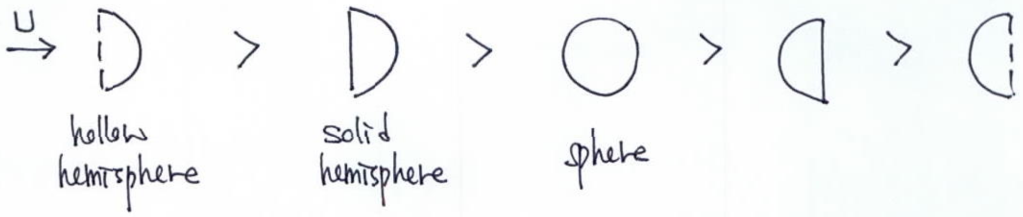
Chap. 6. The drag of simple shapes and sessile systems

· Reducing drag (besides streamlining)

- maintaining laminar flow by sucking fluid in through the porous skin of an object. e.g. sponge
- ejecting high-velocity fluid in a downstream direction around the normal separation point
  - e.g. ram ventilation
- splitter plates behind bluff bodies to reduce the rate at which vortices are shed
  - e.g. trailing part of cephalopod (두족류; 오징어·낙지 등) shell
  - tail of a gliding tadpole (올챙이)

Fig. 6.4. Drag coefficients of bluff bodies

C_{D_f} 

∴ C_{D_f} of concave front ↑

e.g. suspension feeders (filter feeders)

: sea pen, black fly larvae (fan)

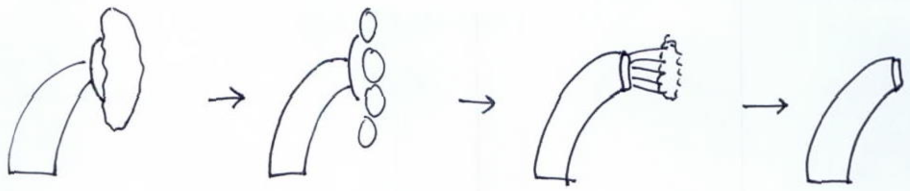
(Fig. 6.5)

§ Flexibility

drag on a compliant body → reconfiguration of the body (active or passive)

← change in flow profile ↙

e.g. sea anemone (말미잘) Fig. 6.6



U ↑

C_{Df} 0.9 0.4 0.3 0.2

§ A measure of reconfiguration

for bluff stiff bodies $(100 < Re < 10^4)$

$$F_D \sim U^2$$

$$C_D \sim \frac{F_D}{\rho U^2 S} \sim U^0 \sim Re^0.$$

or $$\frac{F_D}{U^2} \sim Re^0 \sim U^0$$

└ speed-specific drag

for flexible bodies

$$\frac{F_D}{U^2} \sim U^E.$$

E : measure of reconfiguration

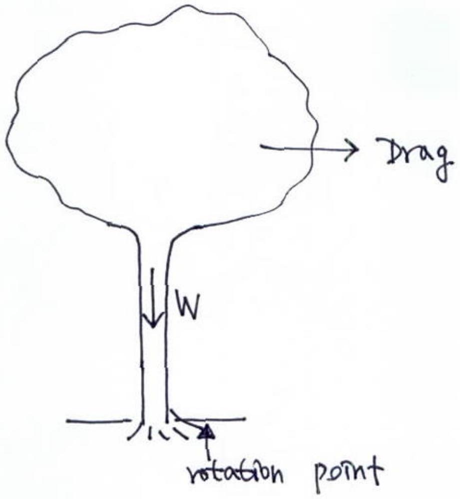
$E > 0$: drag more sensitively increases with U

$E < 0$: drag less 〃 〃 U

~ most observations

Table 6.1

§ Drag of leaves on trees



- major contributor to the drag of most trees : leaves
- leaves reconfigures into cones and cylinders : Fig. 6.9

C_D : cylindrical reconfiguration
< conical reconfiguration

Fig. 6.4.

e.g. pine trees.

S (exposed area) $\sim \frac{1}{U}$

$F_D \sim U^2 \cdot S \sim U$

$\frac{F_D}{U^2} \sim U^{-1}$ (experimentally, $U^{-0.72}$)

* If periods of substantial wind are short and intermittent
→ flexibility (giving up photosynthesis / suspension feeding for short periods)

If rapid flows are chronic
→ streamlining in the flow direction
: branches protrude mainly downwind