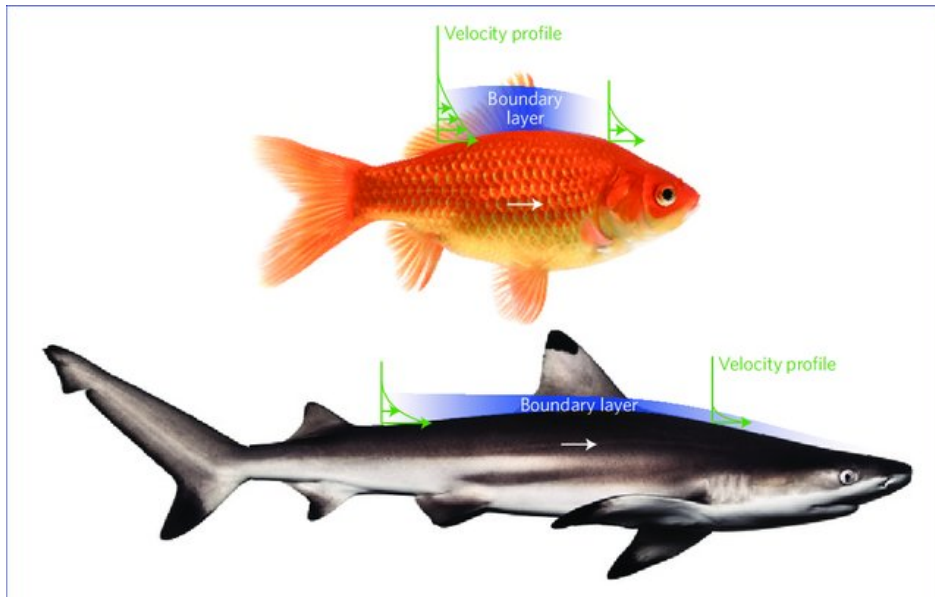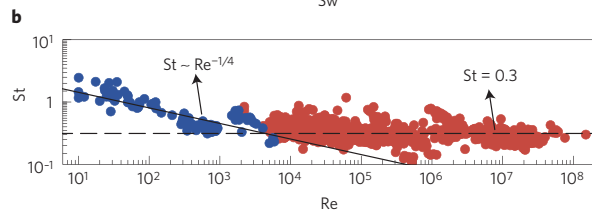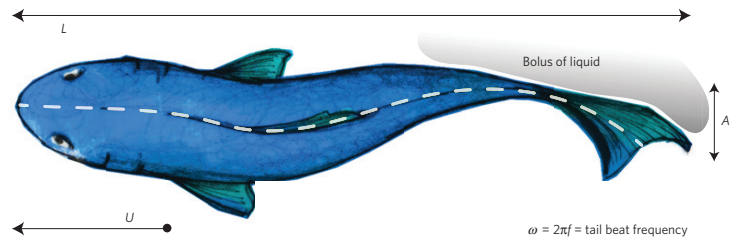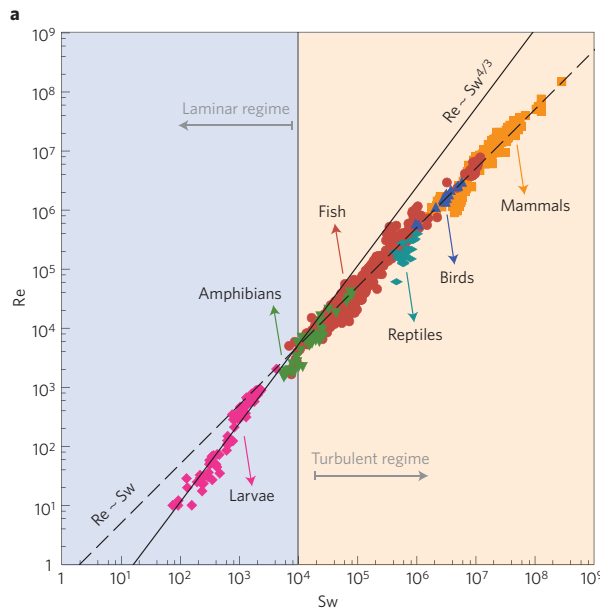# Boundary Layer - Thicknesses

Baumgart, J. and Freidrich, B.M., 2014, "Swimming across scales", *Nature Physics*, Vol. 10, pp. 711 – 712.
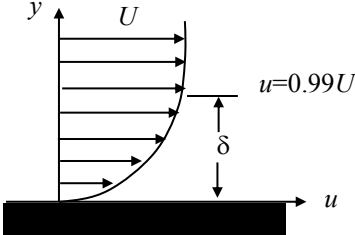
Gazzola, M., Argentina, M., and Mahadevan, L., 2014, "Scaling macroscopic aquatic locomotion", *Nature Physics*, Vol. 10, pp. 758 – 761.
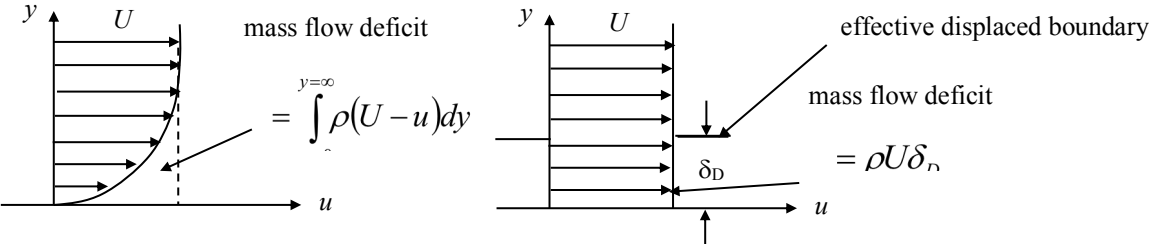

Swimming #, Sw = ωAL/ν

Boundary Layer - Thicknesses
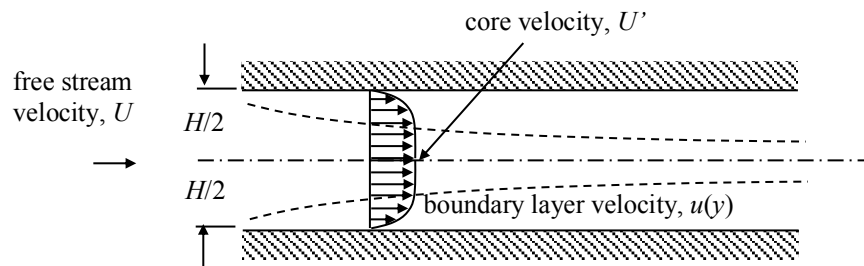
1.   (99%) boundary layer thickness, δ:

2.   displacement thickness, δ_D or δ^*:

mass flow deficit

$$= \int_{\hat{}}^{y=\infty} \rho(U-u)\,dy$$

effective displaced boundary

mass flow deficit

$$= \rho U \delta_D$$

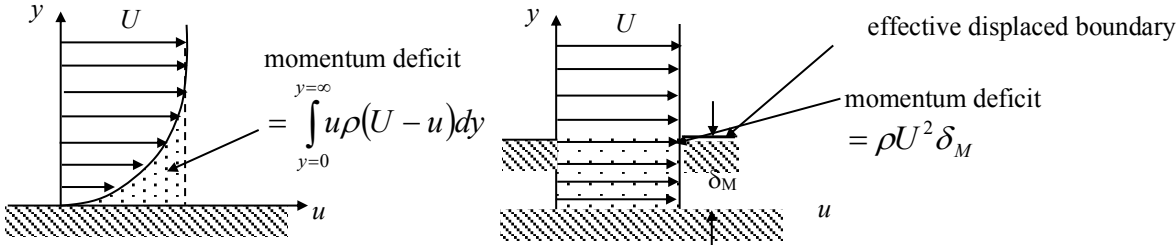# Boundary Layer - Thicknesses

Example:

Consider the mass flow rate between two parallel plates in which a boundary layer has formed:

Determine the mass flow rate through the channel in terms of the displacement thickness.
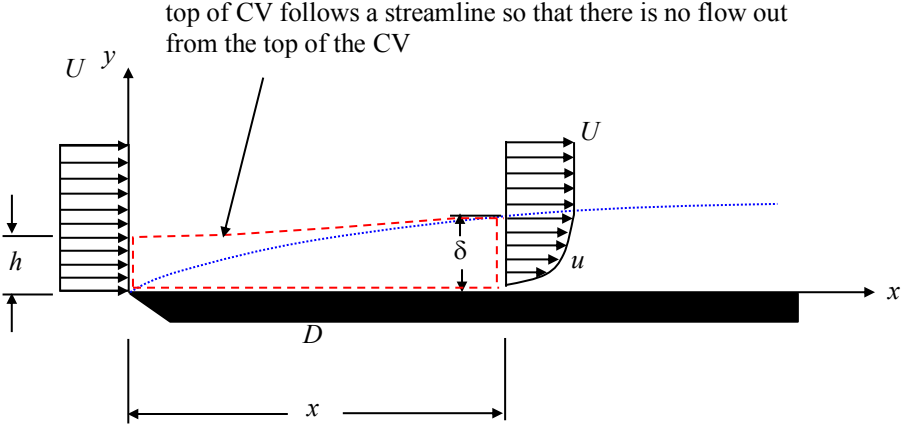
Boundary Layer - Thicknesses

3.　　momentum thickness, δ_M or Θ:

momentum deficit

$$= \int\limits_{y=0}^{y=\infty} u\rho(U - u)dy$$

effective displaced boundary

momentum deficit

$$= \rho U^2 \delta_M$$

Boundary Layer - Thicknesses

Example:

Consider the boundary layer flow over a flat plate.

top of CV follows a streamline so that there is no flow out
from the top of the CV

Determine the drag acting on the plate in terms of the momentum thickness.