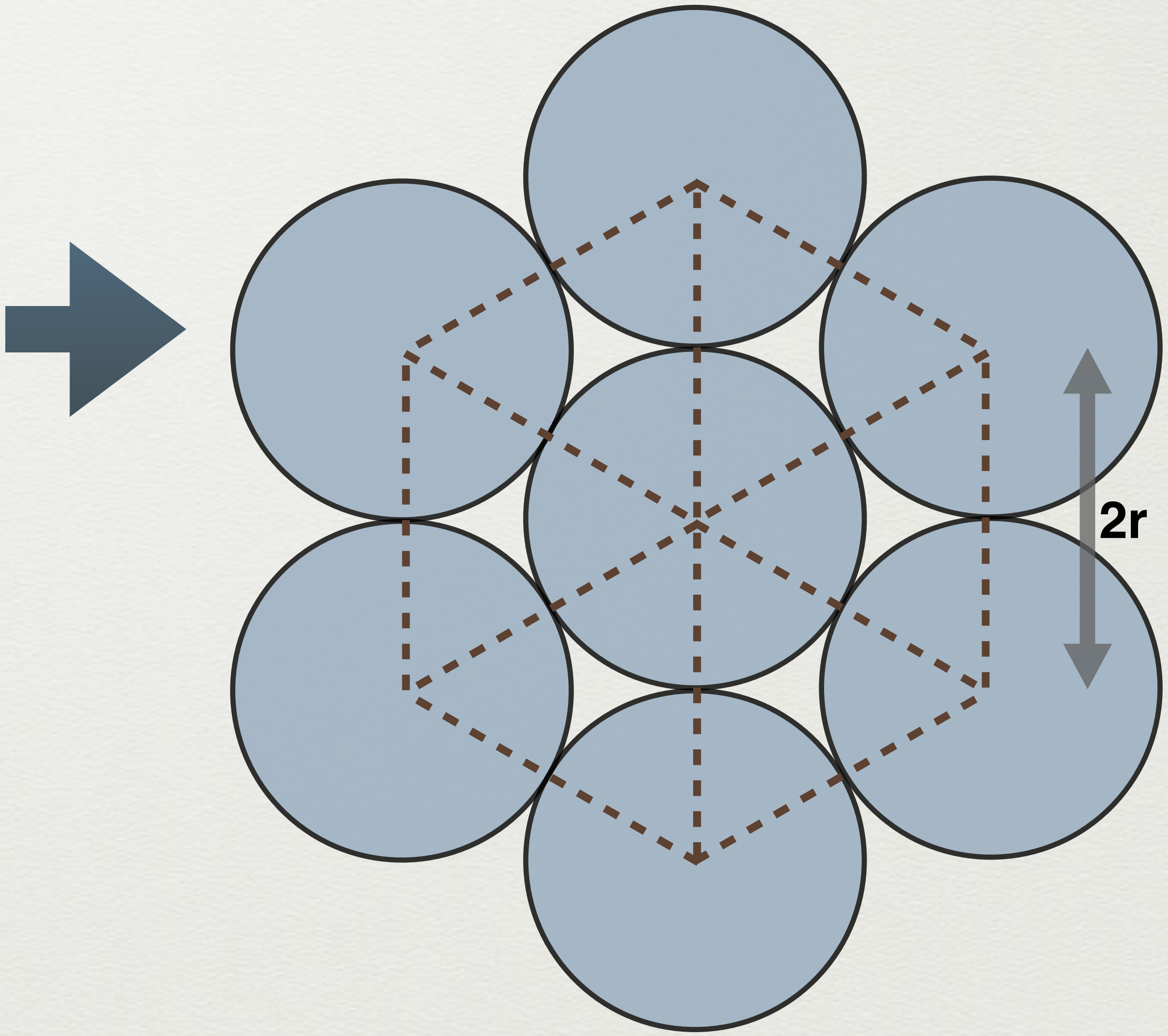
how many molecules can be packed onto a surface?

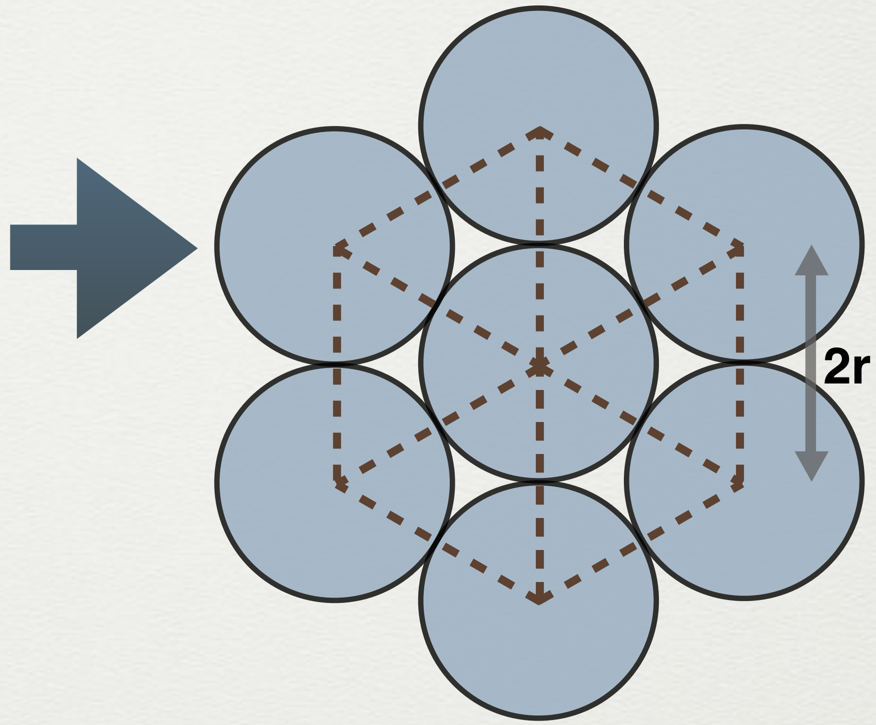
the maximum number of spheres that can be packed onto a surface is through hexagonal close packing



each triangle contains half a sphere
(area of each ▲ = $r^2\sqrt{3}$)

how many molecules can be packed onto surface of a rectangular microfluidic flow channel?

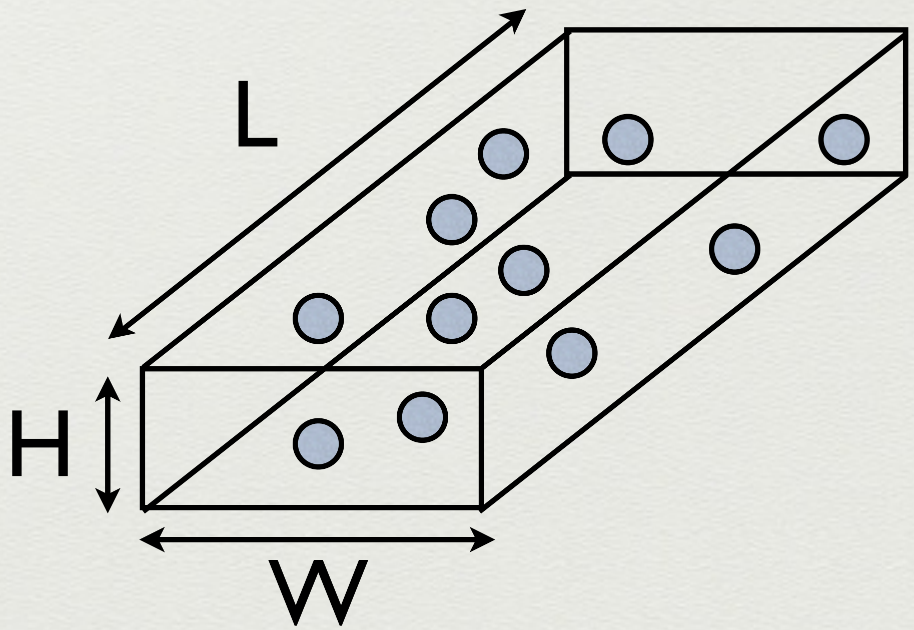
the maximum number of spheres that can be packed onto a surface is through hexagonal close packing



each triangle contains half a sphere (area of each ▲ = $r^2\sqrt{3}$)

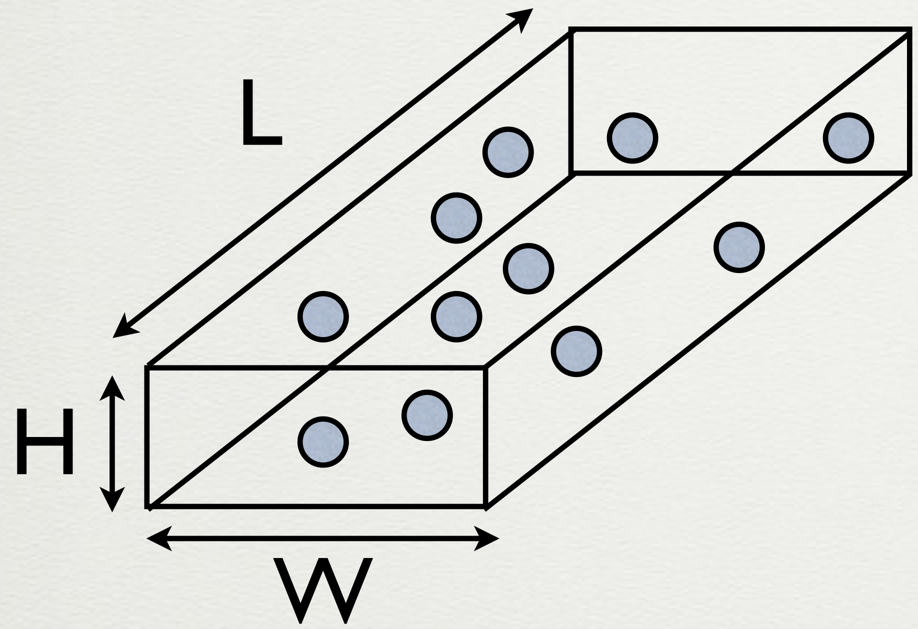
surface area of a rectangular chamber:

$$2(L \cdot W + L \cdot H + W \cdot H)$$



the maximum number of spheres that can be packed onto the surface of a rectangular chamber: $\frac{1}{2}\left[\frac{2(L \cdot W + L \cdot H + W \cdot H)}{r^2\sqrt{3}}\right] = \frac{(L \cdot W + L \cdot H + W \cdot H)}{r^2\sqrt{3}}$

how many molecules can be packed onto surface of a rectangular microfluidic flow channel?



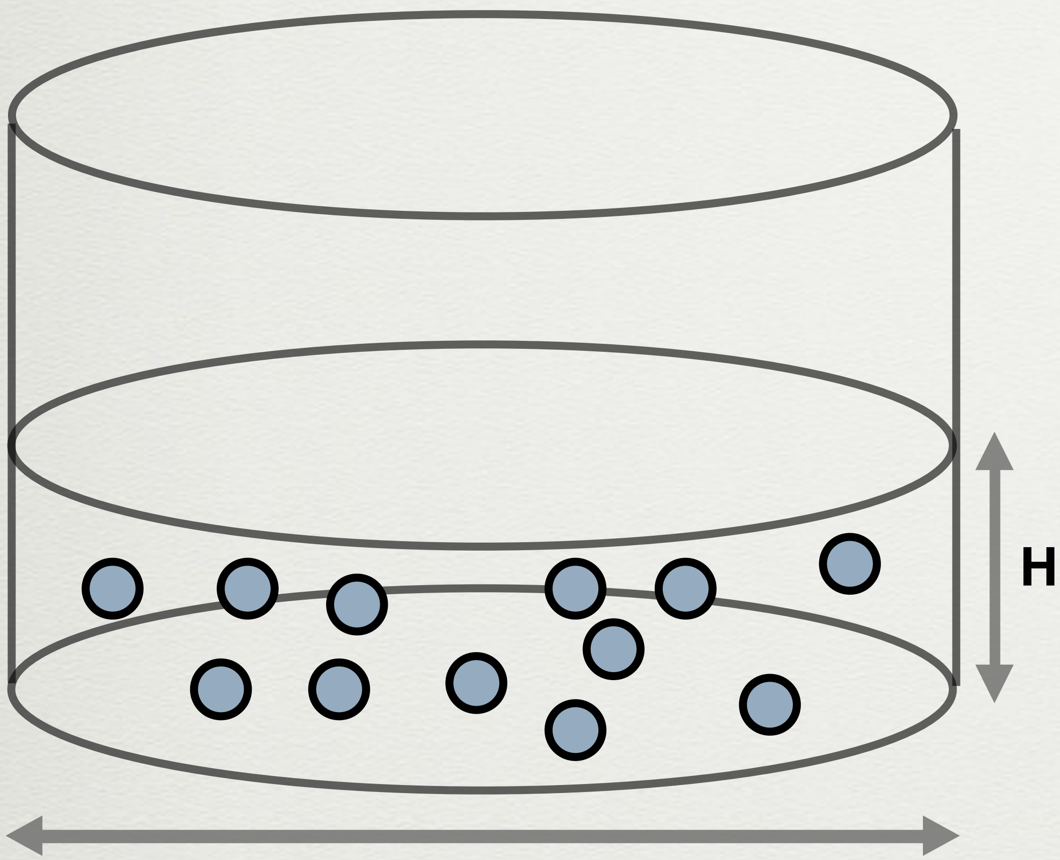
length (L): 1 cm
width (W): 500 µm
height (H): 50 µm

vol: $L \cdot W \cdot H$ (0.25 µL)
total surface area:
$2(L \cdot W + L \cdot H + W \cdot H)$ (0.11 cm^2)

example: BSA adsorption
concentration: 20 µg/mL
vol: 0.25 µL
molecular weight: 66 kDa
total num soluble BSA: 4.5×10^{10}
assumed radius: 5 nm

total surface area:
0.11 cm^2 (4.31×10^{11} BSA)

how many molecules can be packed onto surface of a tissue culture well (on a 24-well plate)?



vol: 300 µL
base area: πR^2
height: vol/base area = 1.5 mm
wall area: $2\pi R \cdot H$
total surface area = $\pi R^2 + 2\pi R \cdot H$

example: BSA adsorption
concentration: 20 µg/mL
vol: 300 µL
molecular weight: 66 kDa
total num soluble BSA: 1×10^{19}
assumed radius: 5 nm

surface area covered by 300 µL in a well:
2.68 cm^2 (1.38×10^{13} BSA)

estimating the time required for adsorption (by diffusion)

molecular diffusion is essentially the same as coin-tossing, and assumes normal distribution given large number of molecules.

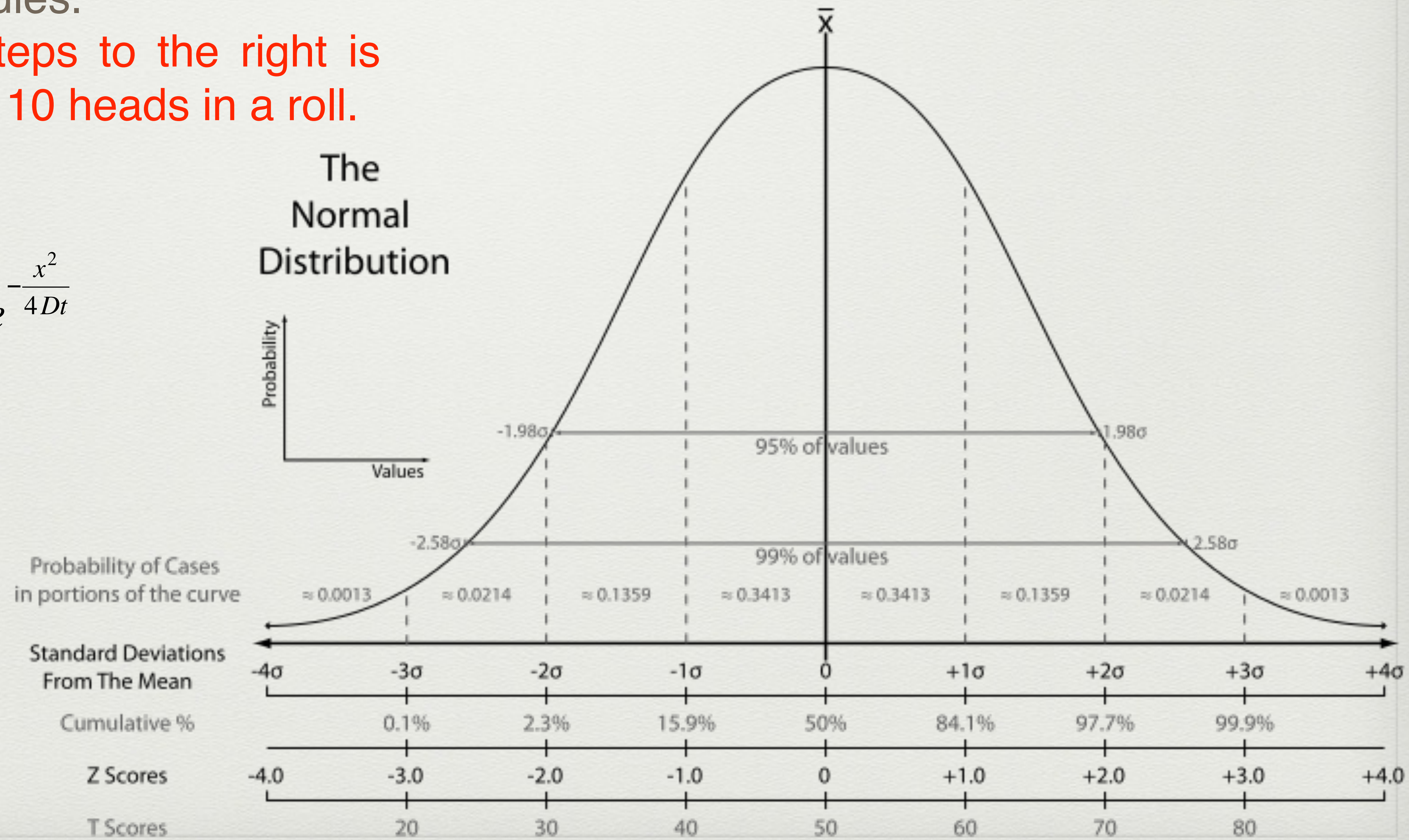
i.e. moving 10 steps to the right is the same tossing 10 heads in a roll.

$$f(x, \mu, \sigma) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

$$p(x,t) = \frac{1}{\sqrt{4\pi Dt}} e^{-\frac{x^2}{4Dt}}$$

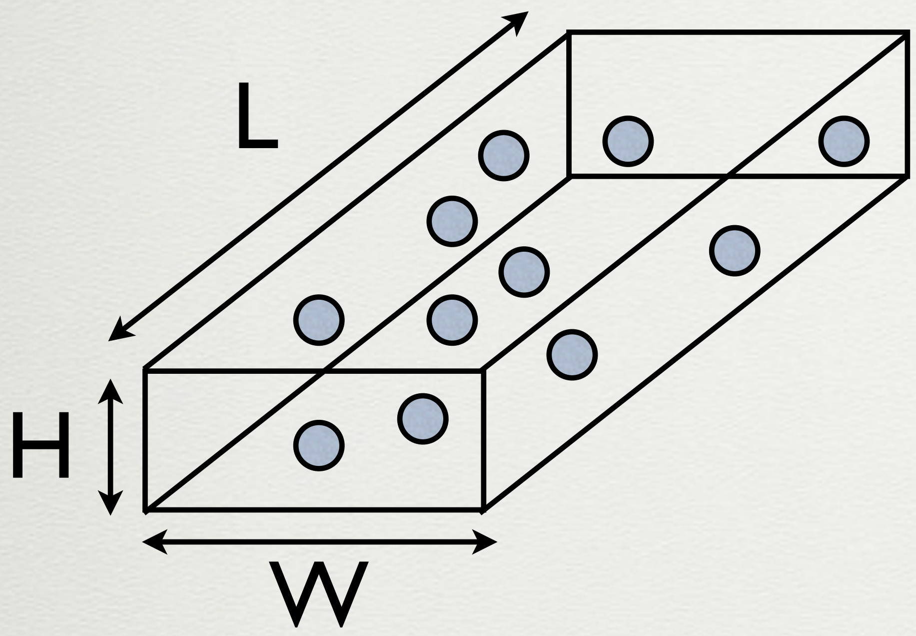
$$D = \frac{\delta^2}{2\tau}$$

$$\tau = \frac{\delta^2}{2D}$$



http://upload.wikimedia.org/wikipedia/commons/thumb/2/25/The_Normal_Distribution.svg/725px-The_Normal_Distribution.svg.png

time required for “most” molecules to be adsorbed onto a rectangular microfluidic flow channel:



length (L): 1 cm
width (W): 500 µm
height (H): 50 µm

$$\delta = \frac{H}{2}$$

(25×10^{-4} cm)

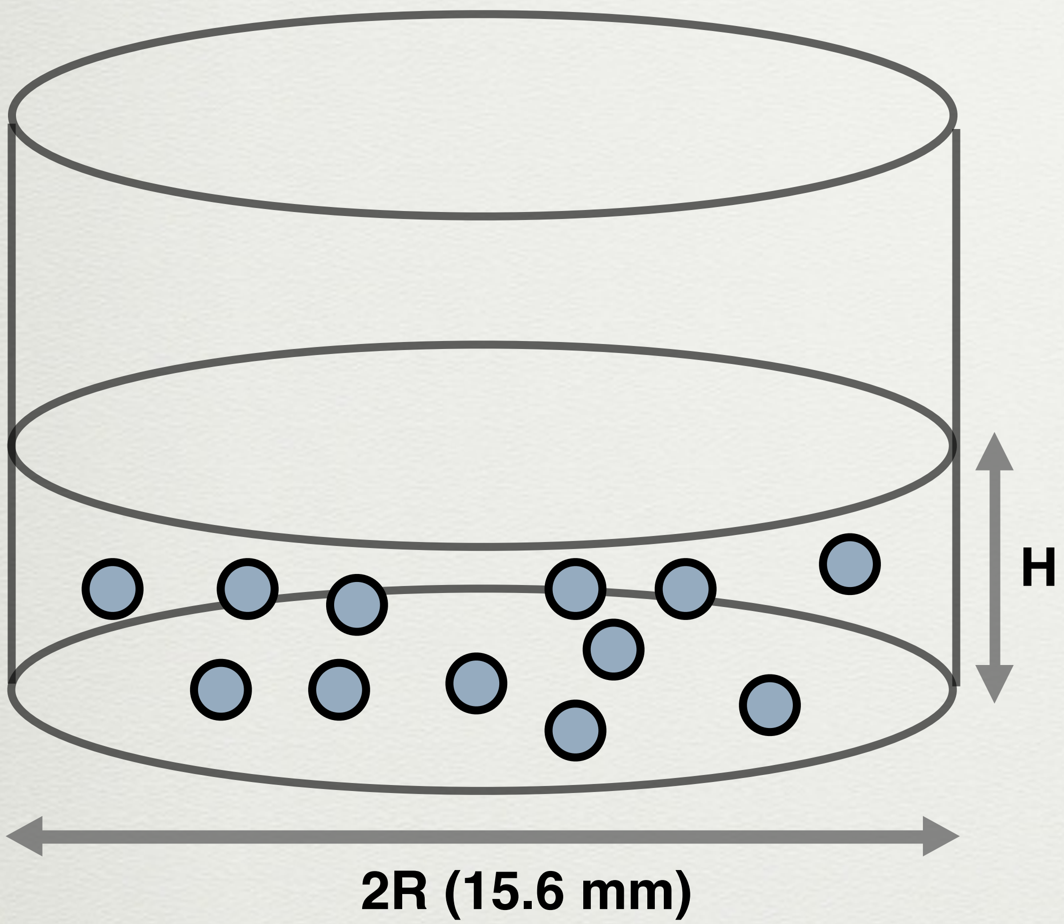
example: BSA adsorption

diffusion coefficient: 8×10^{-7} cm^2/sec

$$\tau = \frac{\delta^2}{2D}$$

(~7.8 sec)

time required for "most" molecules to be adsorbed onto a tissue culture well (on a 24-well plate):



vol: 300 µL
base area: πR^2
height: vol/base area = 0.15 cm
wall area: $2\pi R \cdot H$
total surface area = $\pi R^2 + 2\pi R \cdot H$

example: BSA adsorption

concentration: 20 µg/mL
vol: 300 µL
molecular weight: 66 kDa
total num soluble BSA: 1×10^{19}
diffusion coefficient: 8×10^{-7} cm^2/sec

$$\tau = \frac{\delta^2}{2D}$$

given half an hour (τ = 1800 sec), a volume with a height of 0.04 cm (δ) has been "depleted", this volume contains 9.73×10^{12} BSA

number of BSA in depletion zone: 1.38×10^{13} BSA