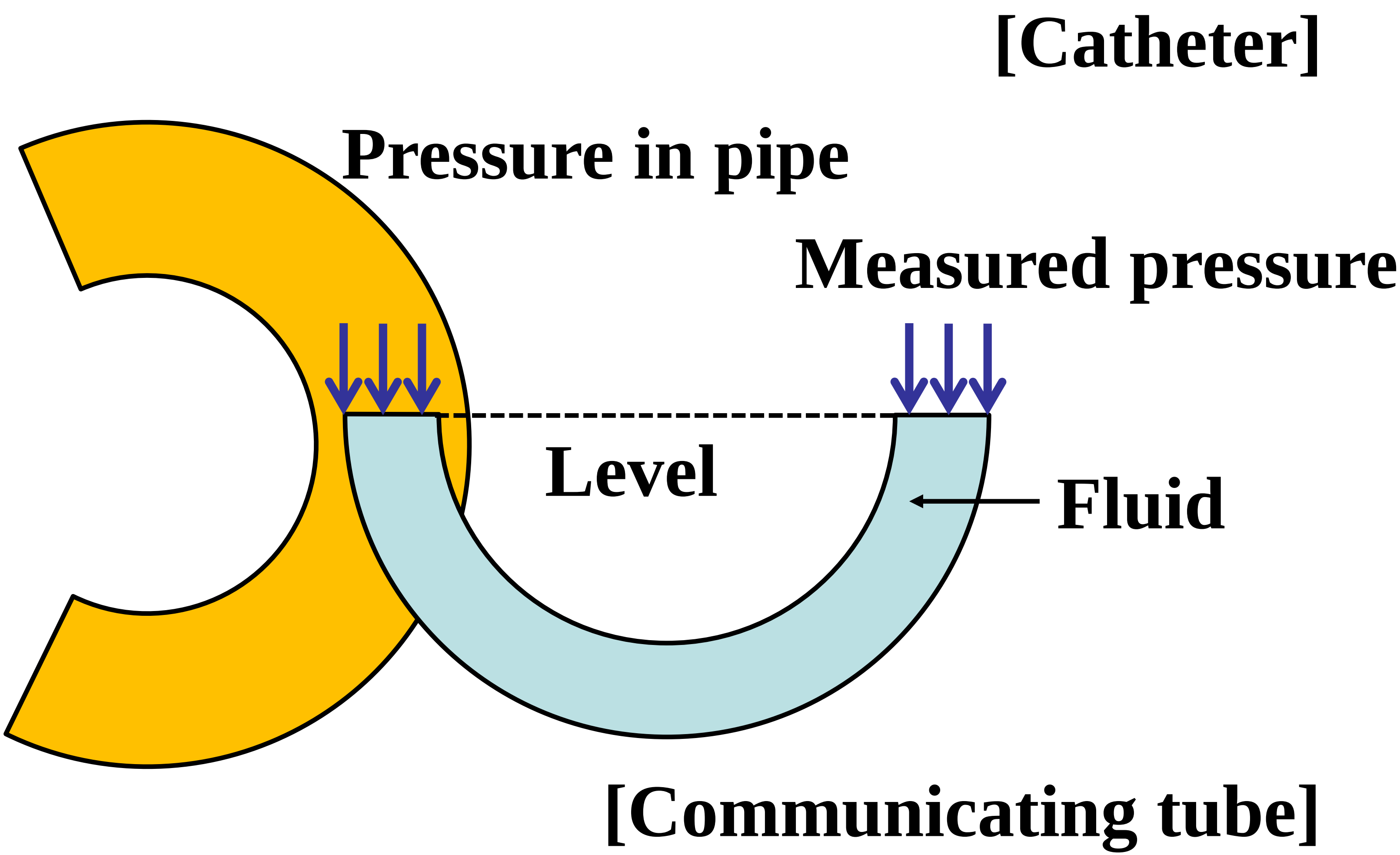
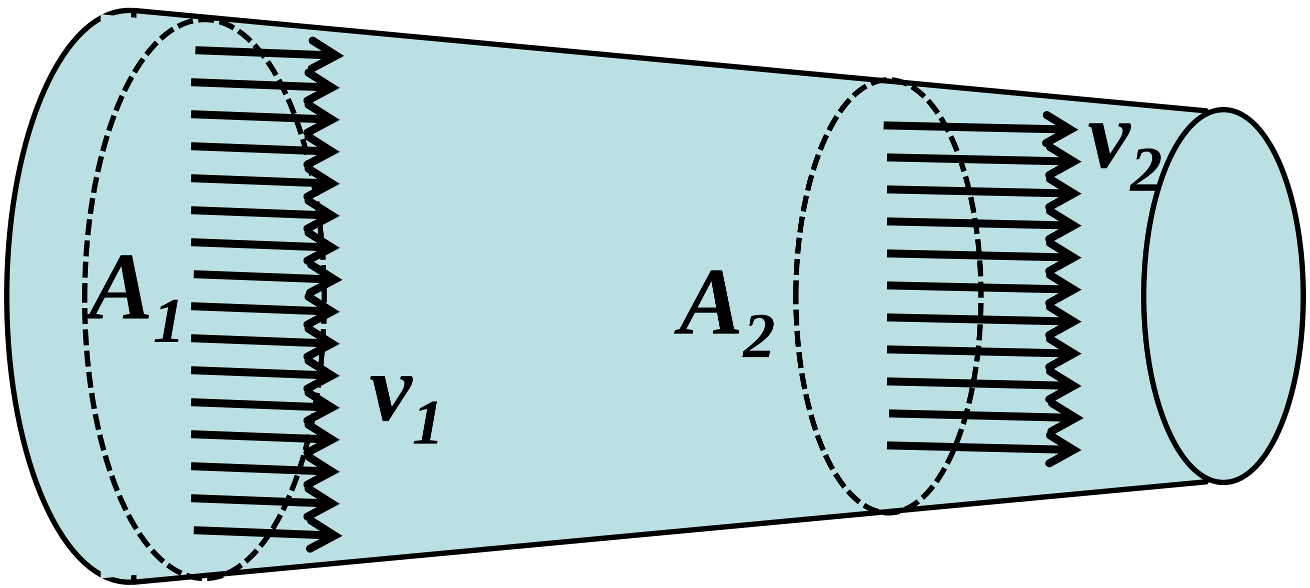
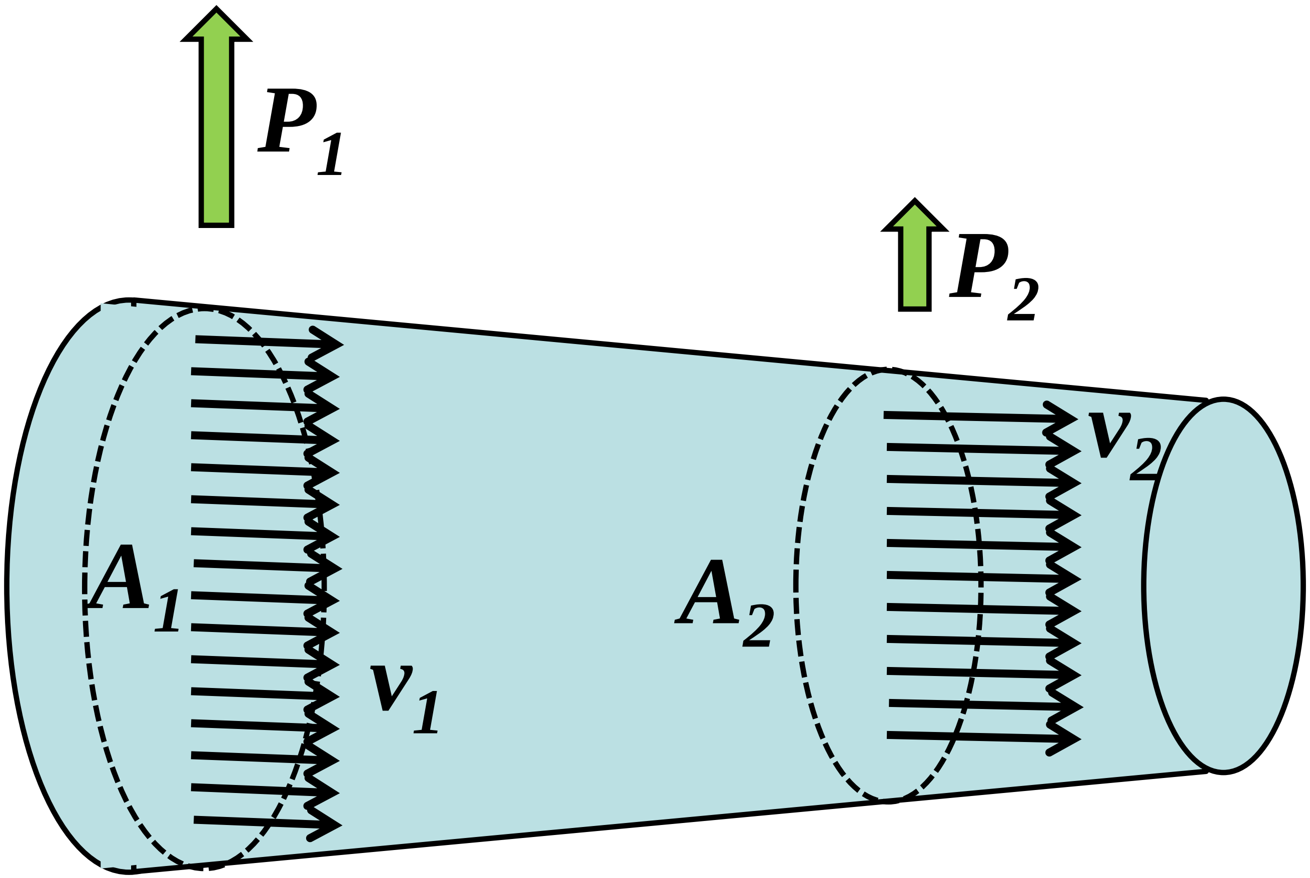


Fig. 4.3: Continuity



Density
Compressibility
Incompressible fluid
Law of conservation of mass

Fig. 4.4: Expression of Bernoulli



$$(1/2)\rho v^{2} + p = \text{constant} \qquad (4.2)$$

Fig. 4.5: Head drop

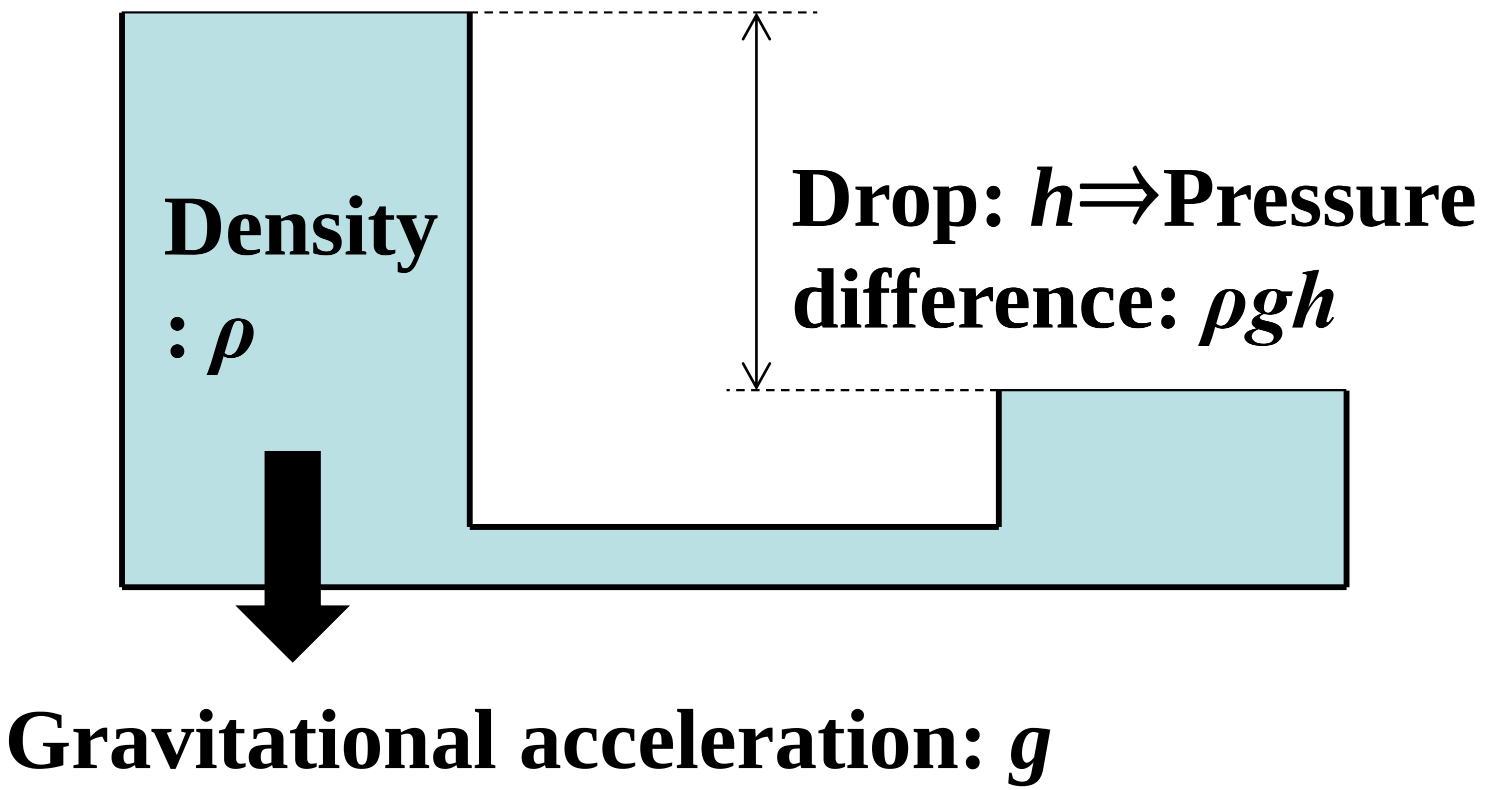


Fig. 4.6: Shunt

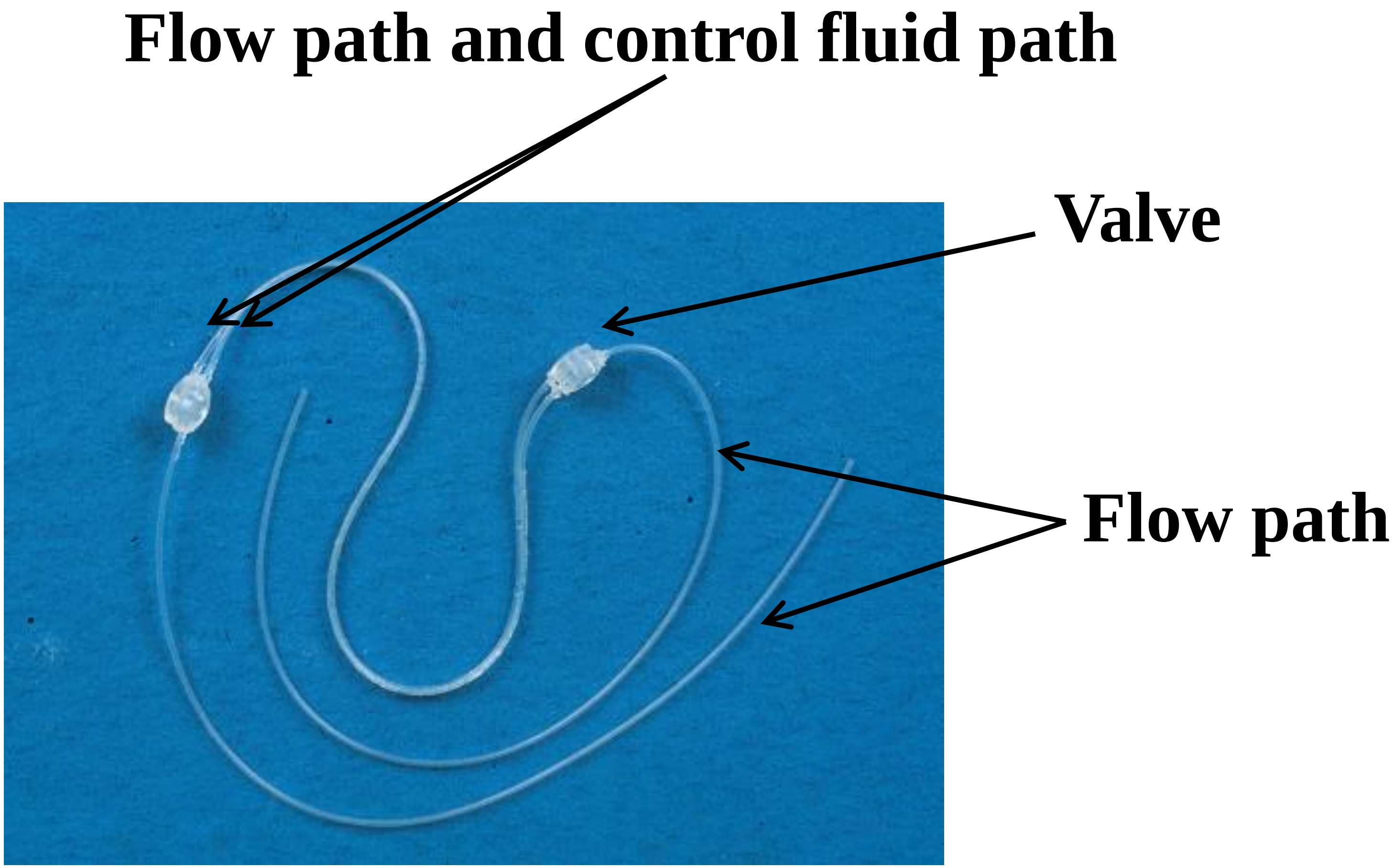
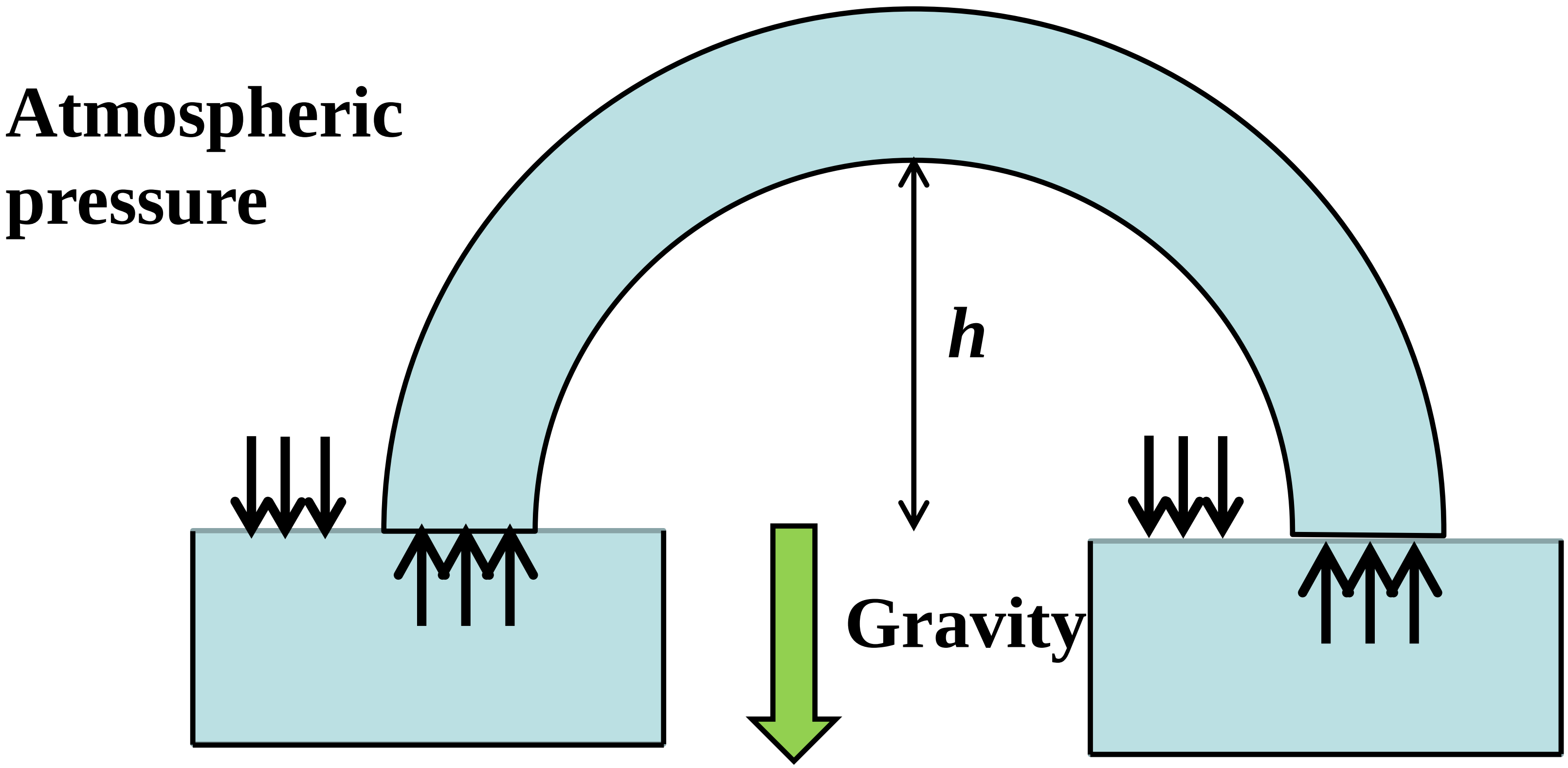


Fig. 4.7: Principle of siphon



$$1.0 \times 10^3\ \mathrm{kg\ m^{-3}} \times 9.8\ \mathrm{m\ s^{-2}} \times 10\ \mathrm{m} = 98\ \mathrm{kPa} \qquad (4.4)$$

$$101.325\ \mathrm{kPa} - 98\ \mathrm{kPa} = 3.325\ \mathrm{kPa} \qquad (4.5)$$

Fig. 4.8: Collapse

(a) Vein collapse (b) Blood removal cannula

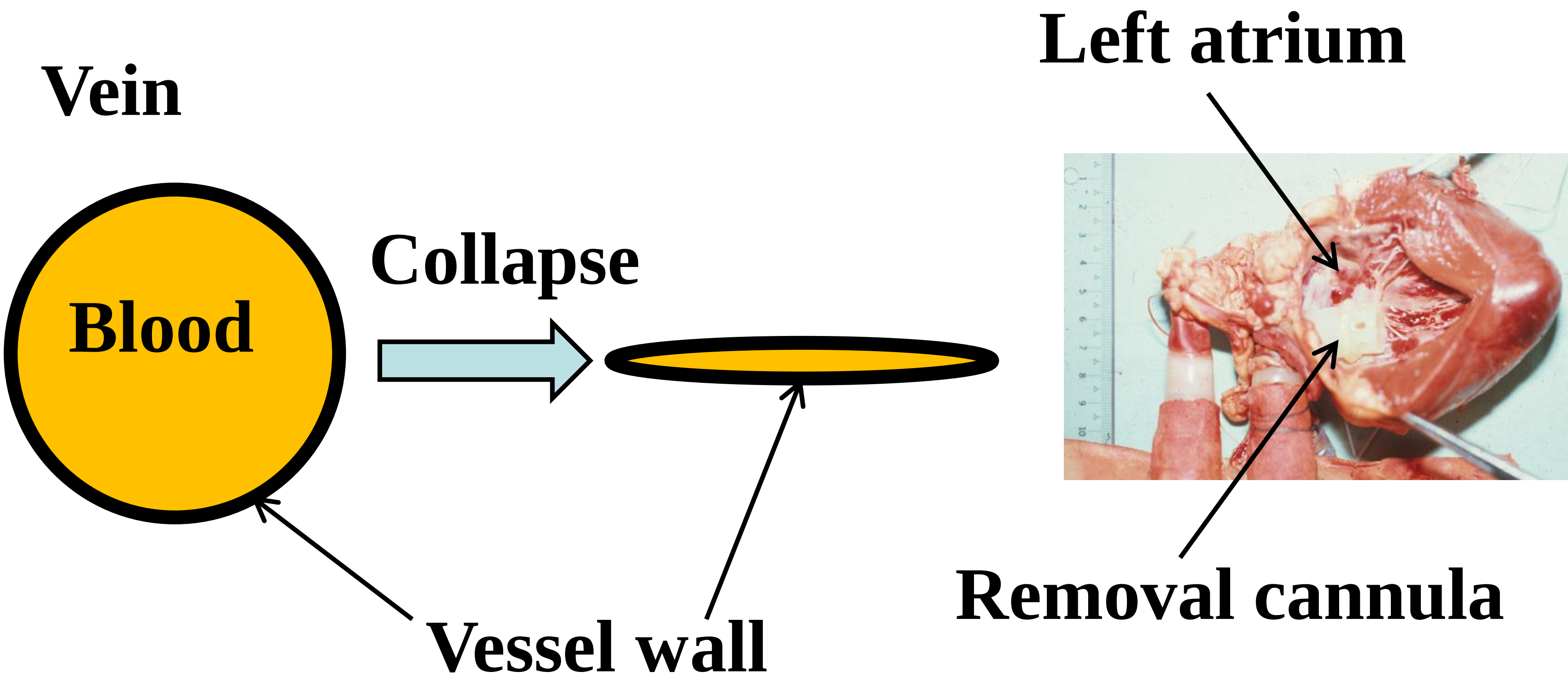


Fig. 4.9: Hook elastic body

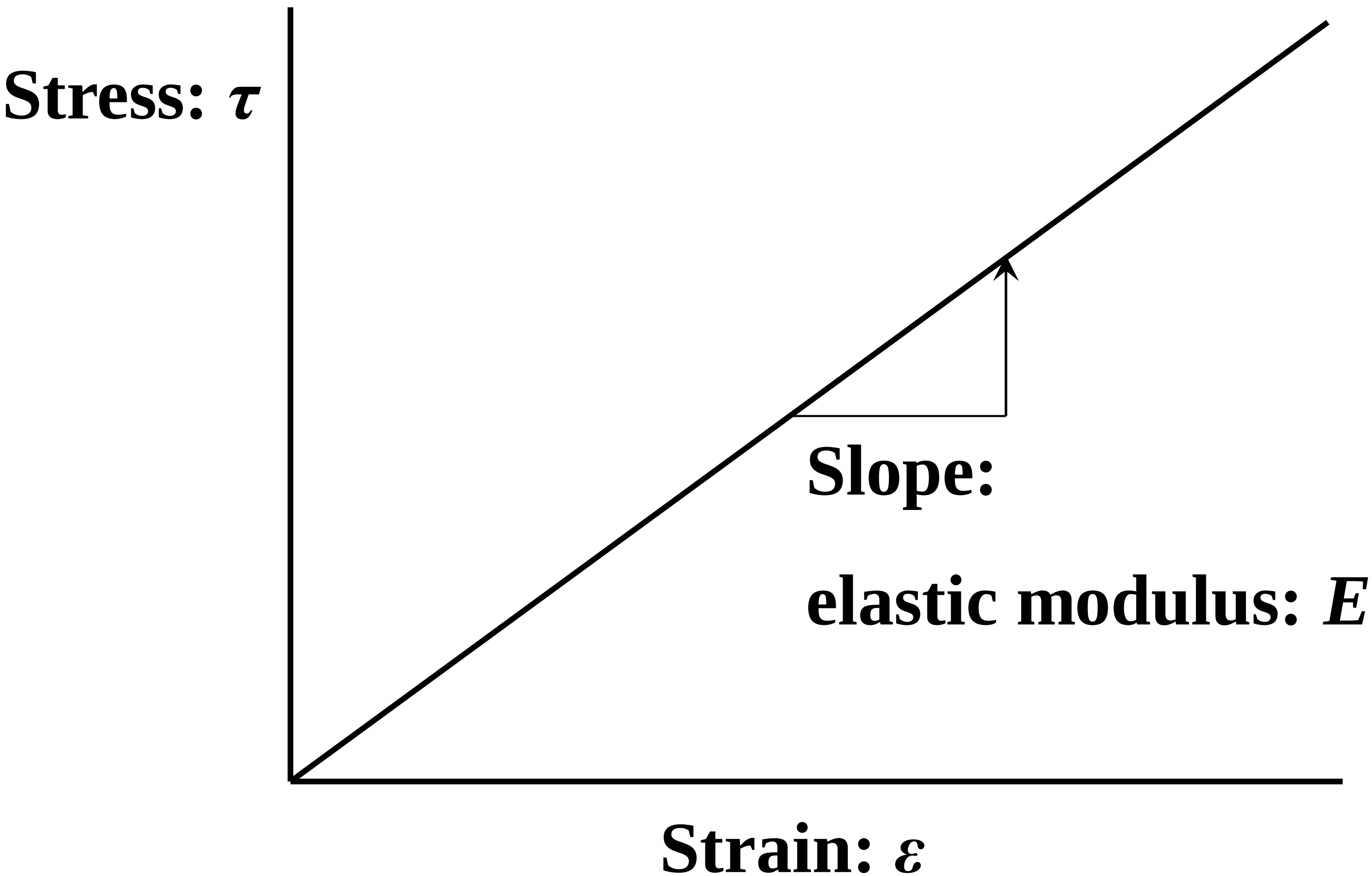
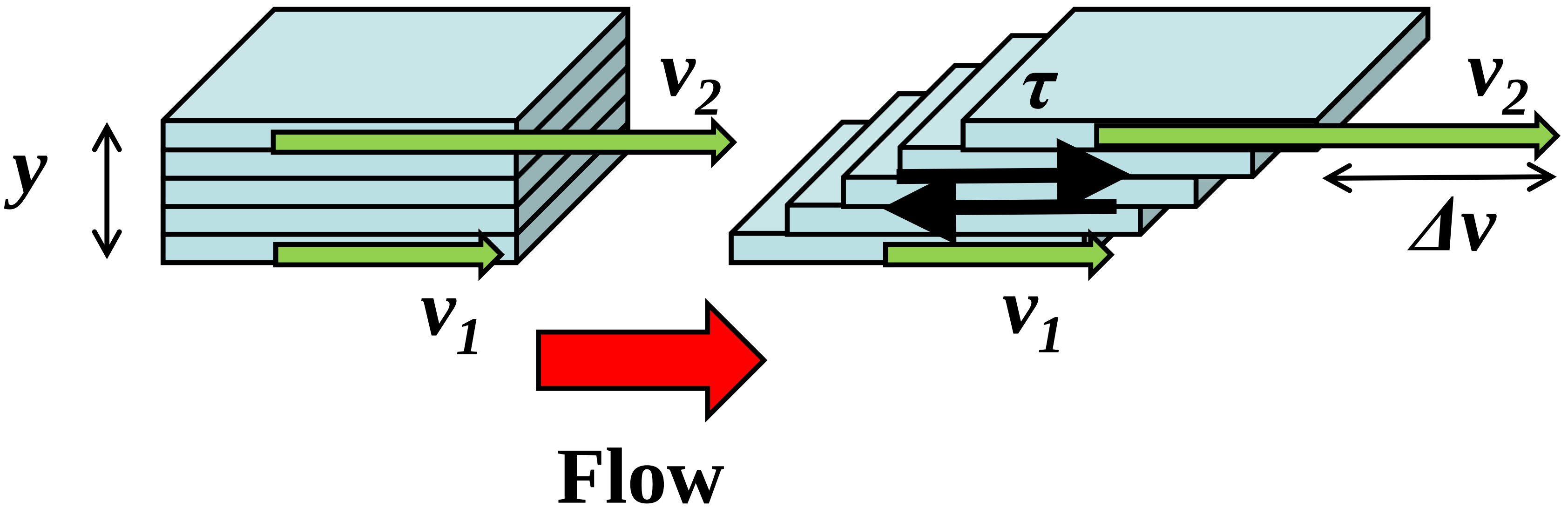
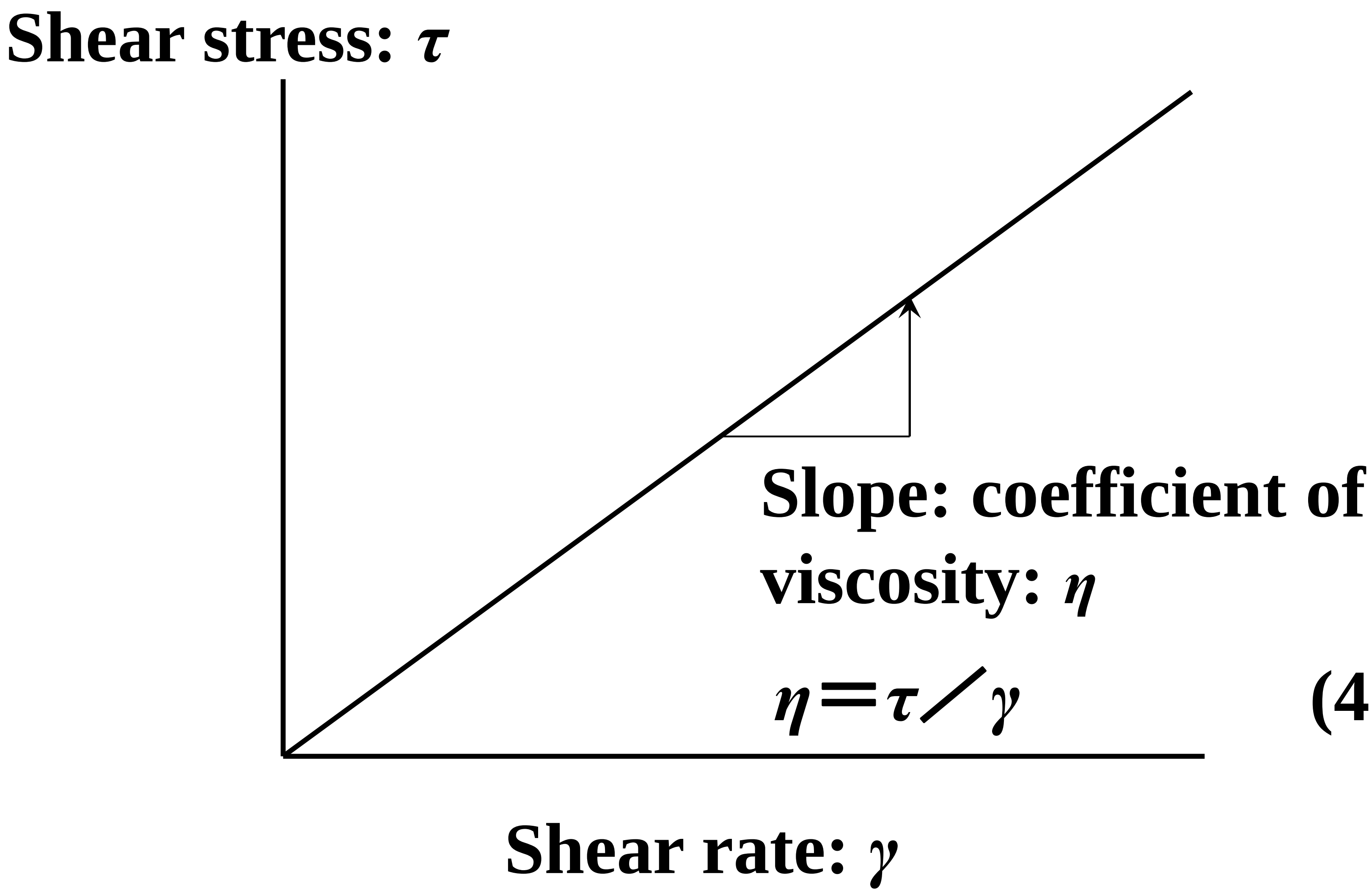


Fig. 4.10: Shear rate



$$\gamma = \Delta v / y \qquad (4.6)$$

Fig. 4.11: Newtonian fluid



$$\eta = \tau / \gamma \qquad (4.7)$$

Fig. 4.12: Viscosity with temperature

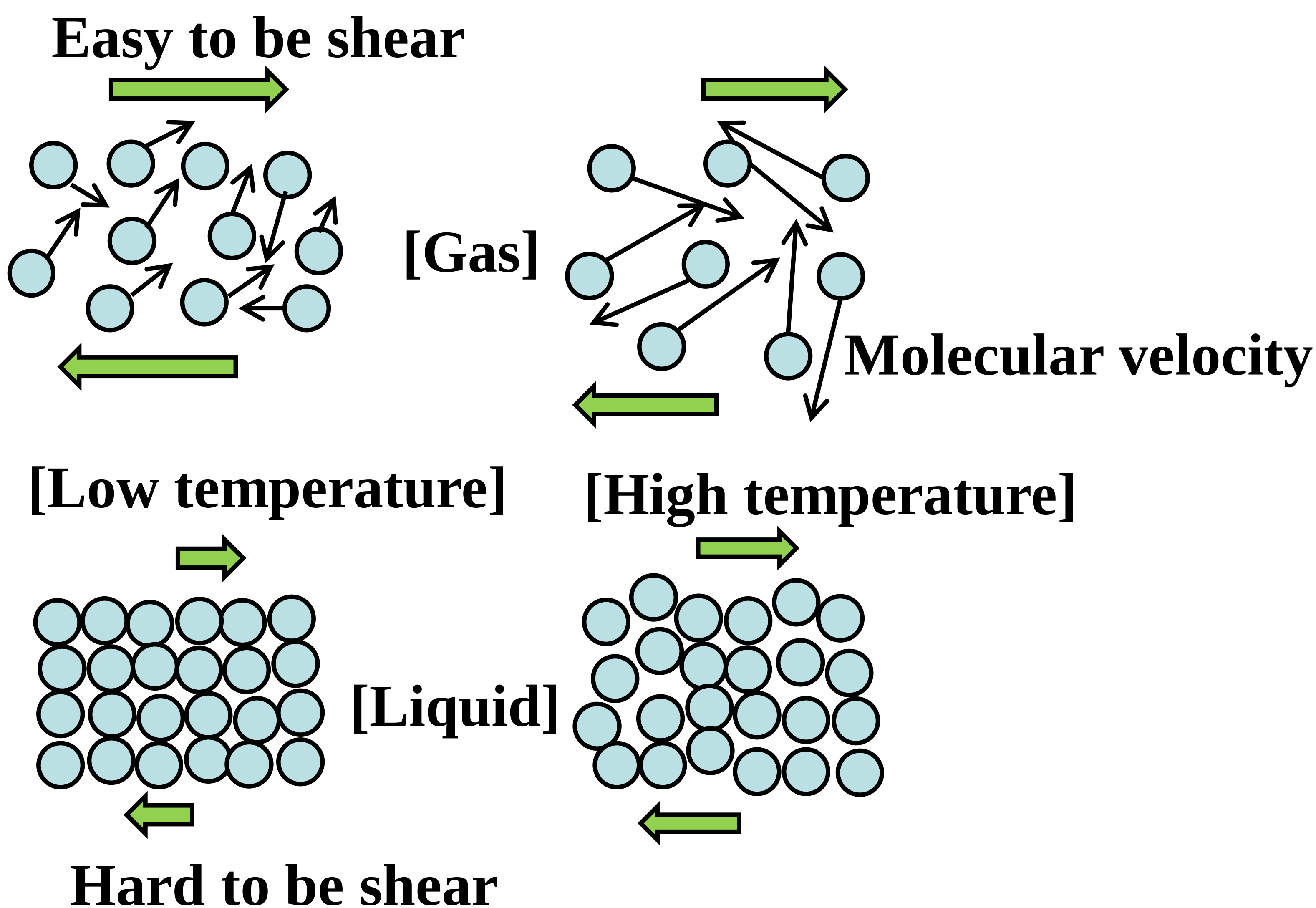


Fig. 4.13: Viscosity with shear rate

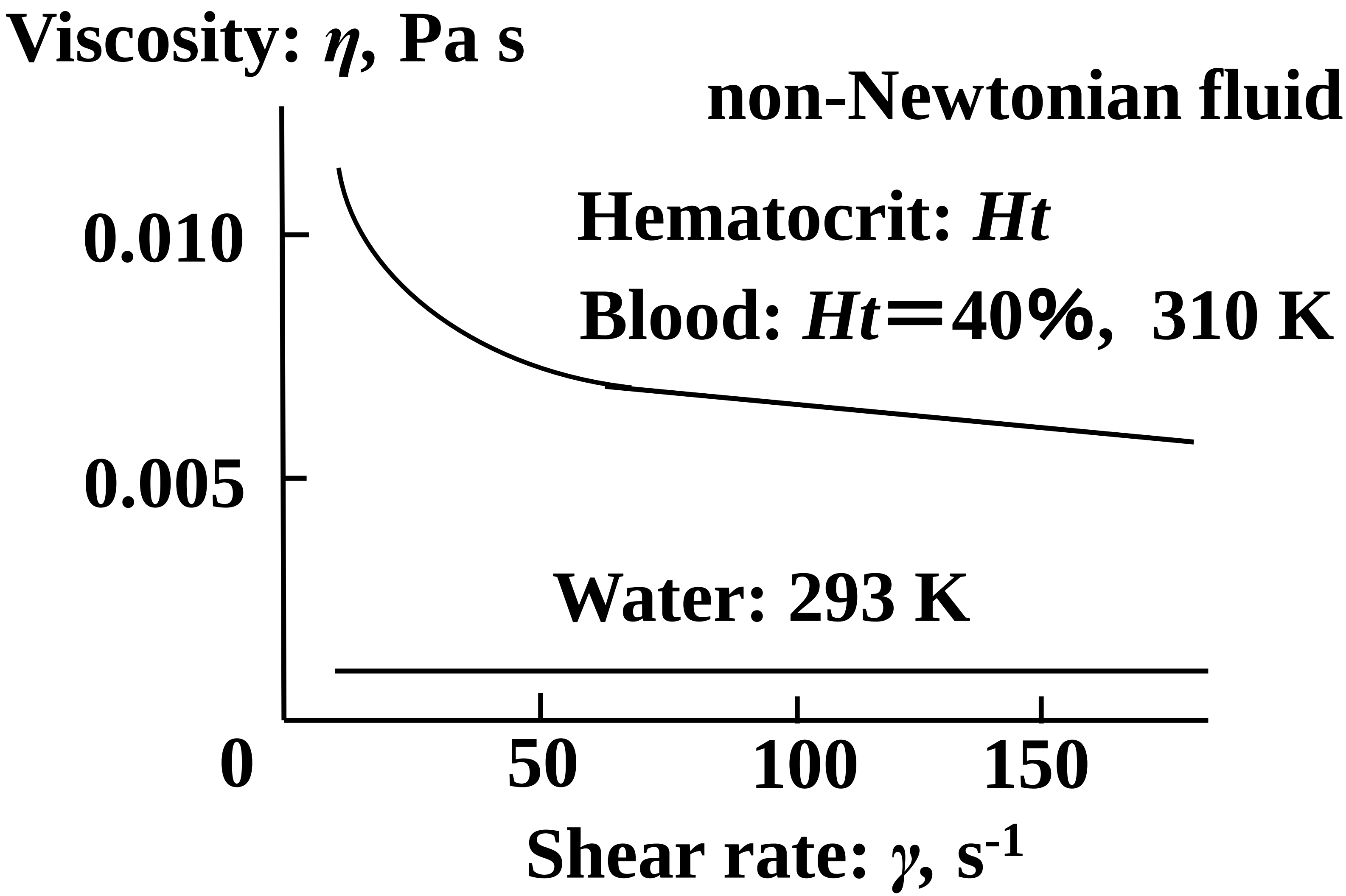


Fig. 4.14: Rouleau formation

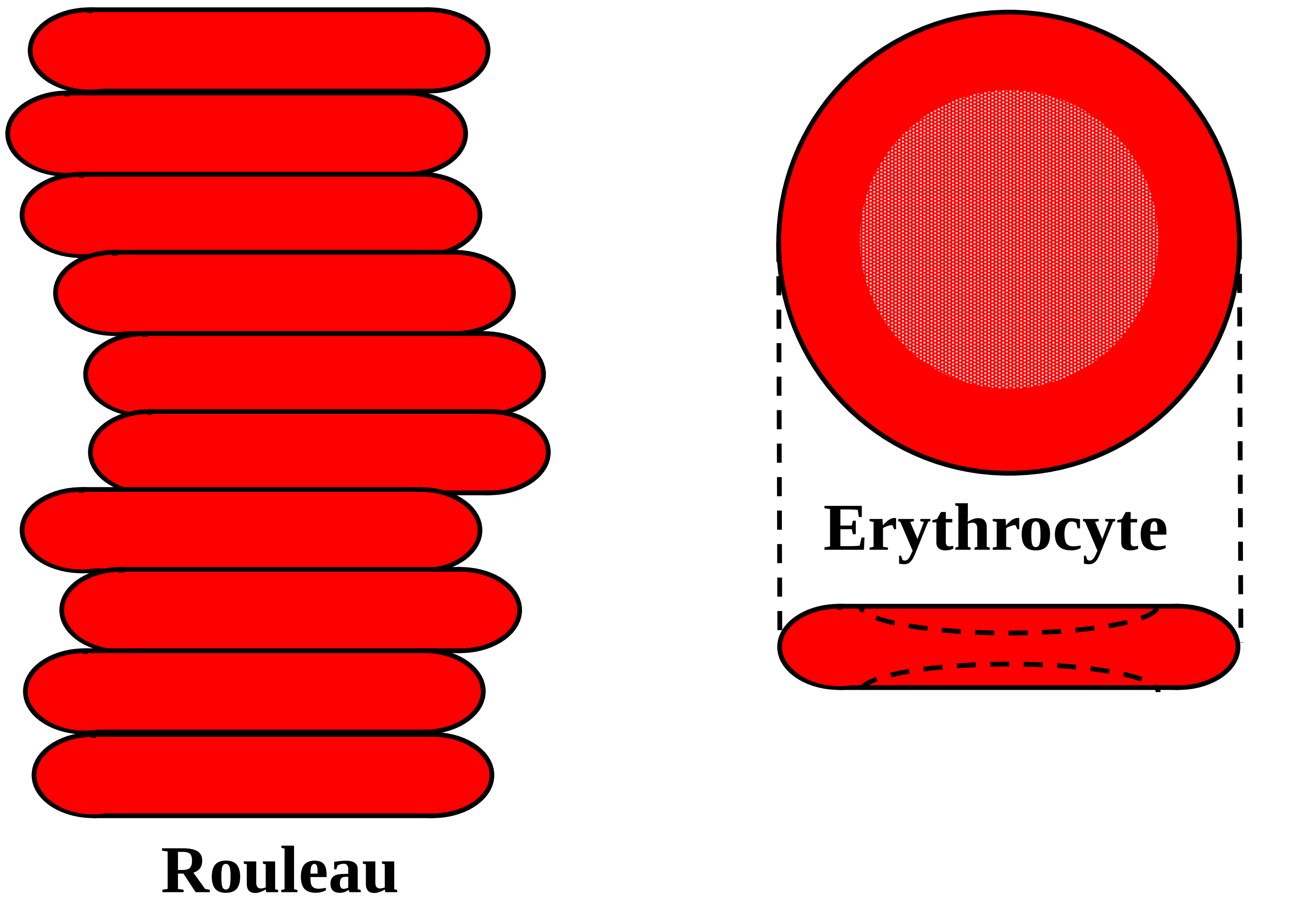


Fig. 4.15: Viscosity tracings with vibrating electrode

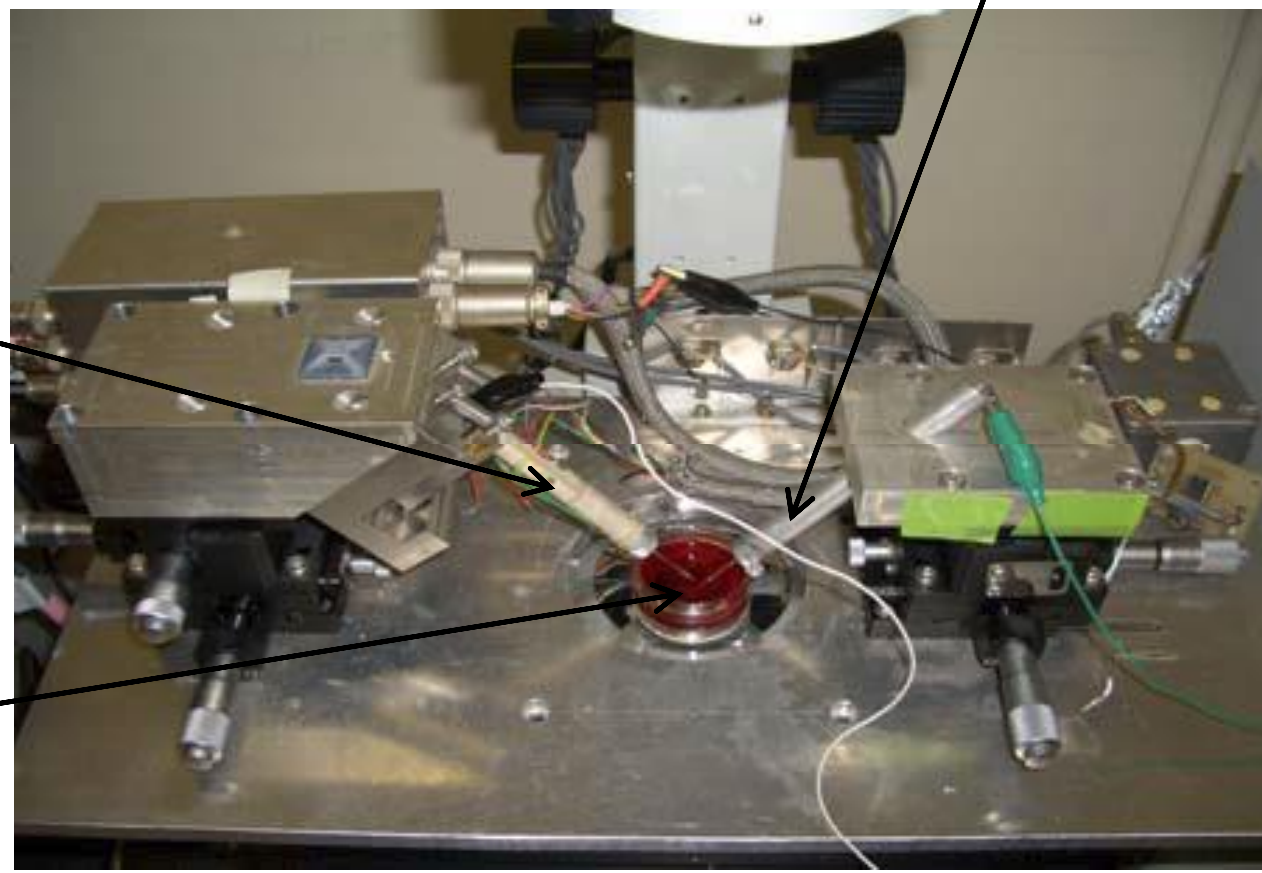


Fig. 4.16: Measurement of local viscosity with vibrating electrode

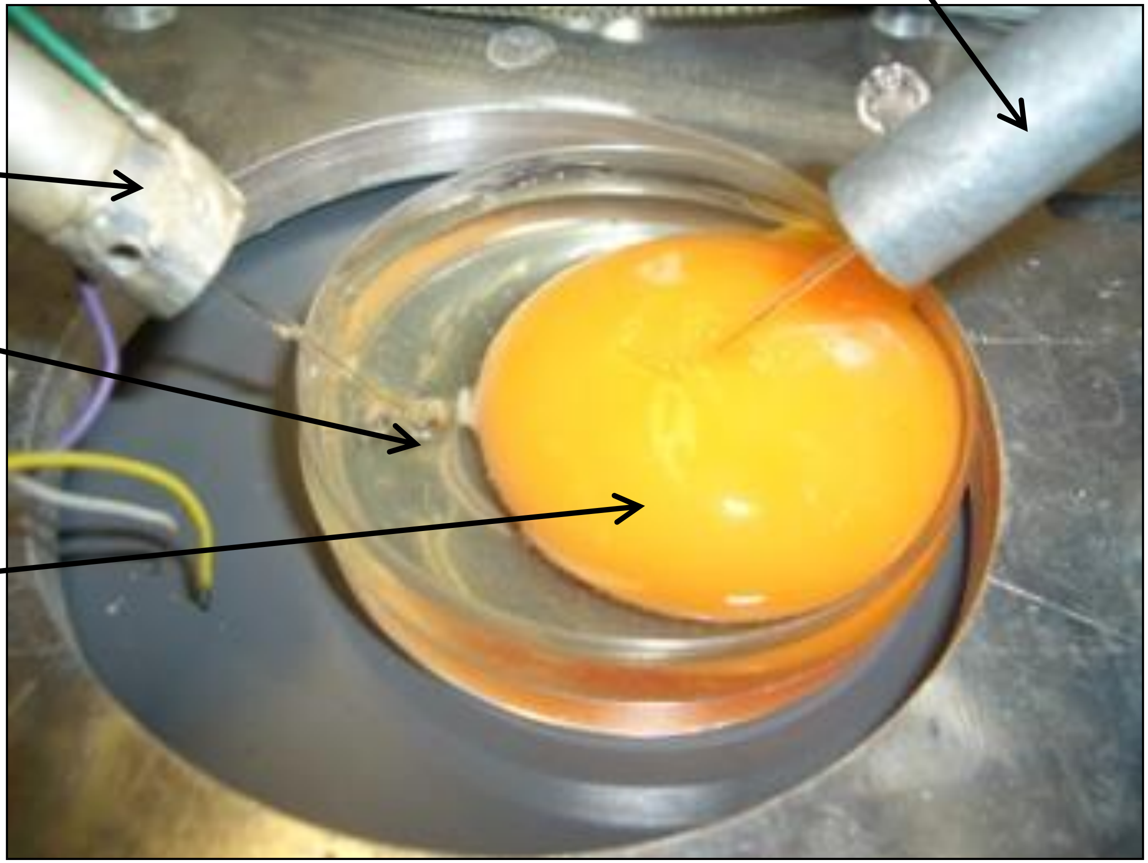


Fig. 4.17: Maxwell model

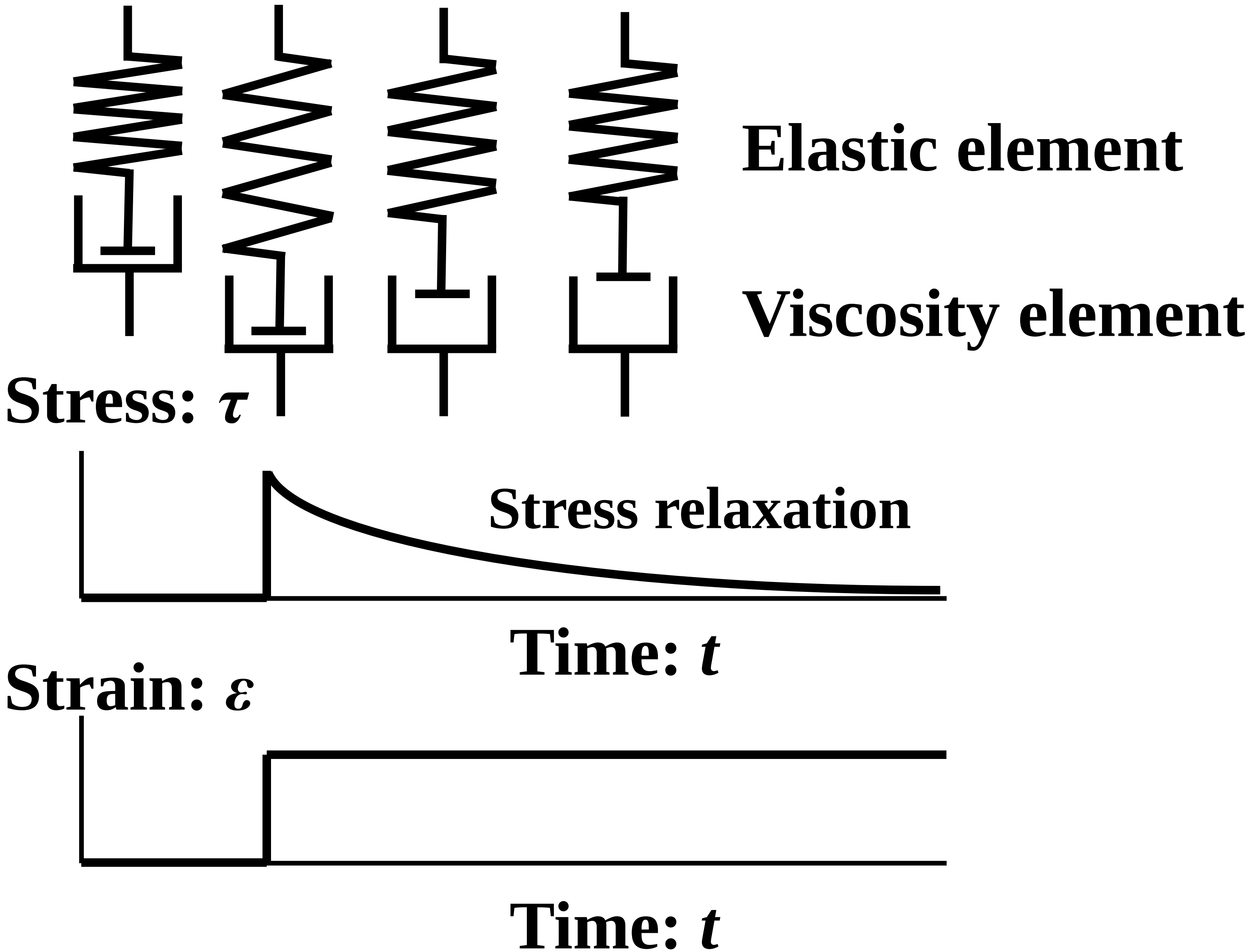


Fig. 4.18: Kelvin-Voigt model

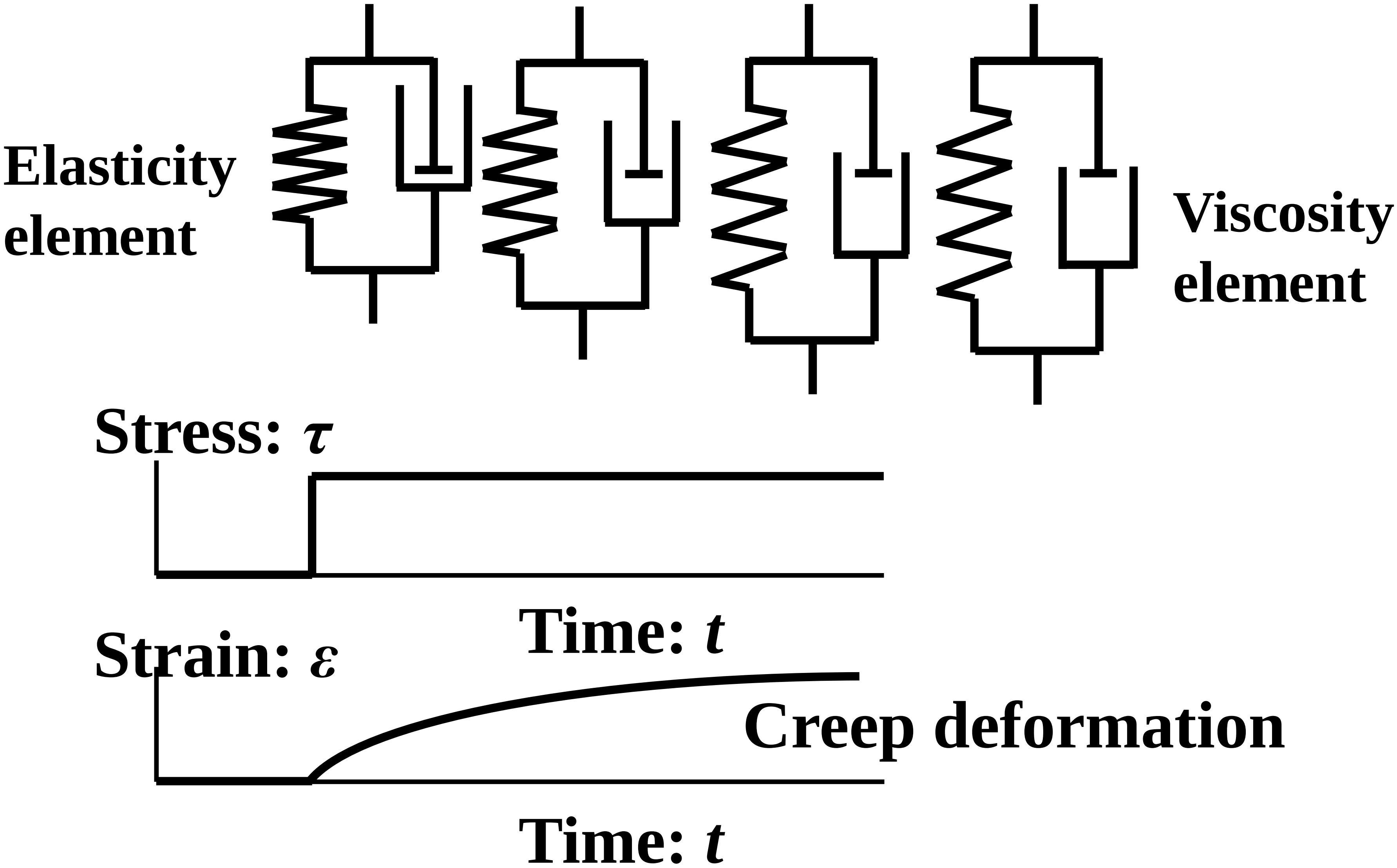


Fig. 4.19: Circulation resistance

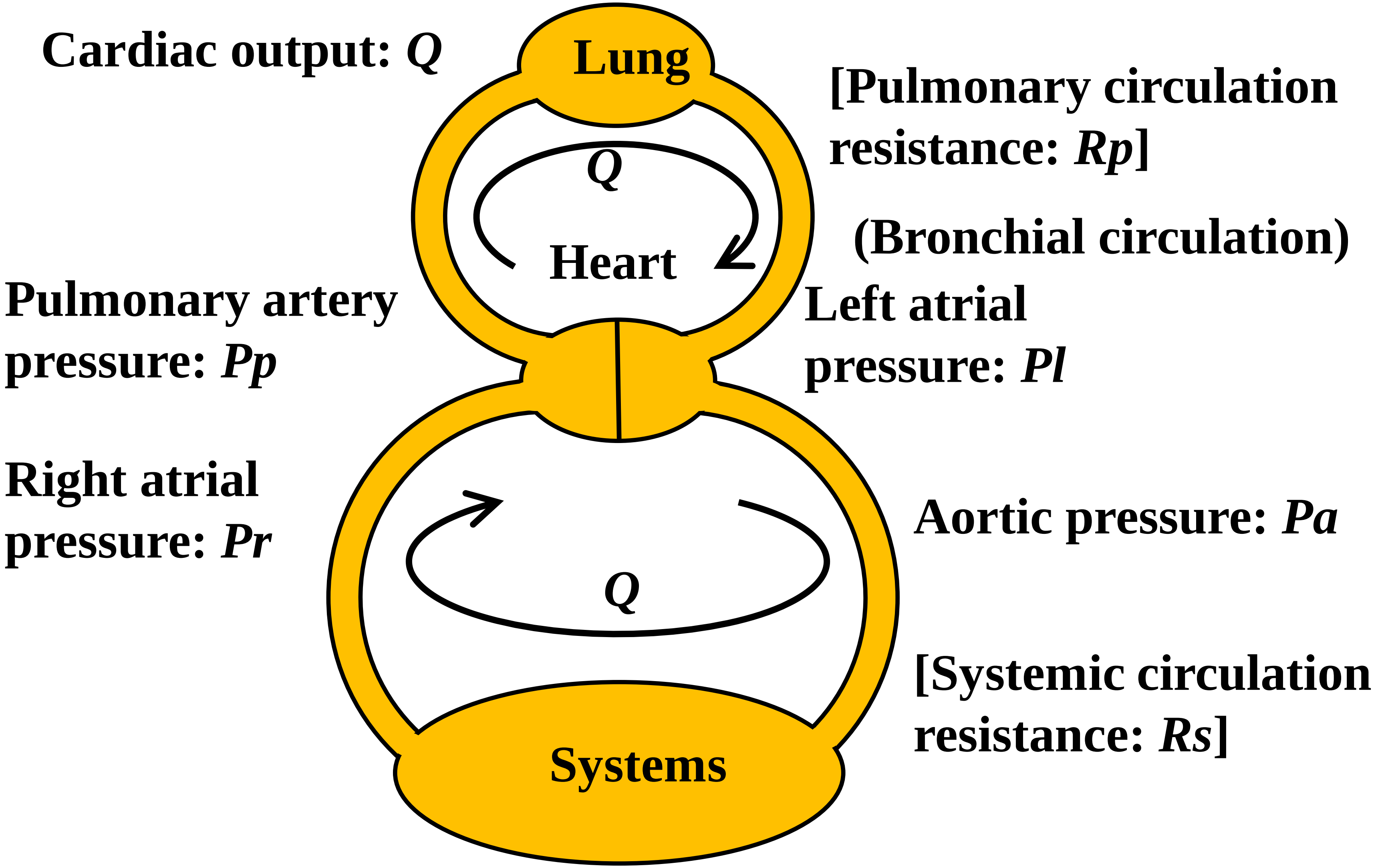
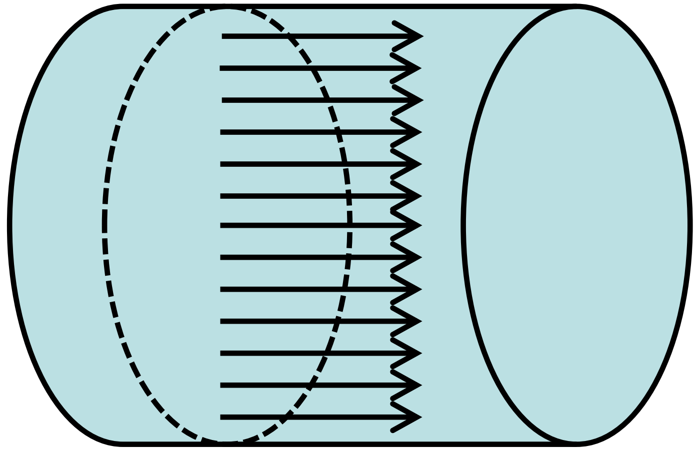
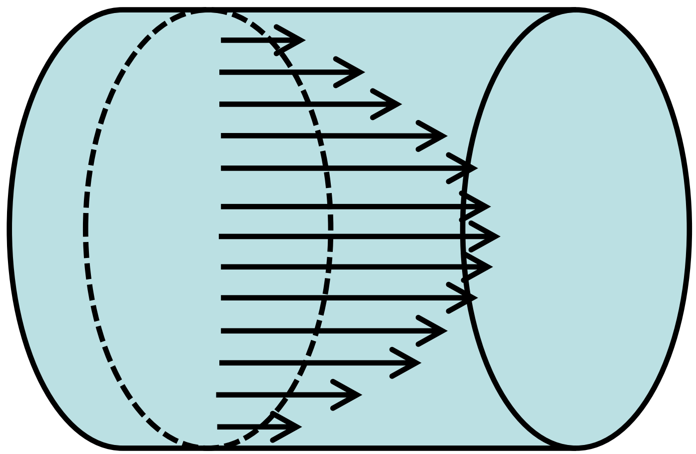


Fig. 4.20: Velocity distribution in pipe



(a) Plug flow



(b) Hagen-Poiseuille flow

Fig. 4.21: Force balance in cylinder in flow

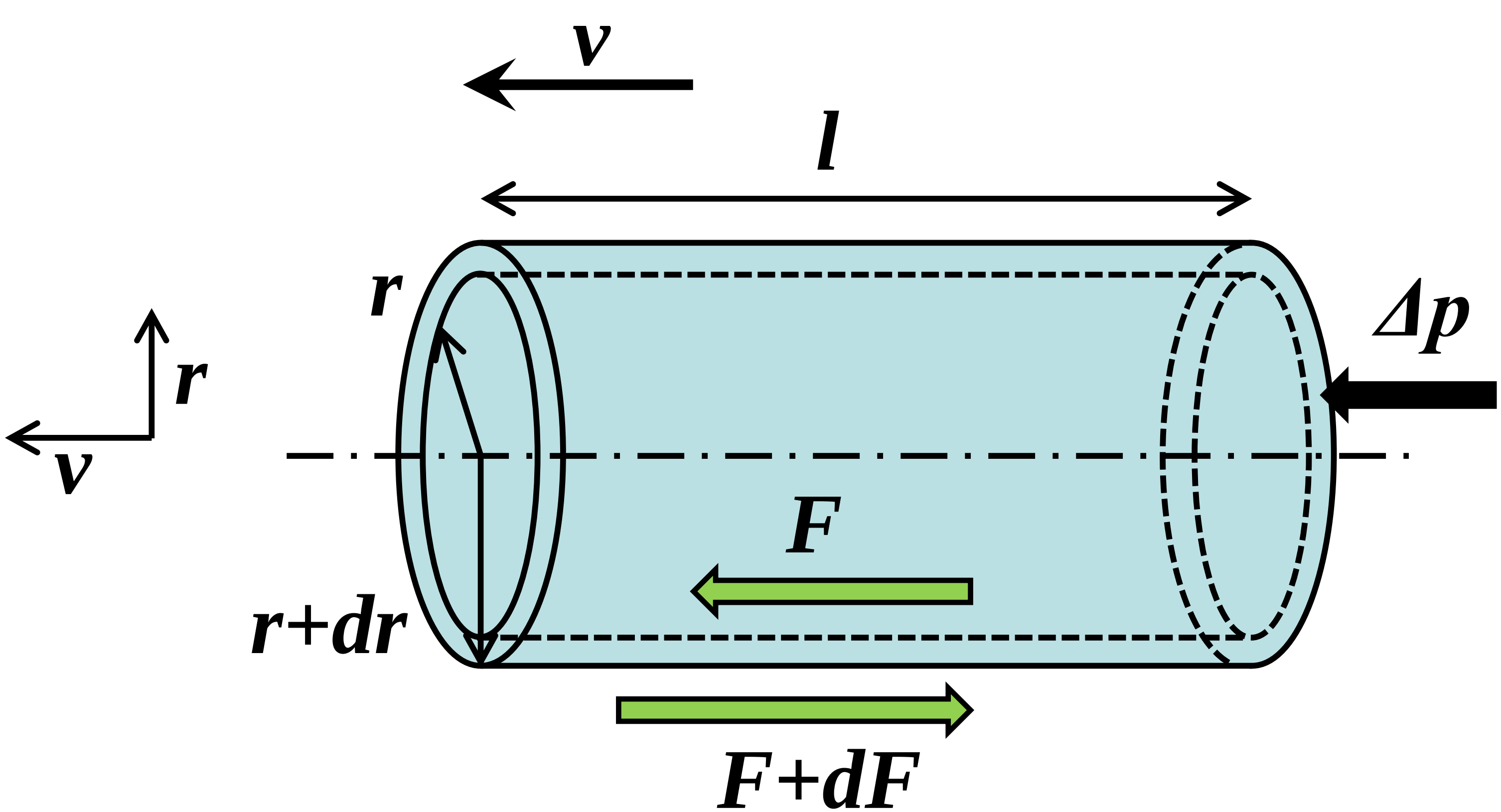


Fig. 4.22: Cylinders of fluid in flow through pipe

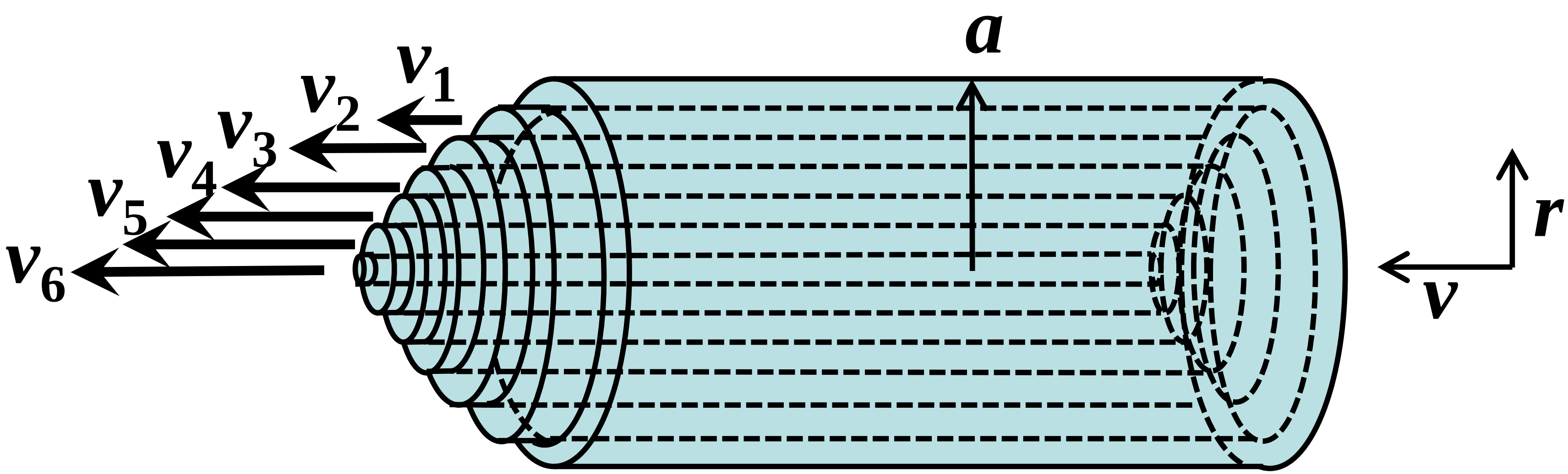


Fig. 4.23: Distribution of velocity

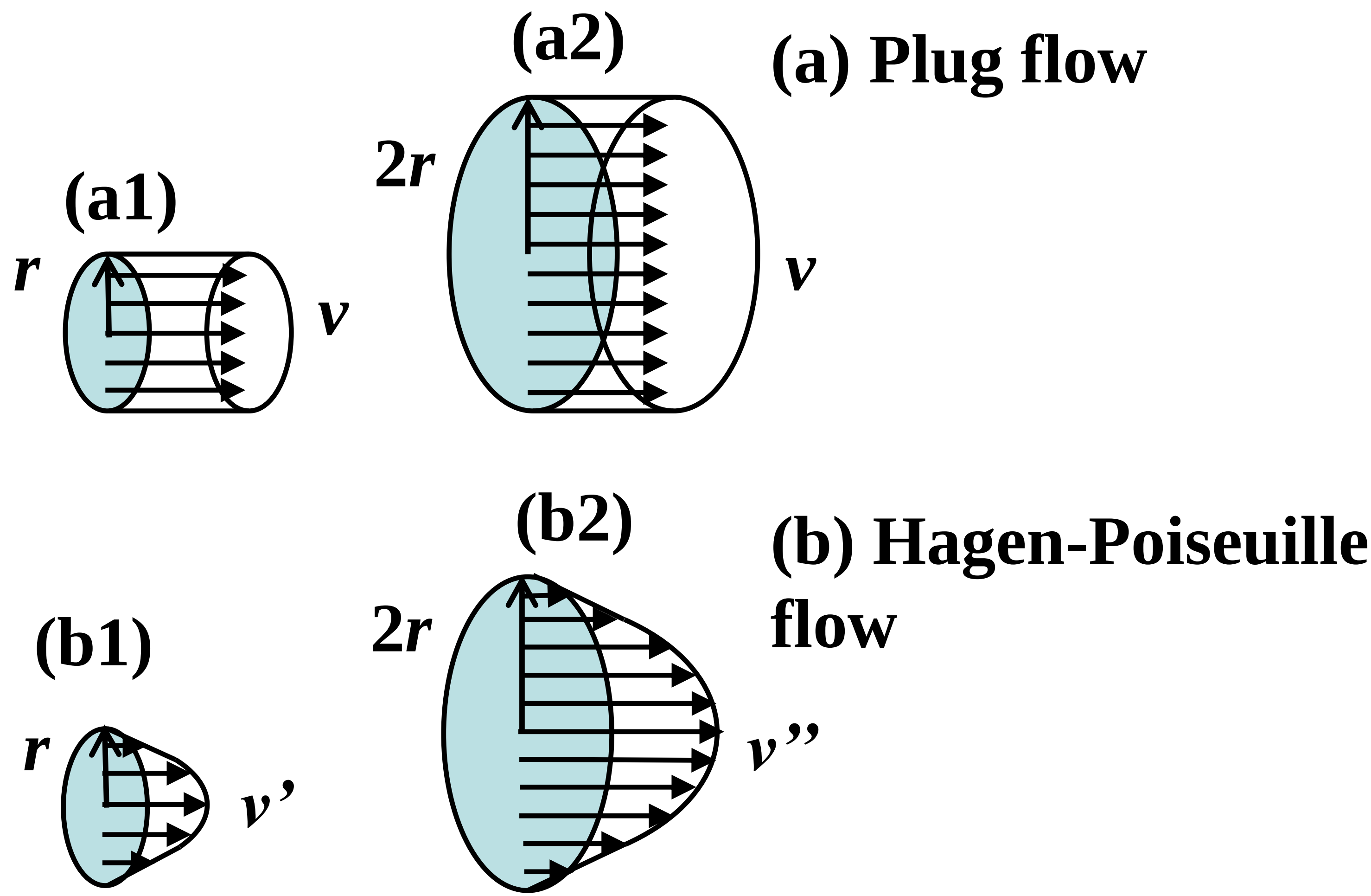


Fig. 4.24: Inlet region

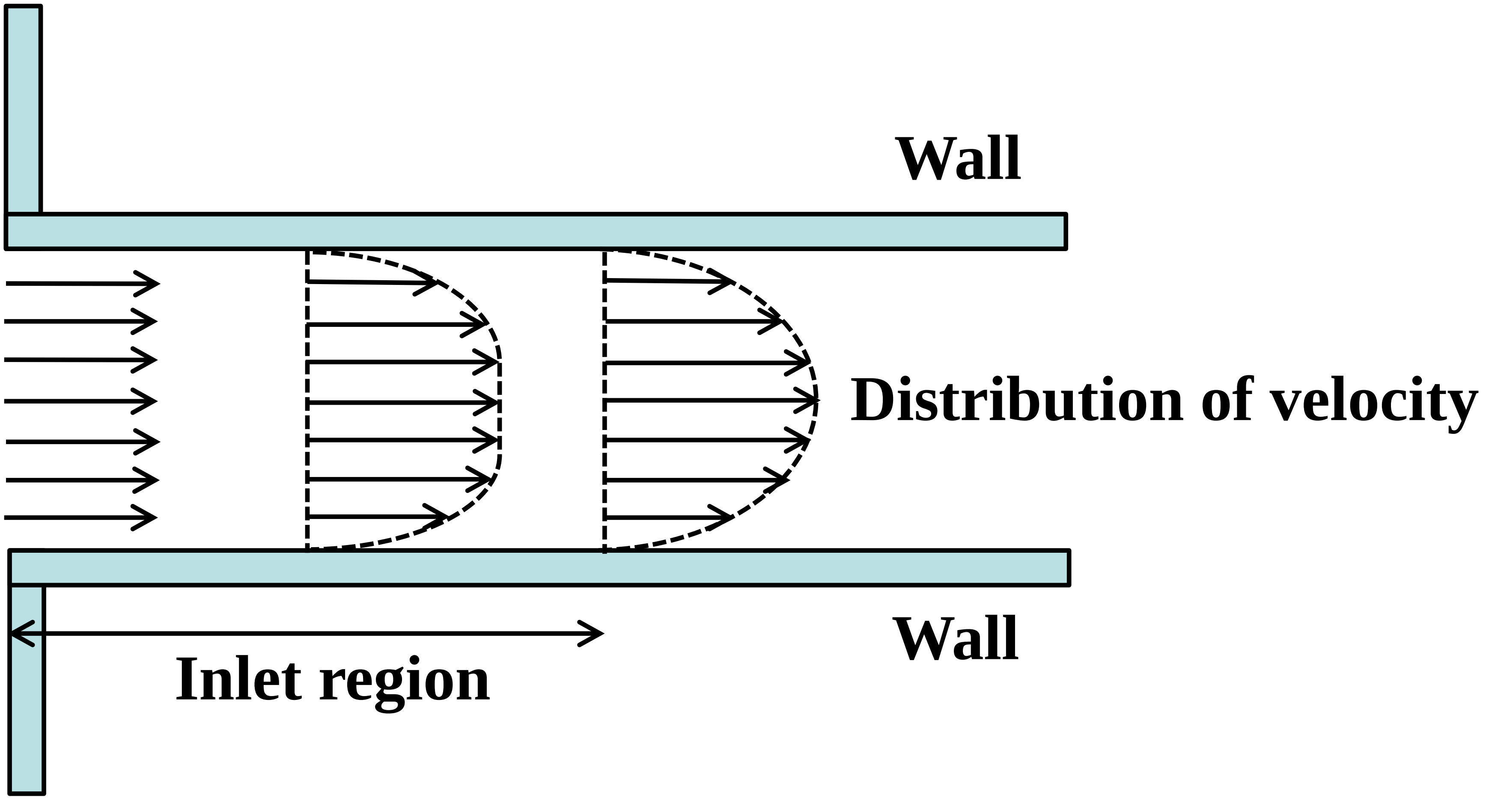


Fig. 4.25: Boundary layer

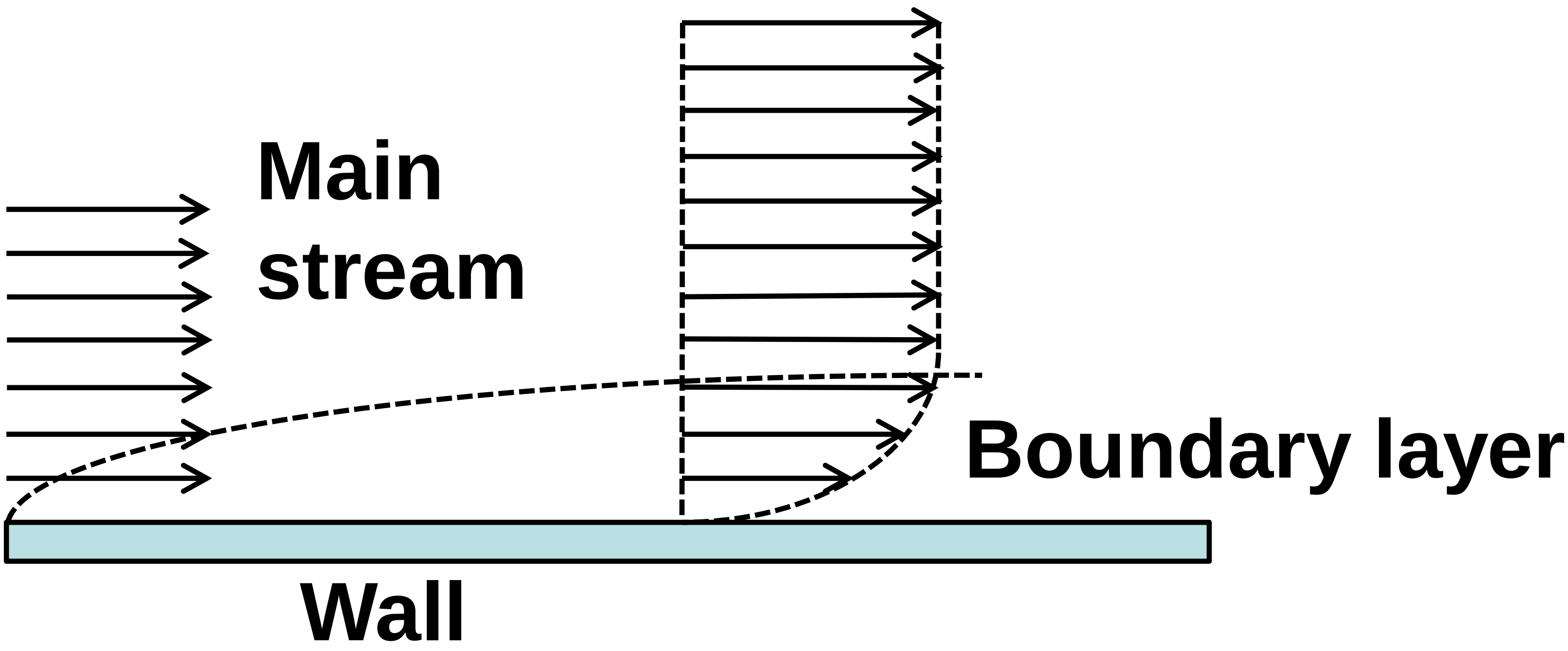
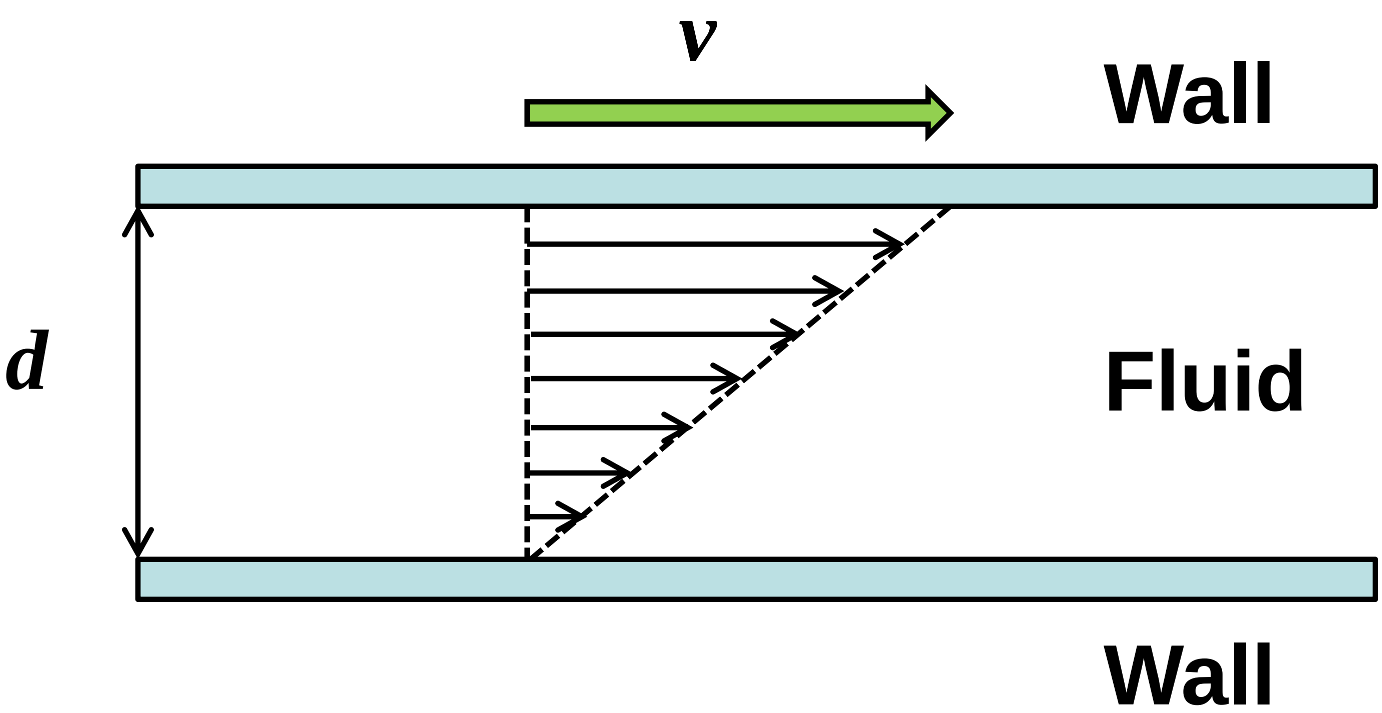
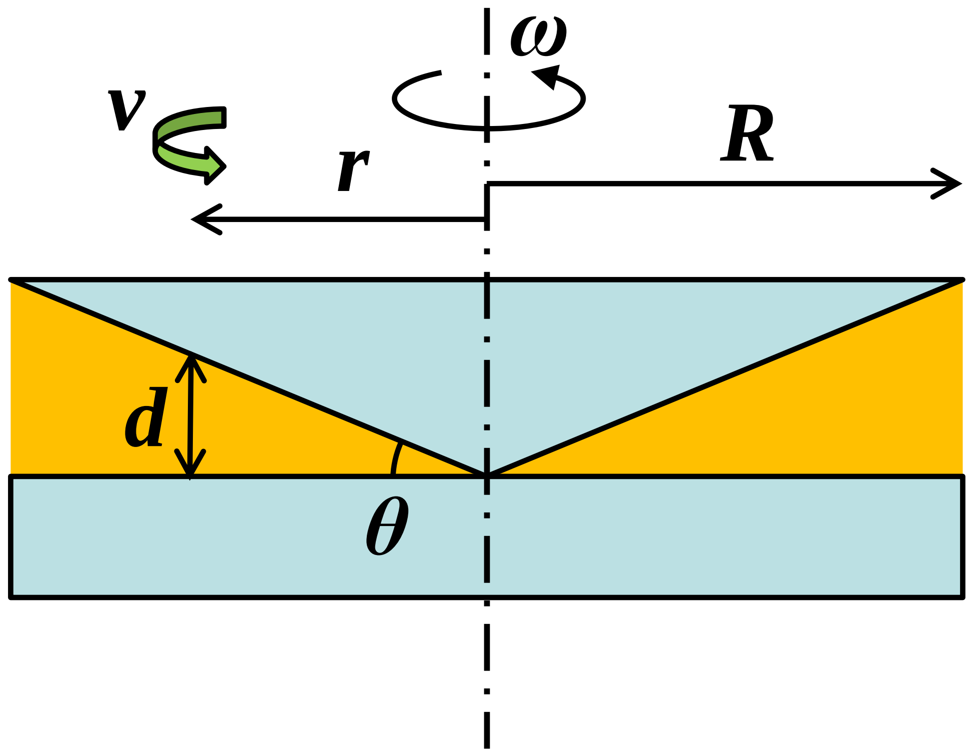


Fig. 4.26: Couette flow



$$\gamma = v / d \qquad (4.37)$$

Fig. 4.27: Flow between rotating cone and stationary plate



$$\gamma = v / d = r\,\omega / (r\,\theta) = \omega / \theta \qquad (4.40)$$

Fig. 4.28: Cone-plate viscometer

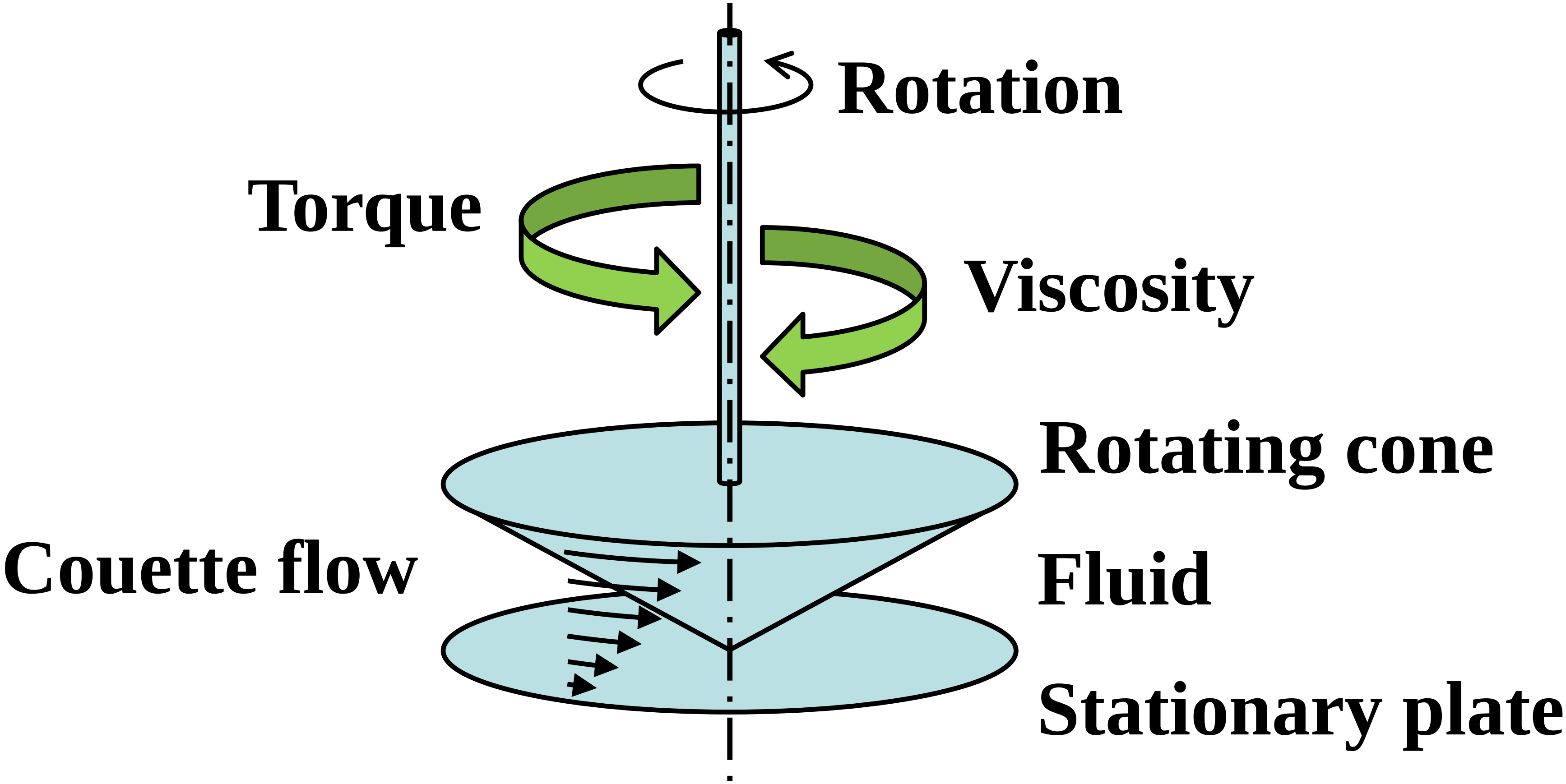
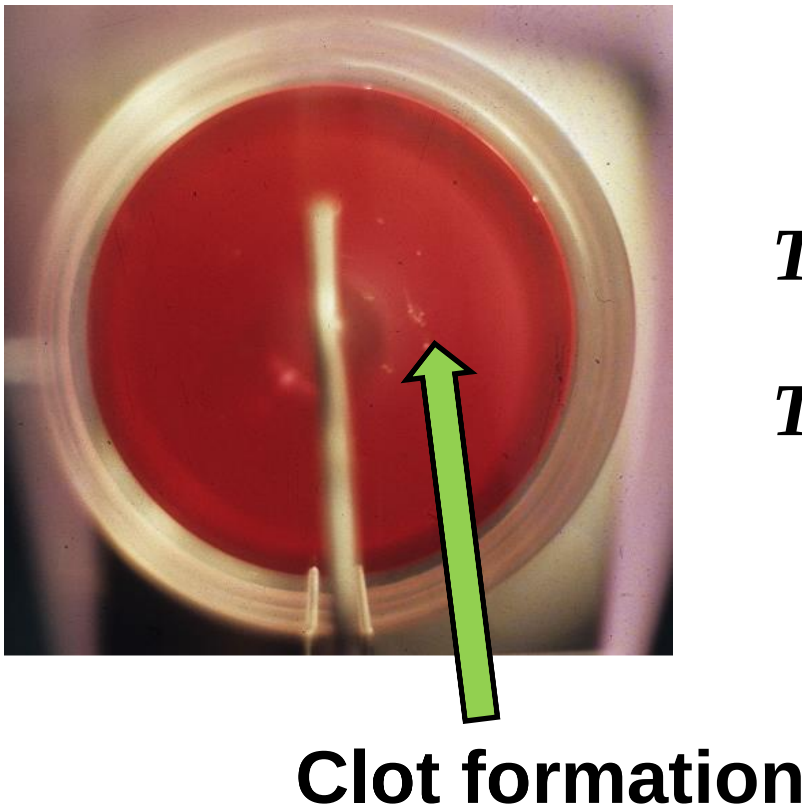
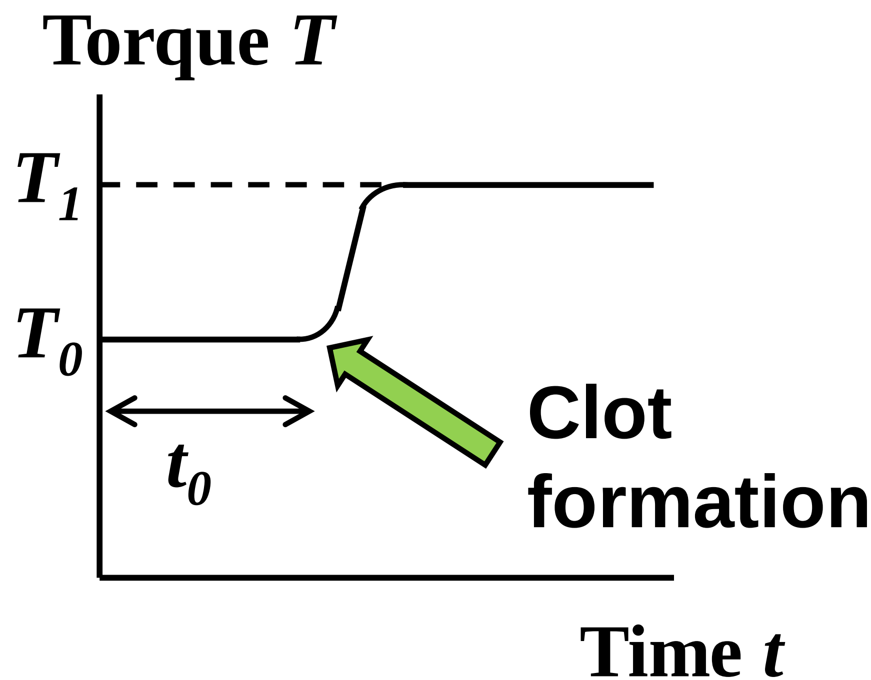


Fig. 4.29: Clotting between rotating cone and stationary plate

(a) Blood between rotating cone and stationary plate



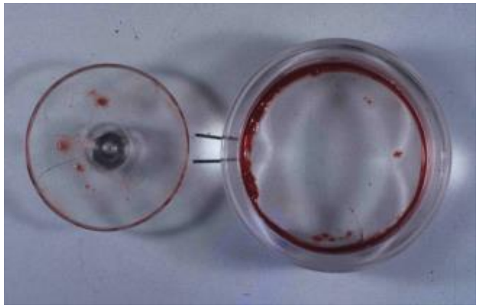
(b) Torque tracings during clot formation



$$Rc = (T_1 - T_0) / T_1 \qquad (4.41)$$

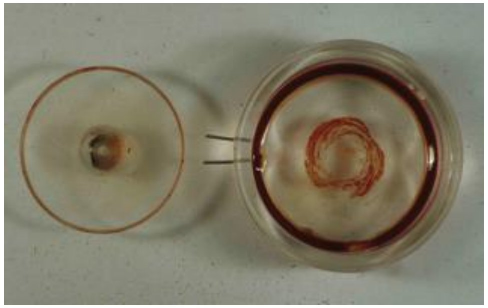
Fig. 4.29: Clot formation between rotating cone and stationary plate

(c) Clot; cone (left), plate (right)



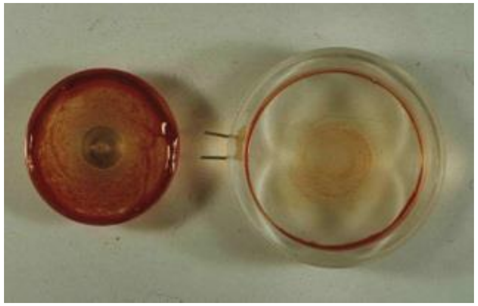
$\gamma = 430\ s^{-1}$ Shear rate

$Rc = 0.45$ Clotting ratio



$43\ s^{-1}$

$Rc = 0.70$



$4.3\ s^{-1}$

$Rc = 0.90$

Fig. 4.29: Clot formation between rotating cone and stationary plate

(d) Shear rate *γ* and Clotting ratio *Rc*

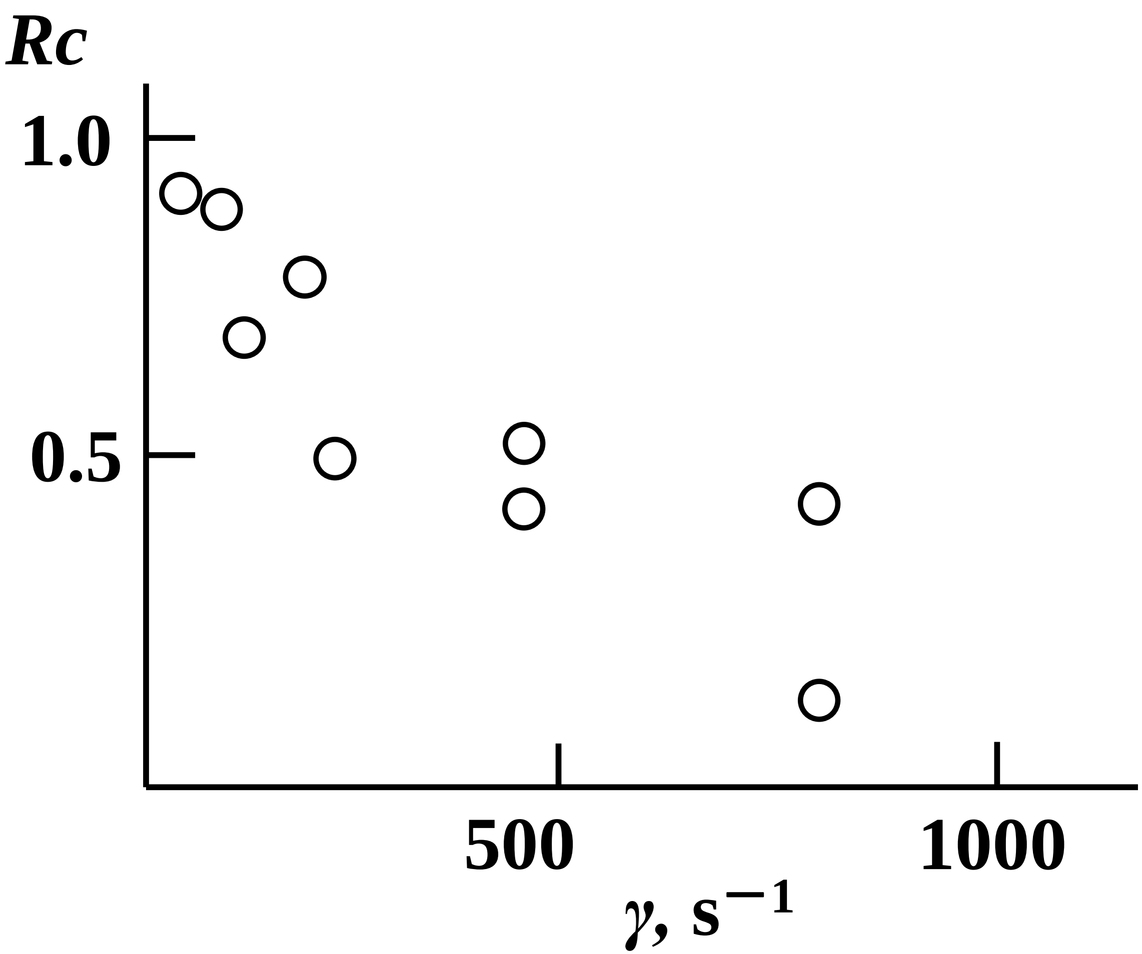


Fig. 4.30(a): Counter rotating rheoscope

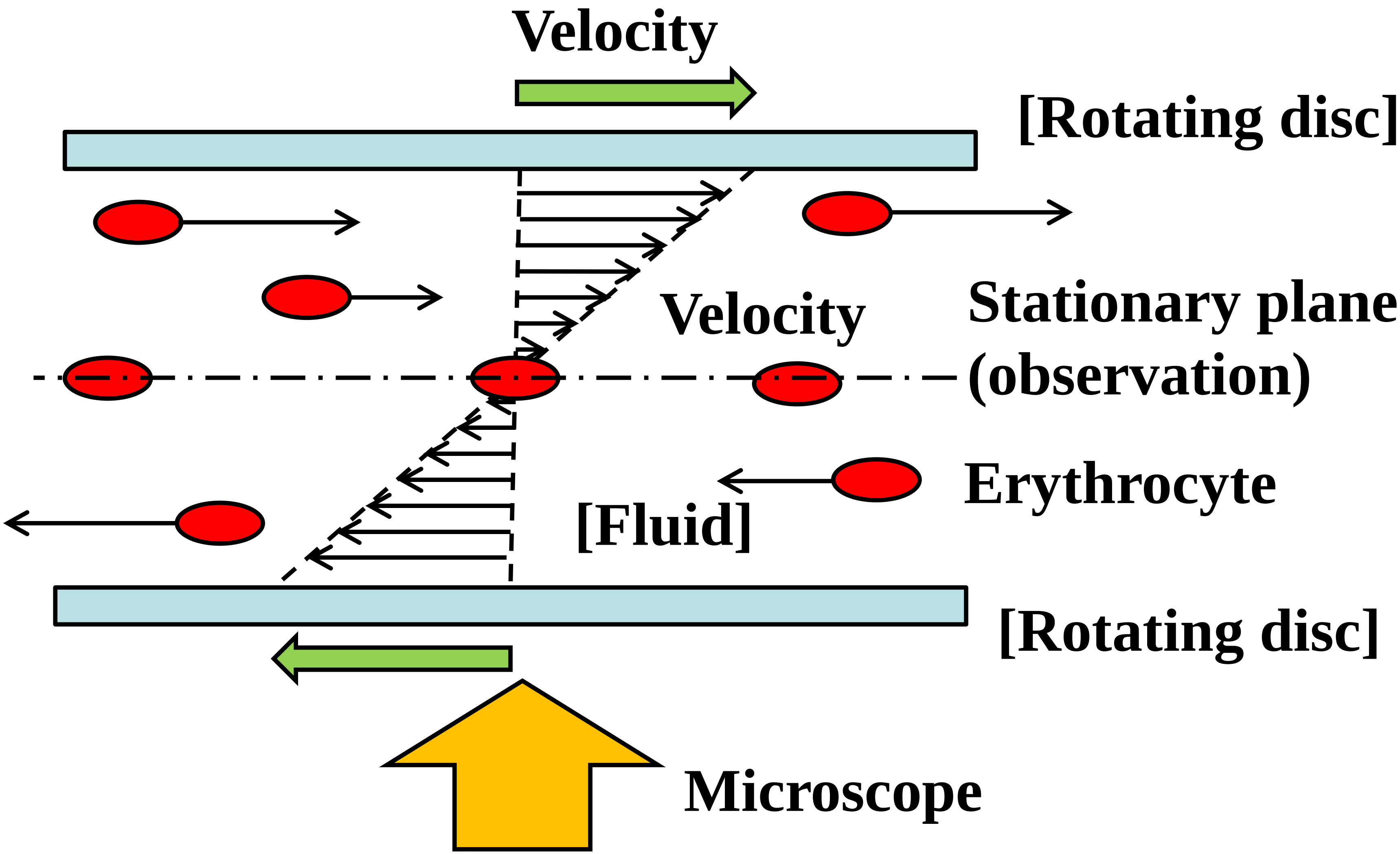


Fig. 4.30(b): Counter rotating rheoscope

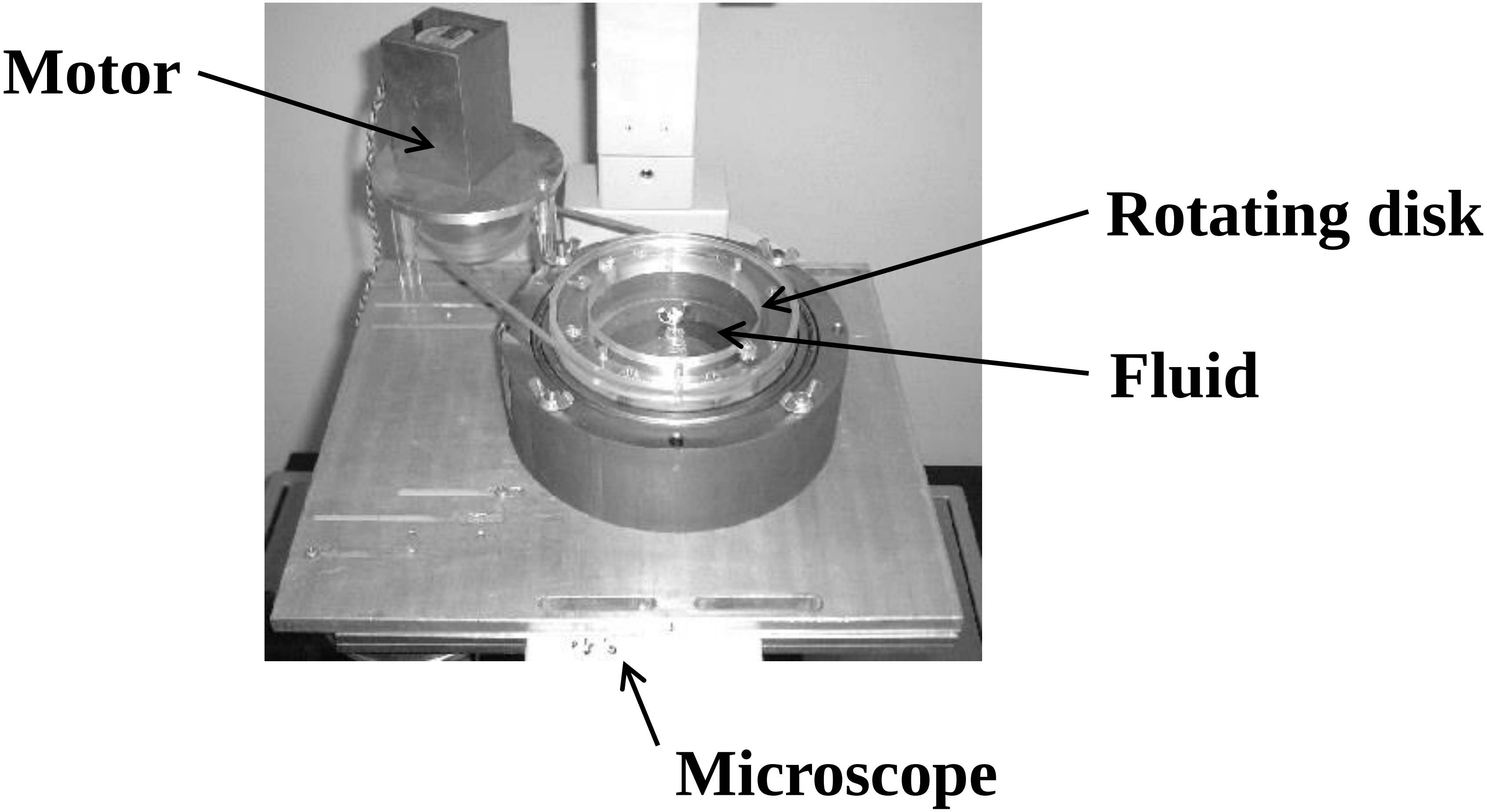
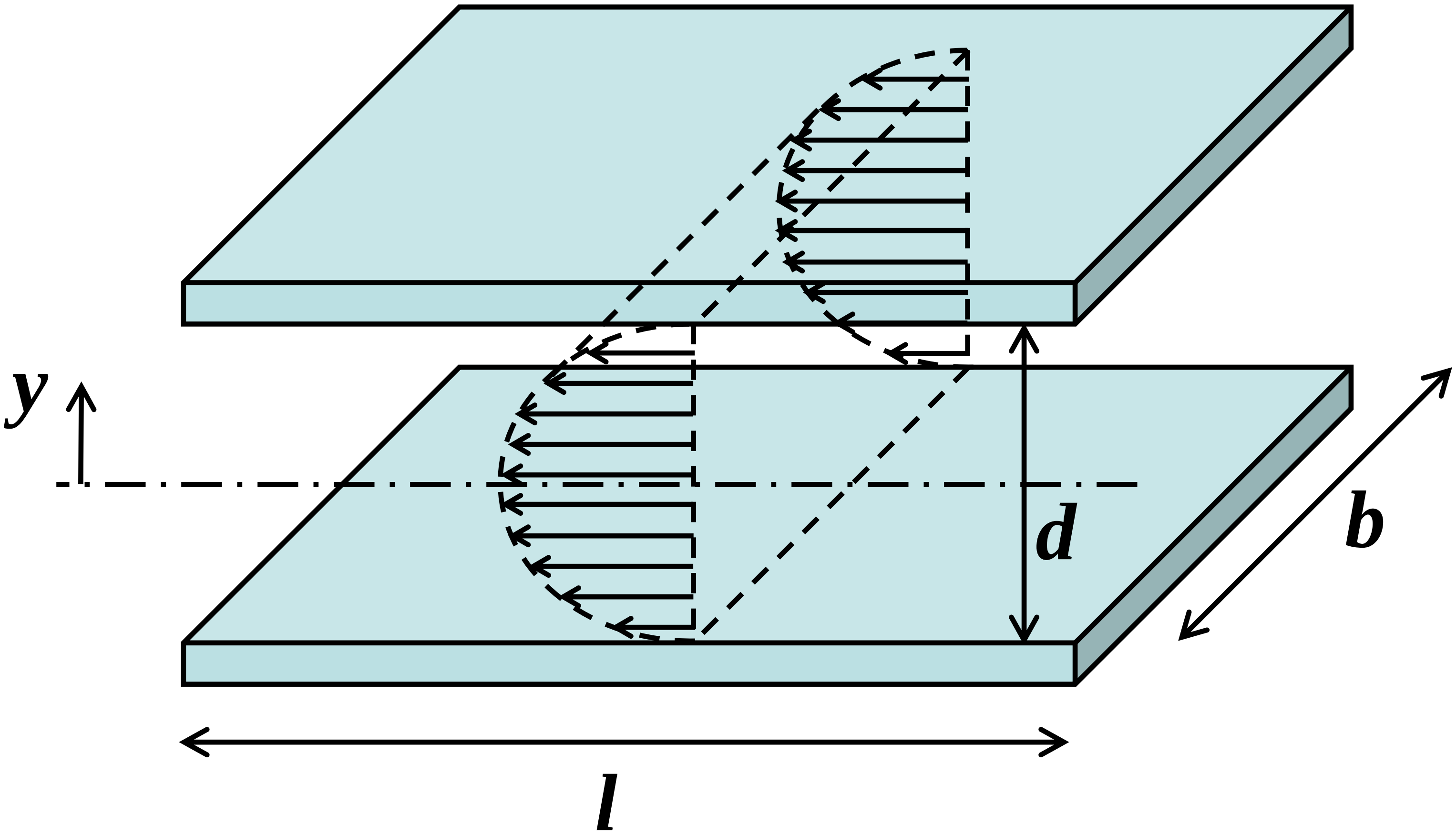
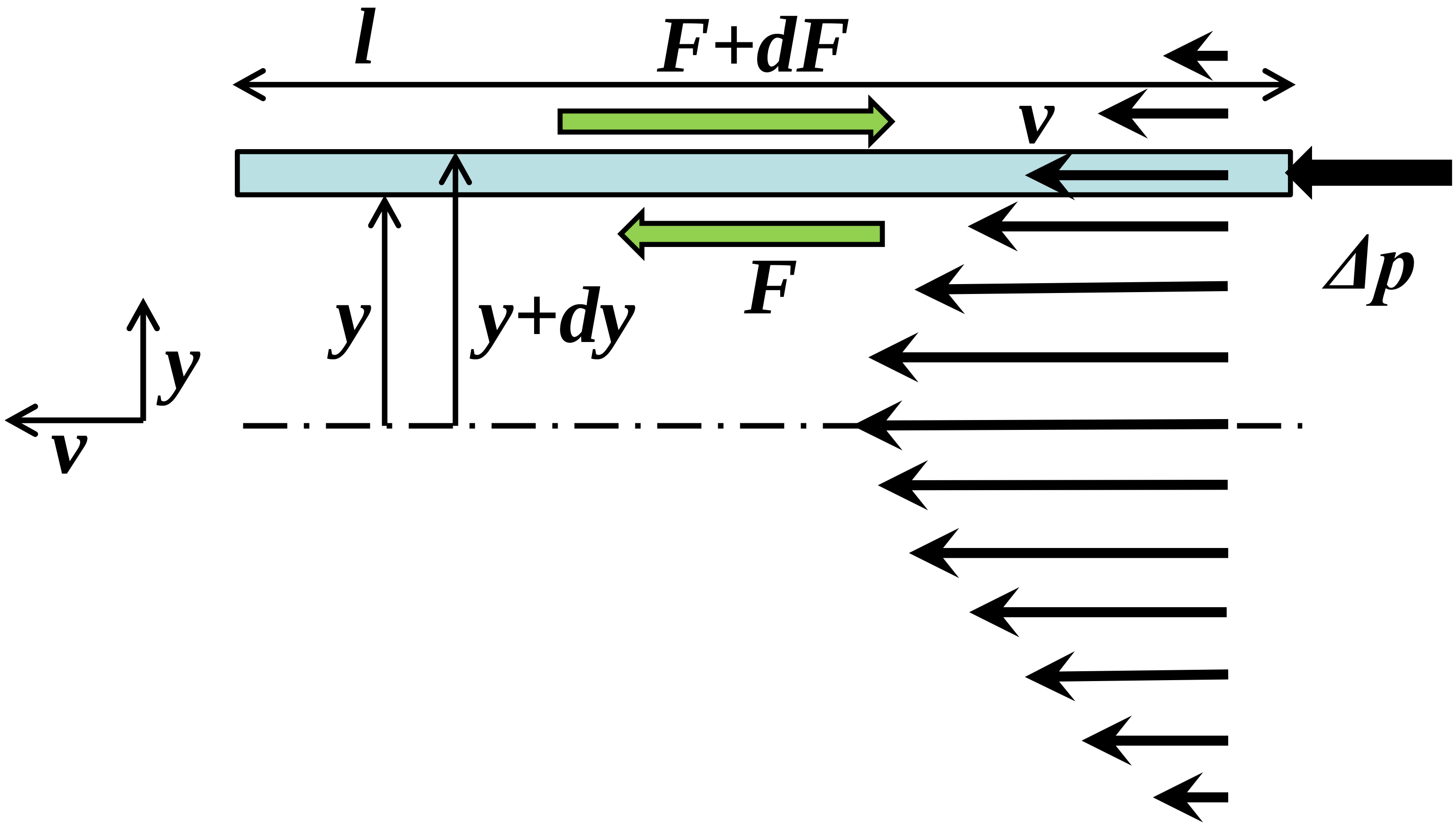


Fig. 4.31(a): Velocity distribution in flow between parallel walls



$$\gamma w = 6\,Q \,/\, (b\,d^{2}) \qquad (4.62)$$

Fig. 4.31(b): Force balance in flow between parallel walls



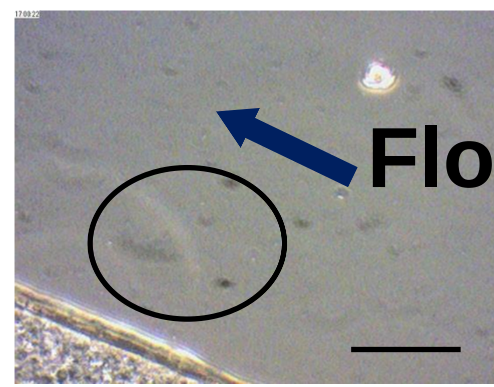
$$dF = b\,dy\,\Delta P \qquad (4.46)$$

Fig. 4.32: Deformation and exfoliation of cell in flow

(1)

(2) Deformation

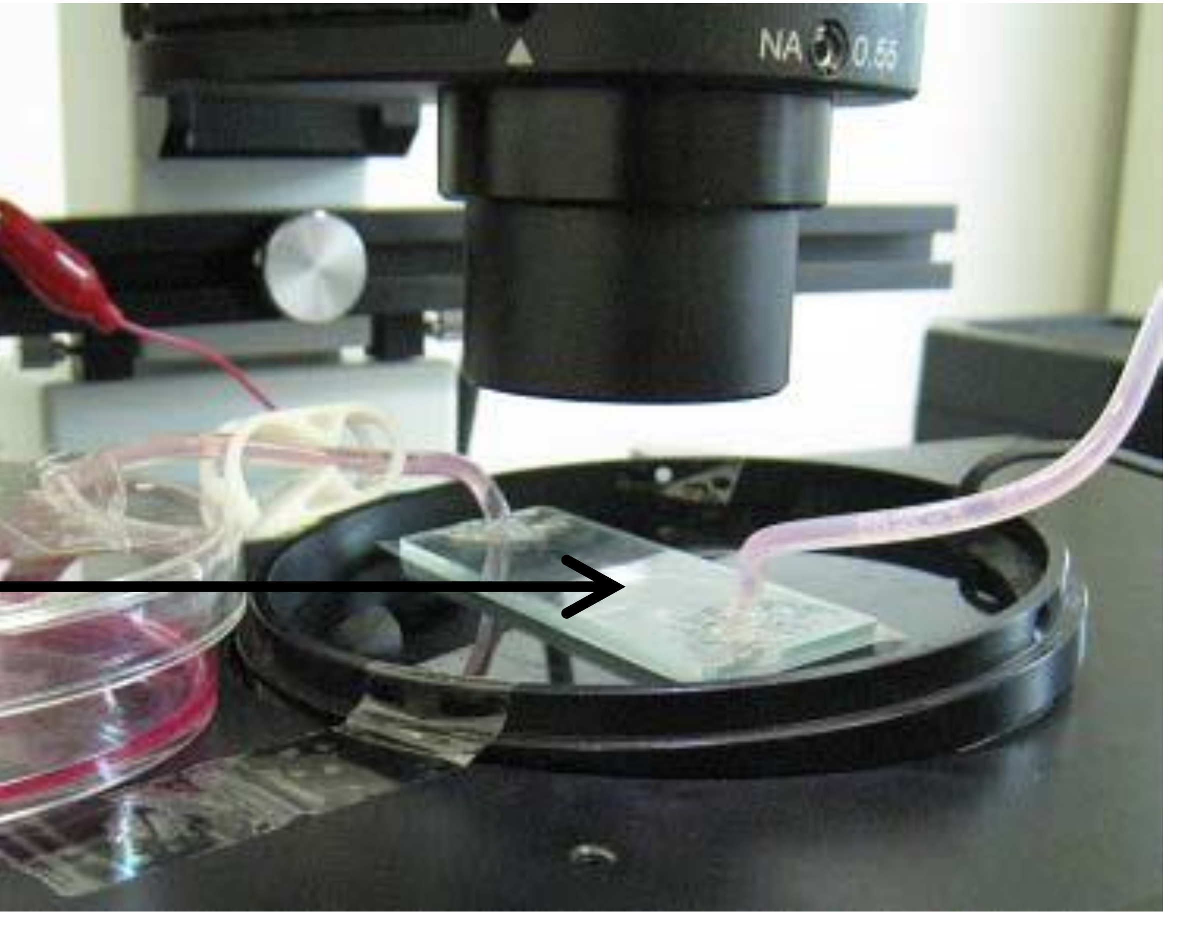
(3) Exfoliation



0.2 mm

Fig. 4.33: Flow channel between parallel walls

Microscope



Flow channel

Fig. 4.34: Flow channel system with parallel wall for microscopic observation

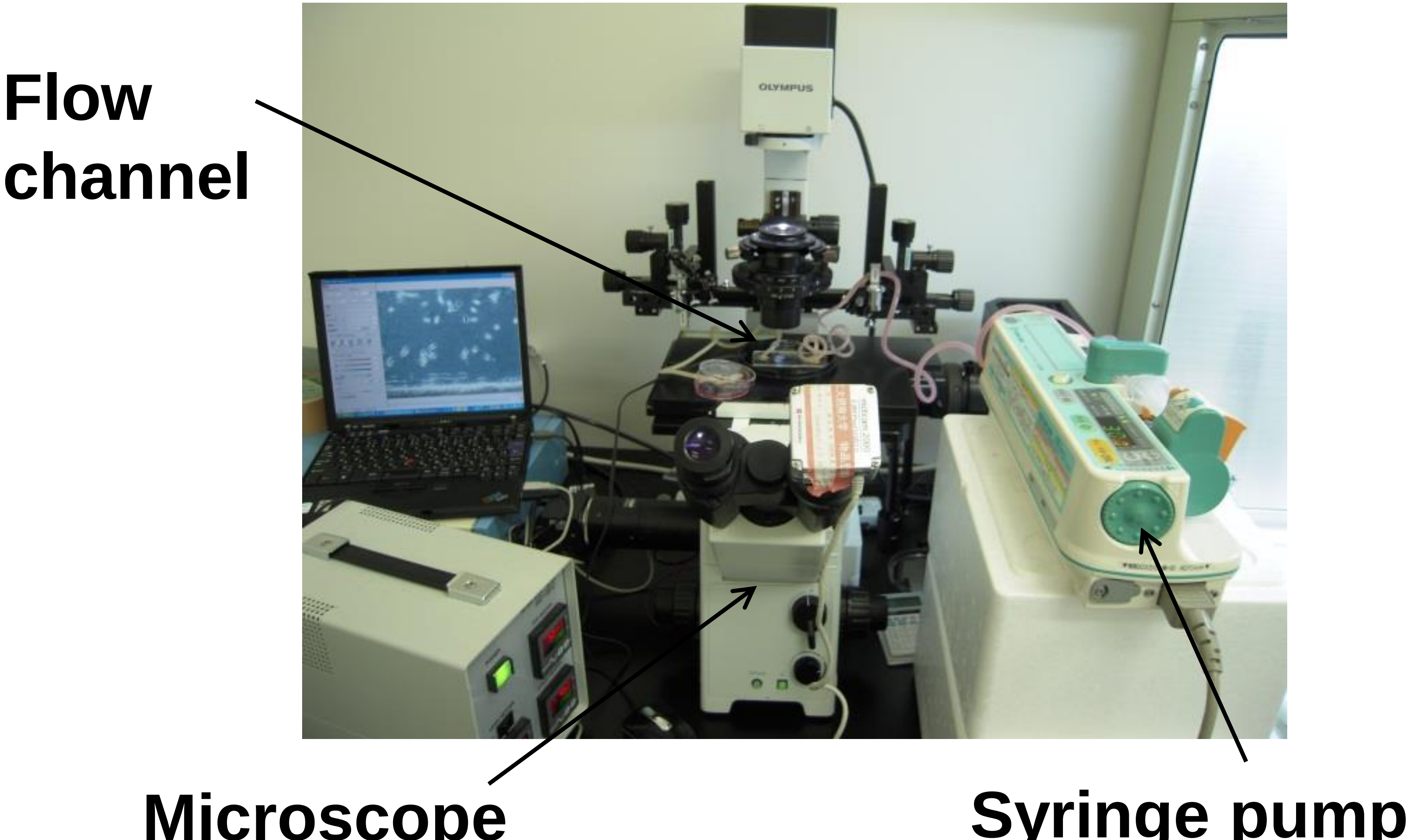


Fig. 4.35: Extension of cell

Fig. 4.36: Movement, deformation, proliferation, orientation, and differentiation of cell

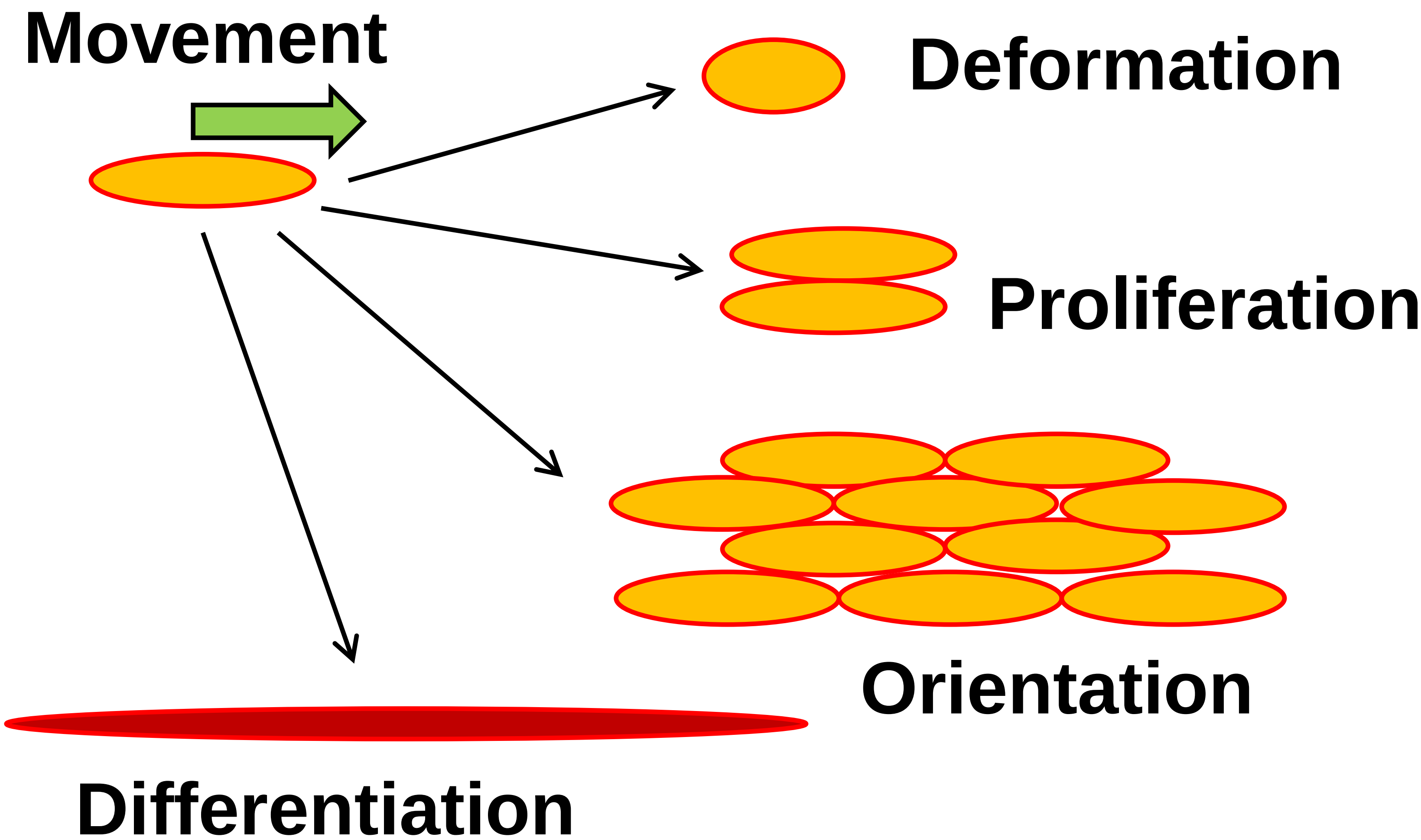
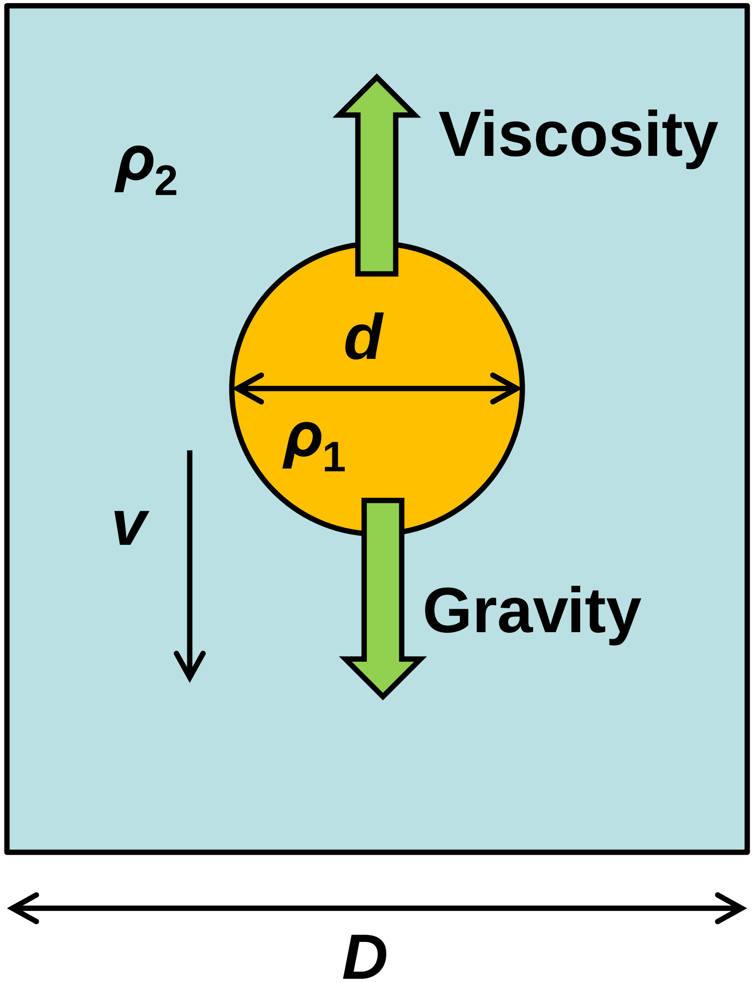


Fig. 4.37: Falling sphere



$$\eta \propto d^2(\rho_1 - \rho_2)/v \qquad (4.63)$$

Fig. 4.38: Magnus effect

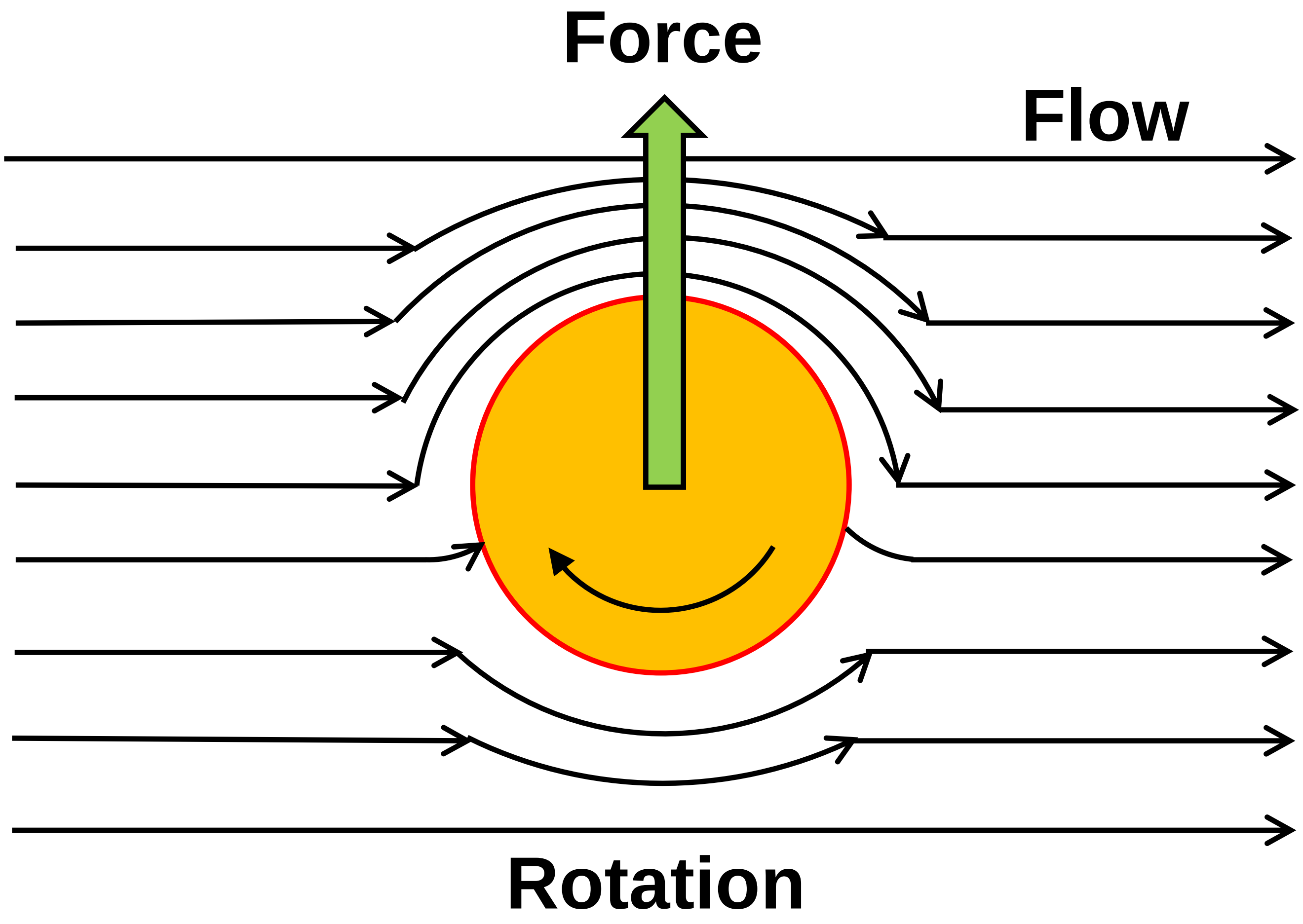


Fig. 4.39: Axis concentration?

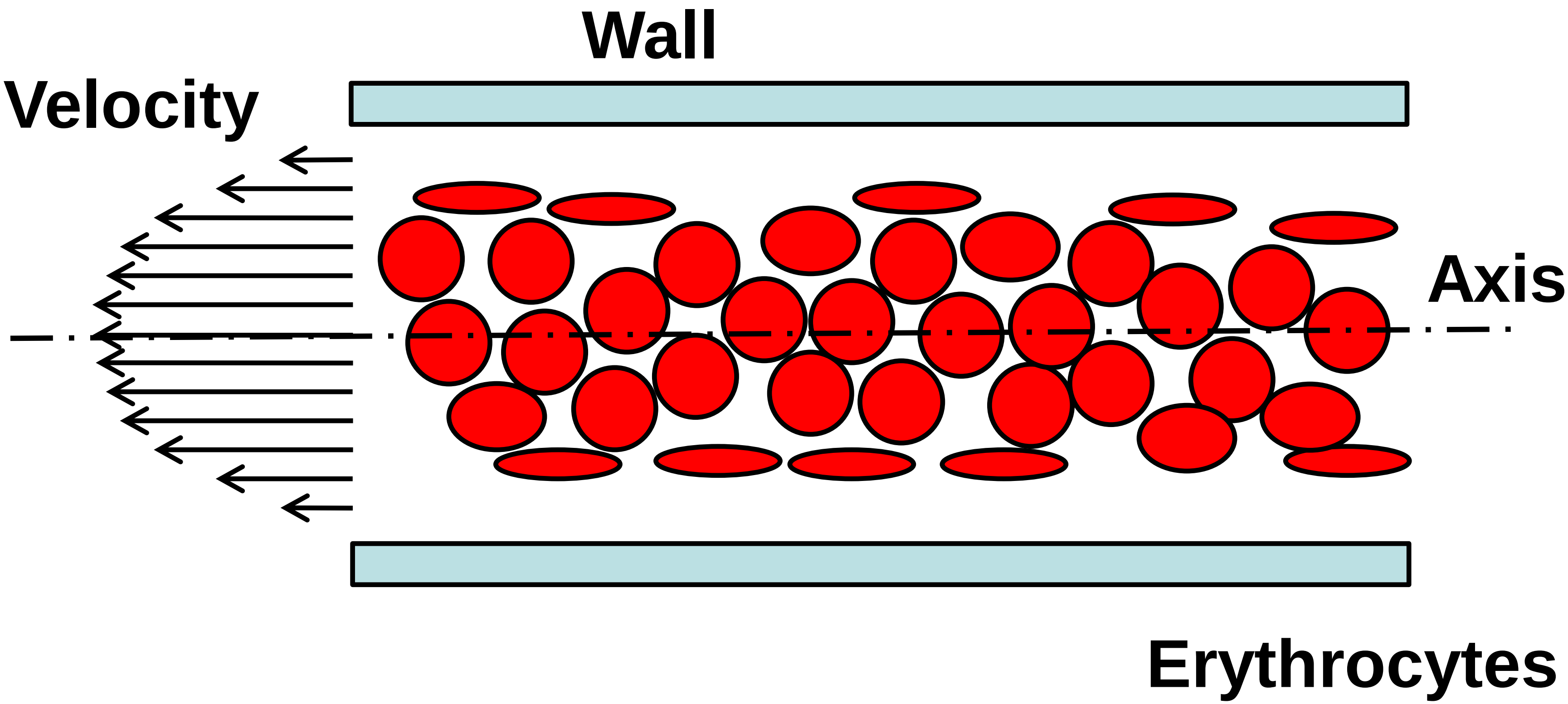


Fig. 4.40: Secondary flow in bend tube

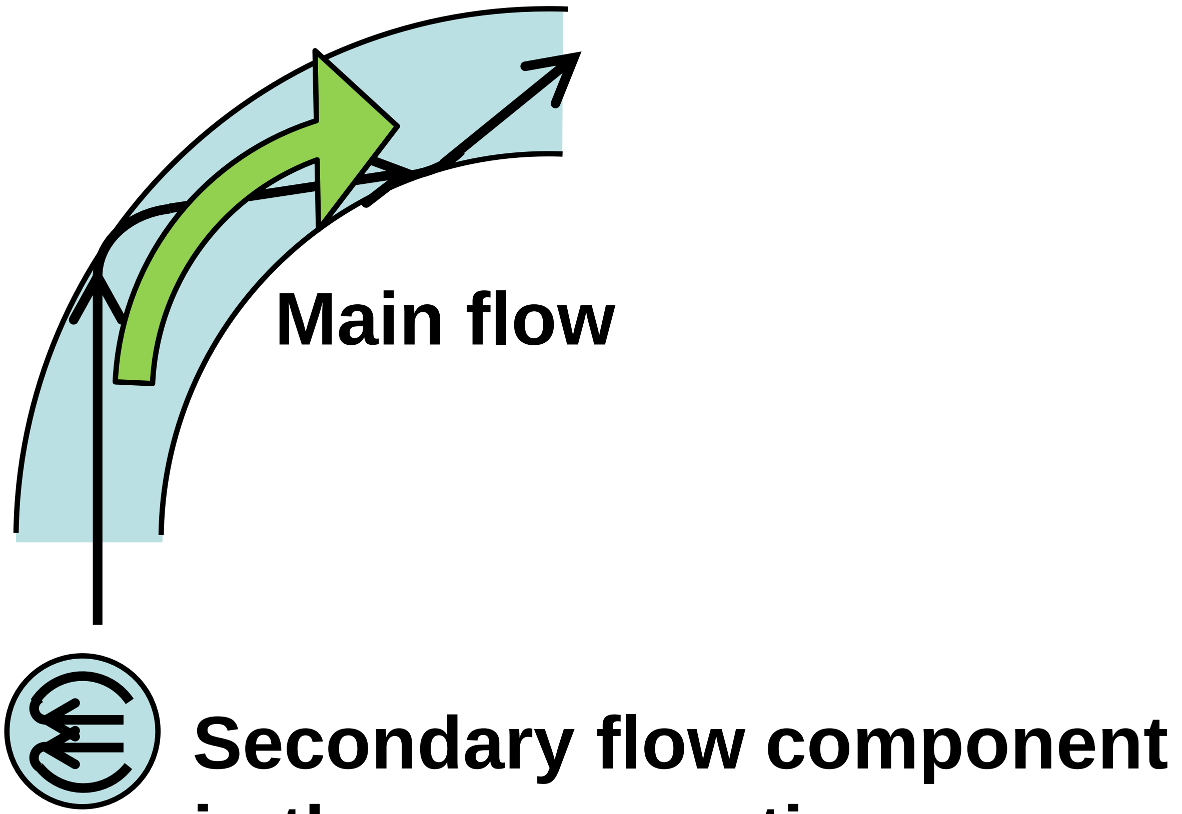


Fig. 4.41: Secondary flow between cylinder (Taylor vortex)

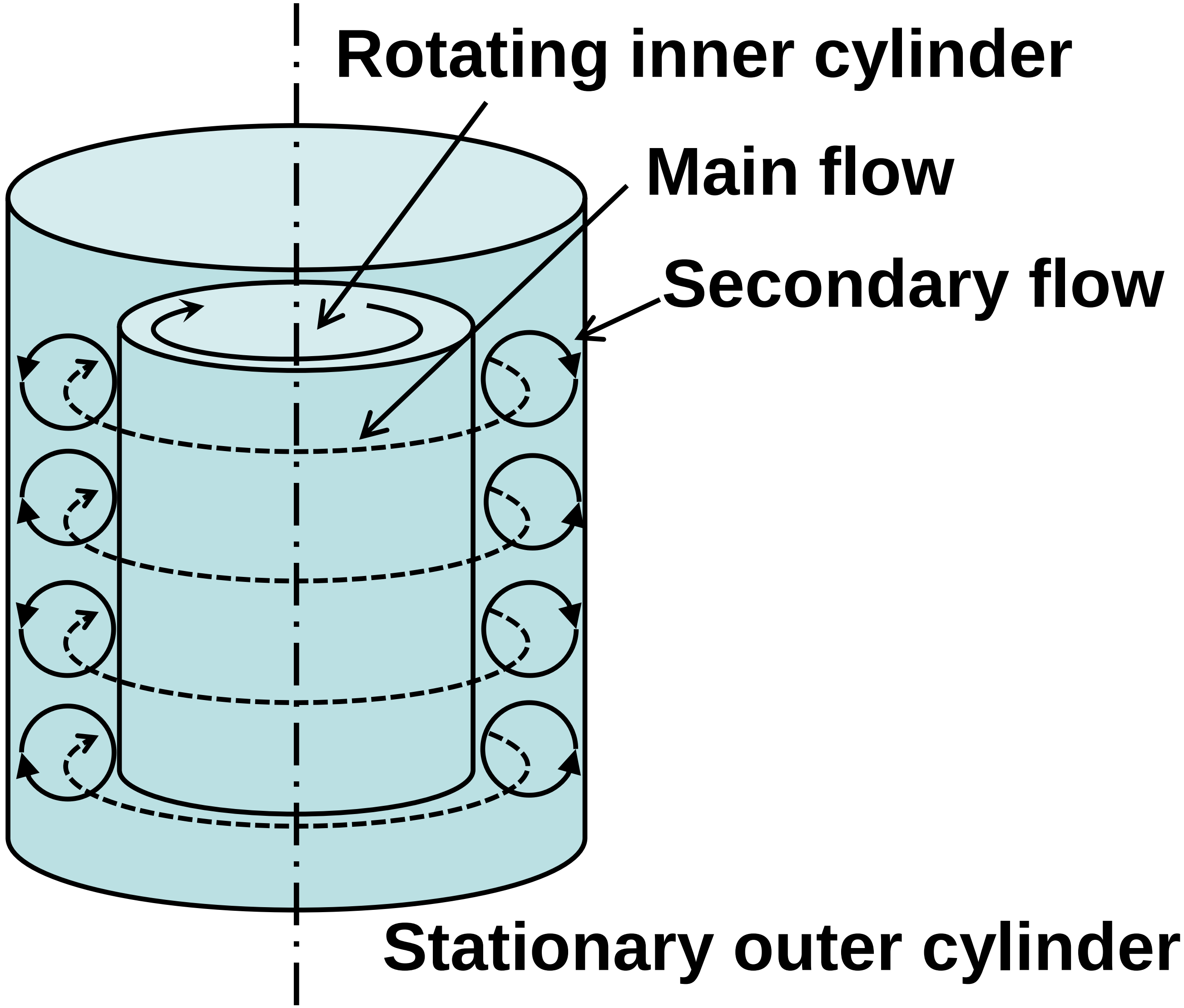


Fig. 4.42: Secondary flow between rotating cone and stationary plate

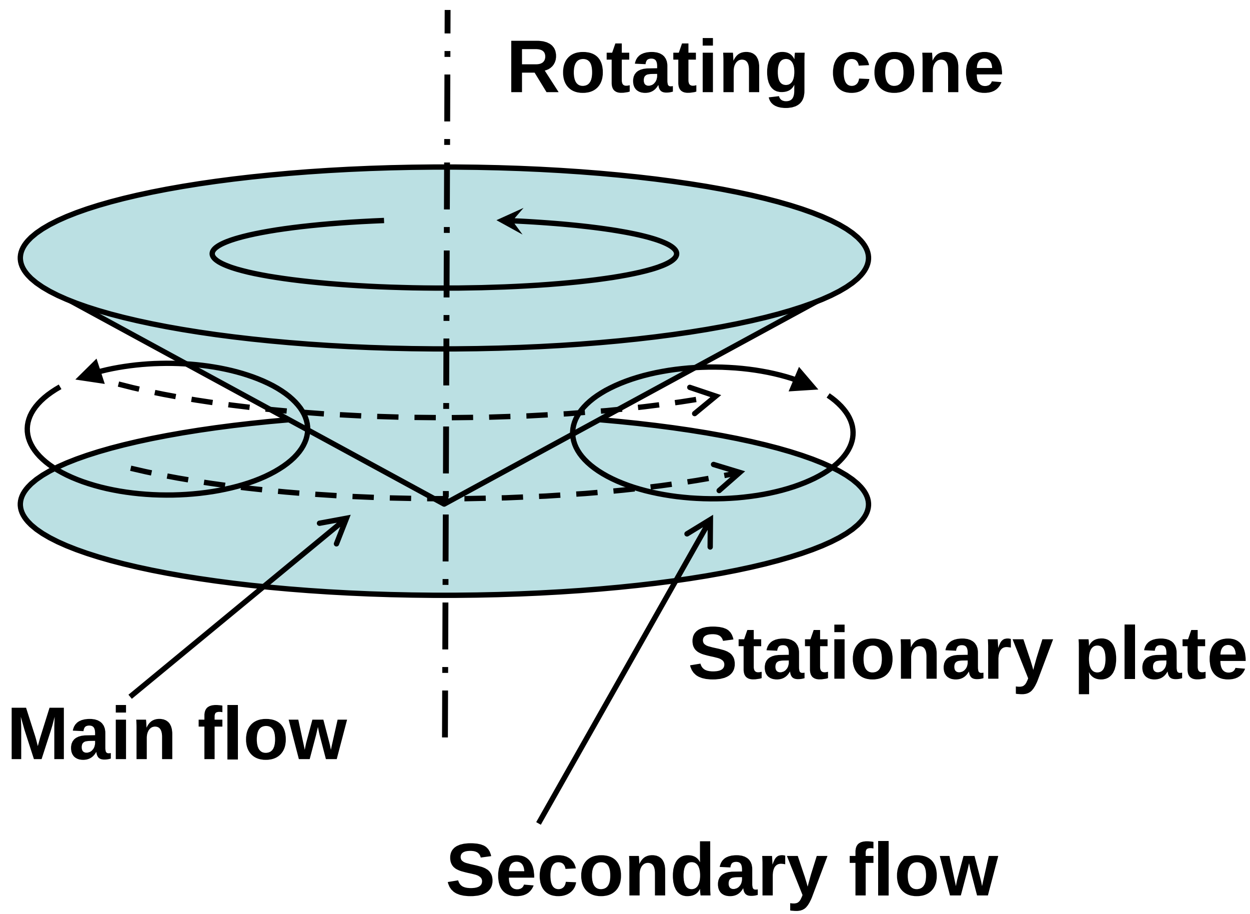


Fig. 4.43: Flow between rotating outer cylinder and stationary inner cylinder

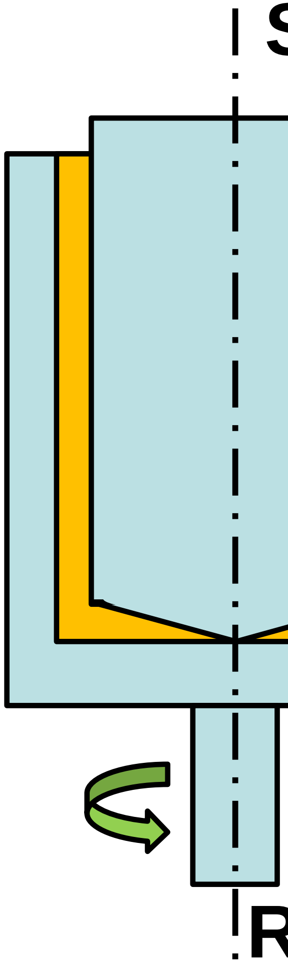
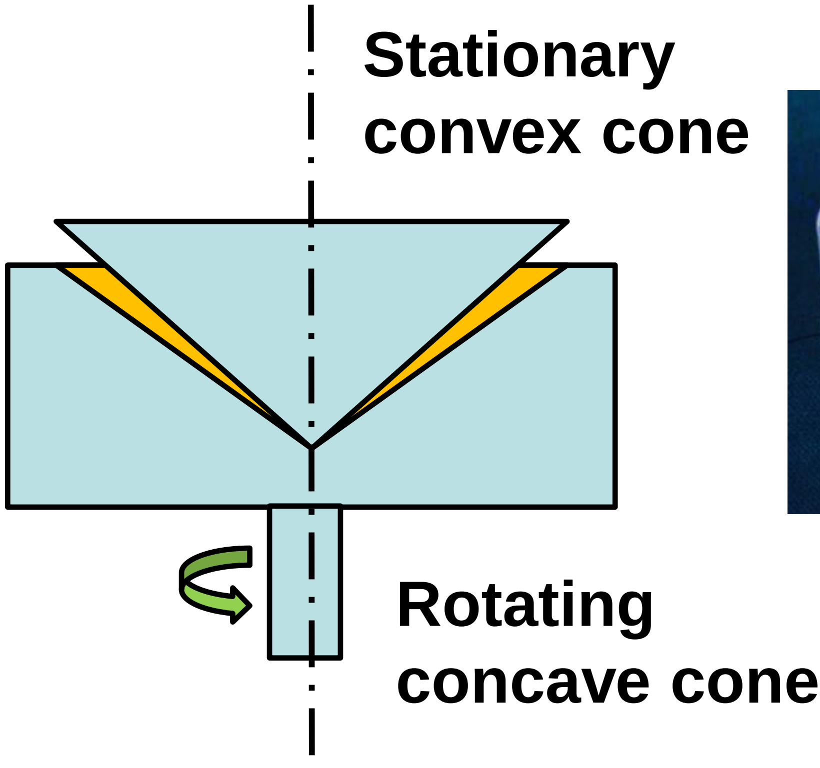


Fig. 4.44: Flow between stationary convex cone and rotating concave cone

(a)



(b) Concave and convex cones

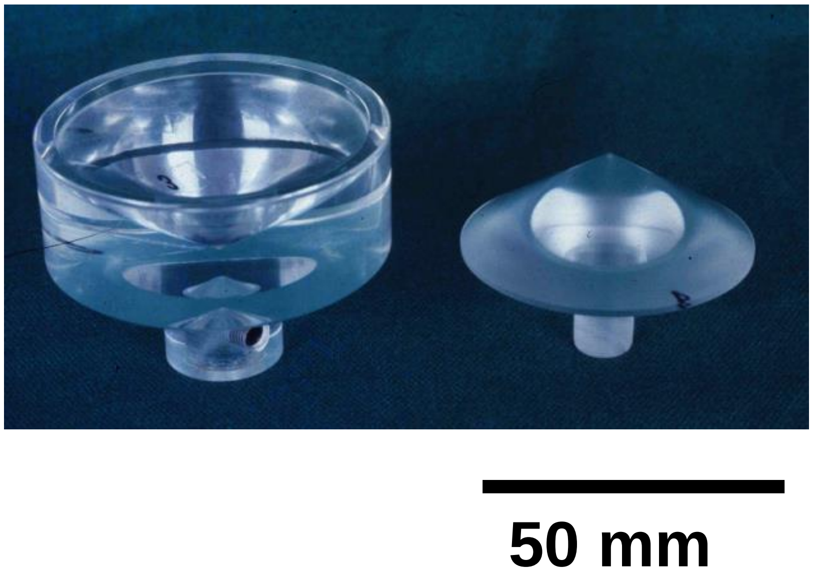


Fig. 4.45: Pressure in pulsatile flow

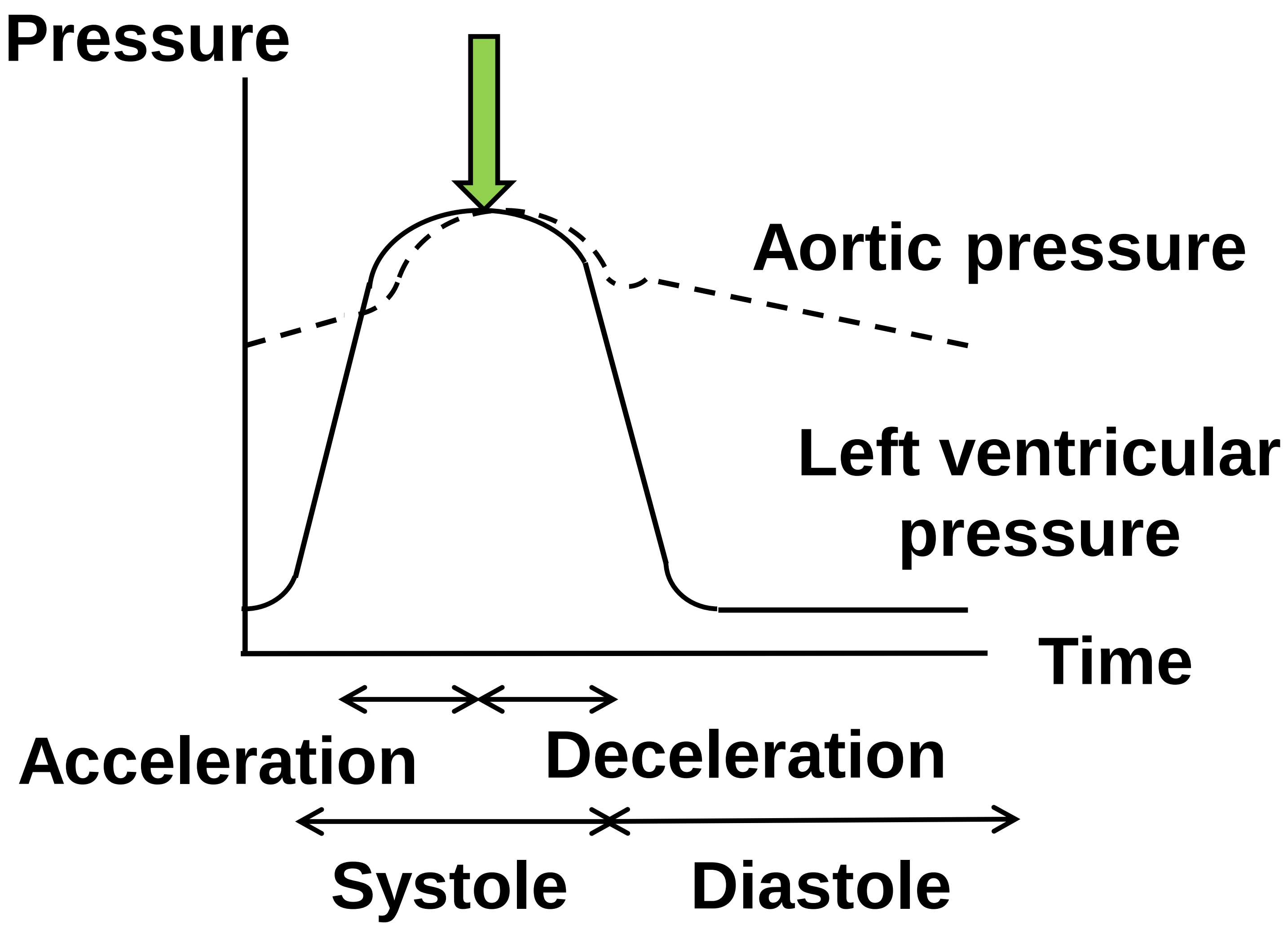


Fig. 4.46: Compliance of tube wall

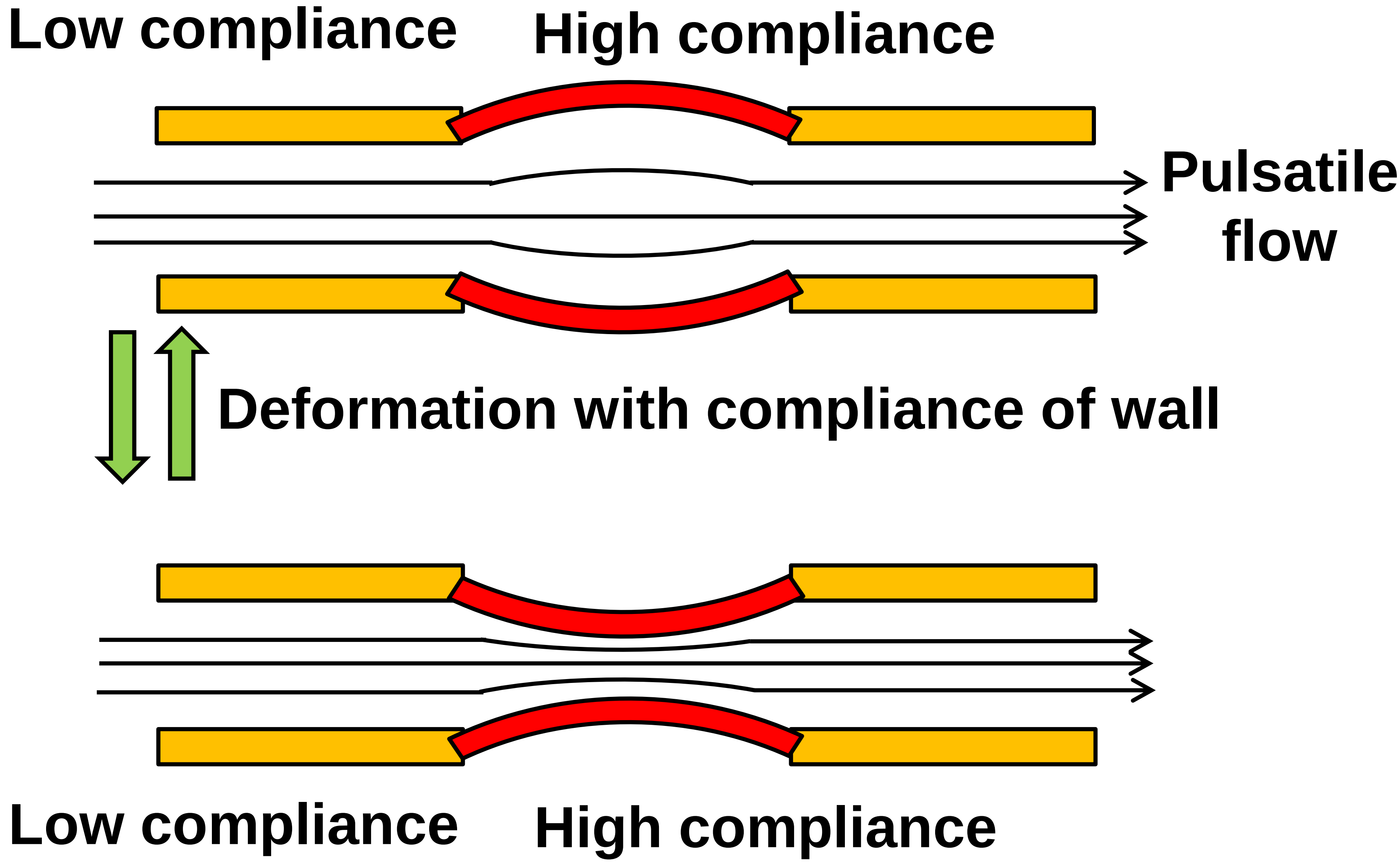


Fig. 4.47: Clot formation and hemolysis with shear rate

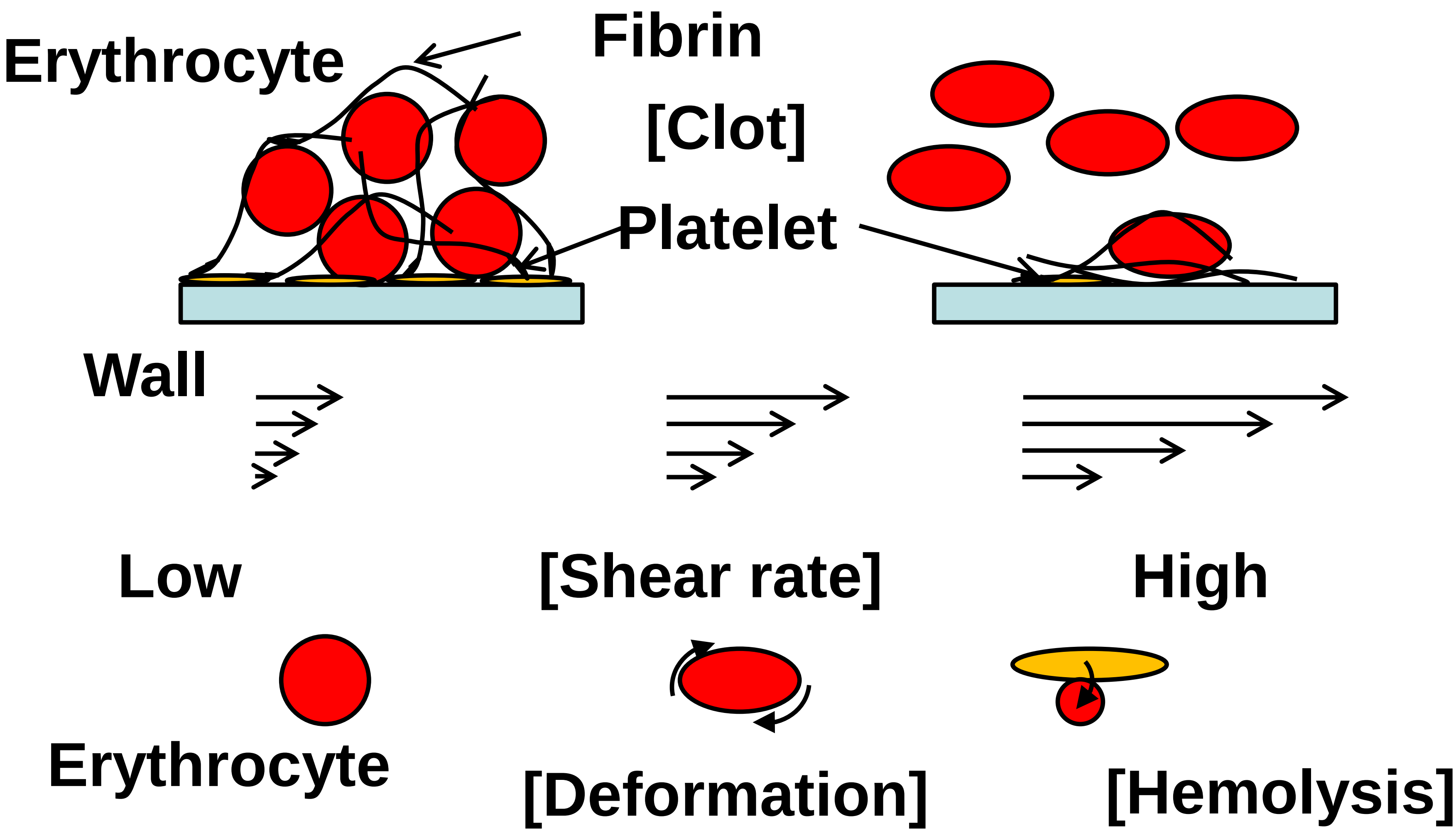
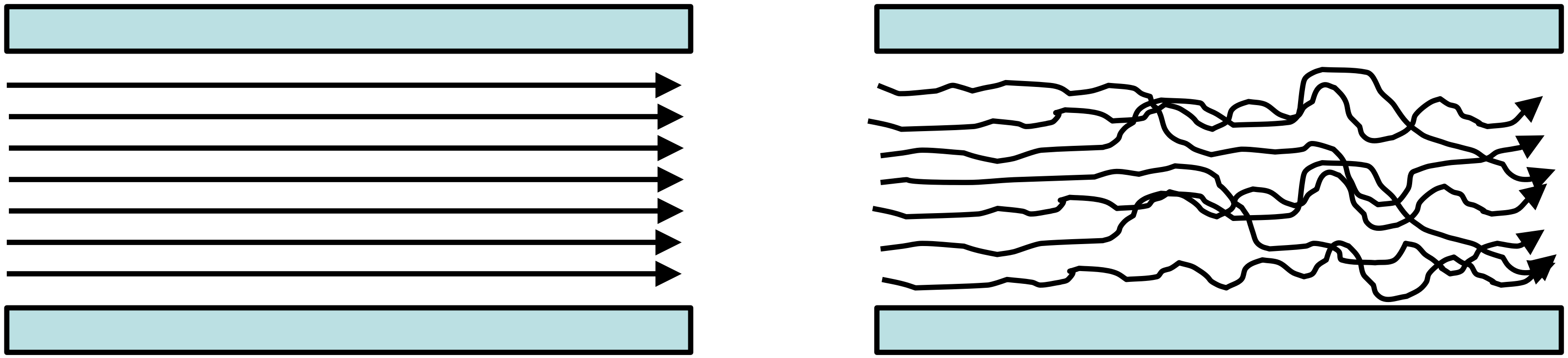


Fig. 4.48: Tracing



(a) Laminar flow

(b) Turbulent flow

$$Re = \rho v x / \eta \qquad (4.64)$$

Fig. 4.49: Streamline

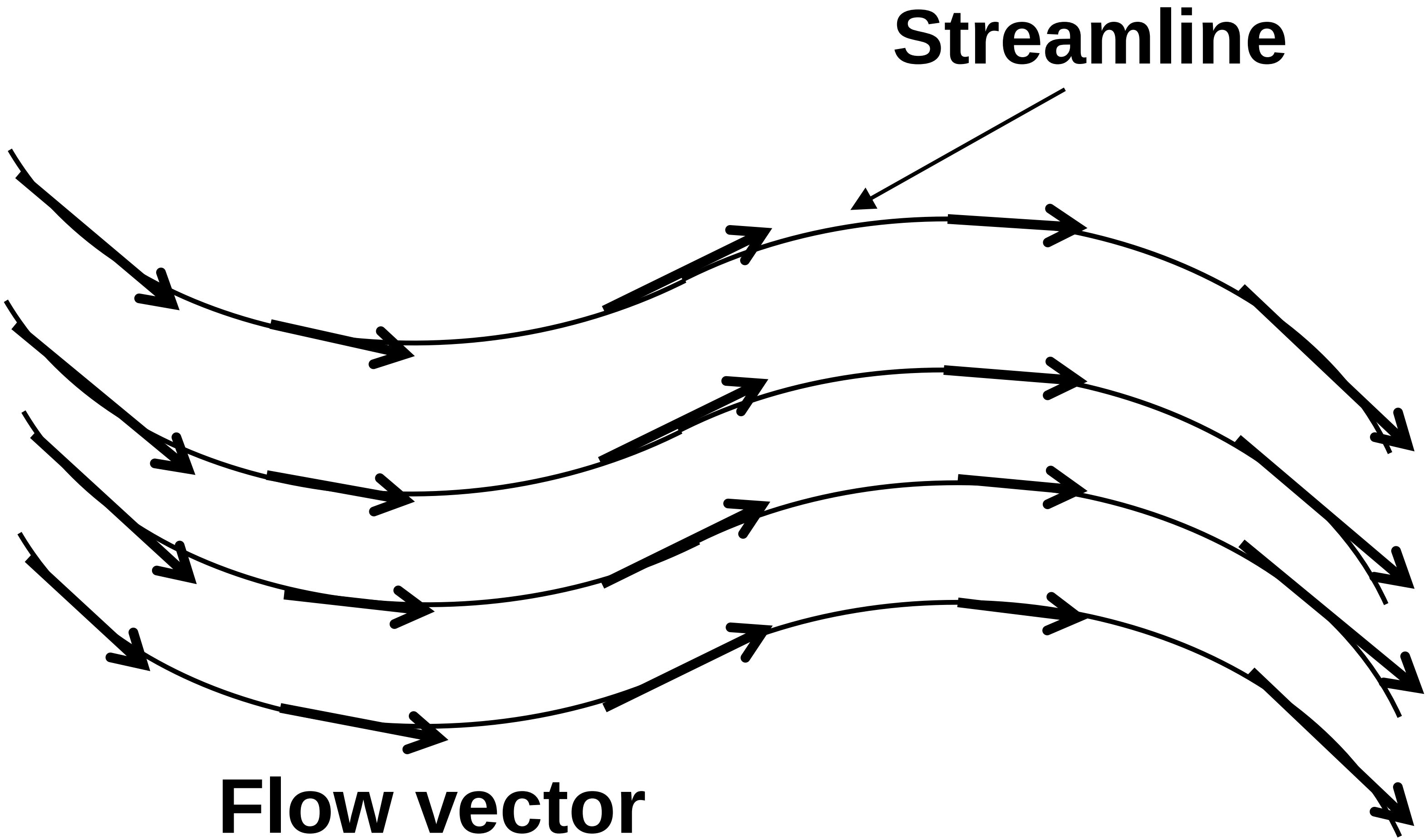
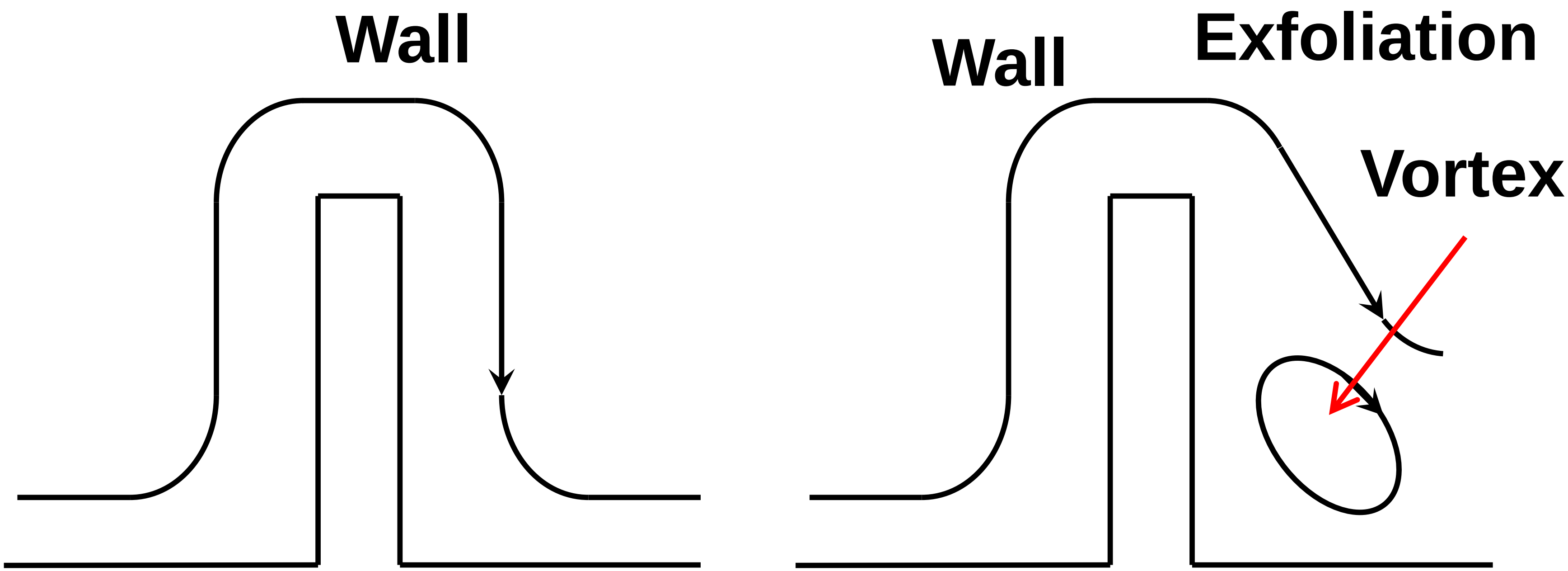


Fig. 4.50: Vortex

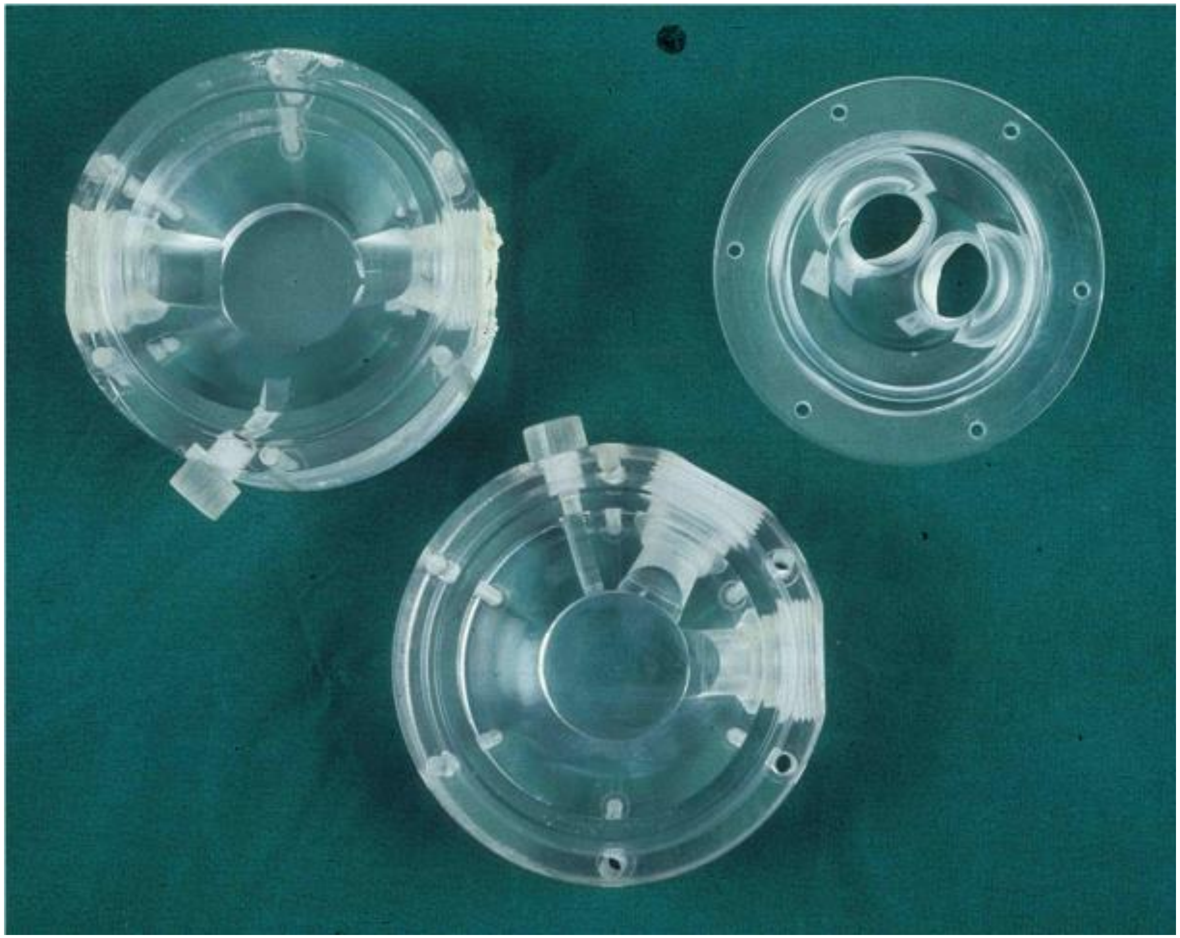


(a) Low Reynolds number

(b) High Reynolds number

Fig. 4.51: Artificial ventricle

(a)



(c)

(b)

Fig. 4.52: Clot in artificial ventricle