$$N_T = N_0 \bullet 2^{(T/g)}$$

as time increases, t/g = 1, 2, 3 ..., thus 2^1, 2^2, 2^3, etc.

g is the generation time

N_0 is the number of cells at time T = 0

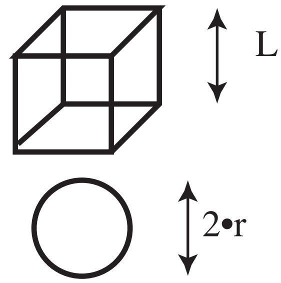
N_T is the number of cells at time T

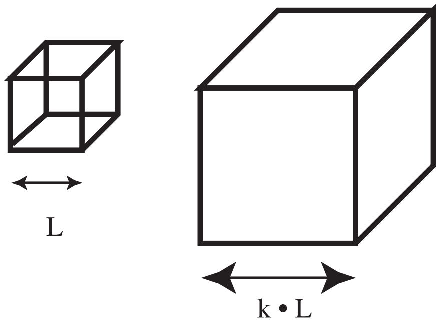
Logistic growth curve:

$$N_T = \frac{K \bullet N_0 \bullet e^{T/g}}{K + N_0(e^{T/g} - 1)}$$

K is the carrying capacity

A cube has a surface area of $6 \bullet L^2$. Its volume is L^3. As long as the shape is constant, the ratio of suraface area to volume will always be $(6 \bullet L^2) / L^3$, or 6/L.
For a sphere, the surface area is $4 \bullet \pi \bullet r^2$, and the volume is $\pi \bullet r^3$; the corresponding ratio of surface area to volume is 4/r.





(area) $A_1 = 6 \bullet L^2$ $A_k = 6 \bullet (k \bullet L)^2$ $A_k = 6 \bullet k^2 \bullet L^2$ ($= k^2 \bullet A_1$)
(volume) $V_1 = L^3$ $V_k = (k \bullet L)^3$ $V_k = k^3 \bullet L^3$ ($= k^3 \bullet V_1$)
The scaling coefficient is different for area (k^2) and for volume (k^3).

Heat conduction rates are defined by the relation: $P_{cond} = Q / t = k \bullet A \bullet [(T_a - T_b) / L]$ where P_{cond} is the rate of conduction (transferred heat, Q, divided by time, t); k is the thermal conductivity; T_a and T_b are the temperatures of the two heat reservoirs a and b; A is the area; and L is the distance. Thermal conductivities of water and air are about 0.6 and 0024 W m^{-1} K^{-1}, respectively.
Thermal radiation is defined by the relation: $P_{rad} = \sigma \bullet \varepsilon \bullet A \bullet T^4$
where P_{rad} is the rate of radiation; σ is the Stefan-Boltzmann constant ($5.6703 \bullet 10^{-8}$ W m^{-2} K^{-4}; ε is the emissivity (varies from 0 to 1, where 1 is for a blackbody radiator); A is the area; and T is the temperature (in Kelvins). The *net* radiative emission or absorption will depend upon the difference in temperature: $P_{net} = \sigma \bullet \varepsilon \bullet A \bullet (T^4_{body} - T^4_{ambient})$

$$\text{compression} = \rho \bullet h \quad F_{cr} = \frac{E \bullet I \bullet \pi^2}{L_{eff}^2} \quad \Psi_{wv} = \frac{RT}{\overline{V}_w} \ln\left(\frac{\%\text{ relative humidity}}{100}\right) + \rho_w g h$$

$$F_{cr} = \frac{E \bullet \frac{\pi \bullet r}{4} \bullet \pi^2}{(2 \bullet h)^2}, \text{ and } F_{cr} = \rho \bullet \pi \bullet r^2 \bullet h$$

velocity (meters sec^{-1})

pressure difference (Pascal = 1 kg m^{-1} sec^{-1})

tube radius

$$v = \left(\frac{\Delta p}{l}\right)\left(\frac{1}{4 \bullet \eta}\right)(R^2 - r^2)$$

distance (meters)

viscosity (water = 0.01 gm cm^{-1} sec^{-1}, or Pa sec)

distance from center of tube

density (water = 1 gm cm^{-3})

velocity (cm sec^{-1})

tube diameter (cm)

$$R_e = \frac{\rho \bullet \nu \bullet l}{\eta}$$

viscosity (water = 0.01 gm cm^{-1} sec^{-1})

$$v = \left(\frac{\Delta p}{l}\right)\left(\frac{1}{4 \bullet \eta}\right) R^2$$

$$J_v = \left(\frac{\Delta p}{1}\right)\left(\frac{\pi}{8 \bullet \eta}\right) \bullet R^4$$

$$J_V = -\frac{r^2}{8 \bullet \eta} \bullet \frac{\partial P}{\partial x}$$

$$J = -D\frac{\partial c}{\partial x}$$

Fick’s First Law of Diffusion: The flux is proportional to the concentration gradient

$$\frac{\partial c}{\partial t} = -\frac{\partial J}{\partial x}$$

Fick’s Second Law of Diffusion: Changes in concentration over time depend upon the flux gradient

$$\frac{\partial c}{\partial t} = D\frac{\partial^2 c}{\partial x^2}$$

$$J = -\frac{1}{2} \bullet \frac{\Delta^2}{\tau} \bullet \frac{dC}{dx}$$

$$\nabla \nu = u\frac{\partial}{\partial x} + v\frac{\partial}{\partial y} + w\frac{\partial}{\partial z}$$

$$D = \frac{1}{2} \bullet \frac{\Delta^2}{\tau}$$

velocity vector —the notation grad ν is sometimes used

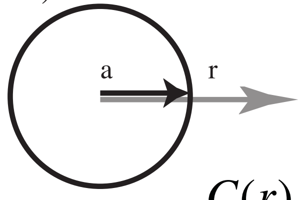
with velocity components, u, v, and w, in the three dimensions, x, y, and z.

units: moles cm^{-2} sec^{-1}

$$J_x = -D\frac{\partial c}{\partial x} + v_x \bullet c$$

(cm sec^{-1})(moles cm^{-3})

(cm^2 sec^{-1})(moles cm^{-4})



Fick's First law : $J_r = -D\frac{\partial C}{\partial r}$

Fick's Second Law : $\frac{\partial C}{\partial t} = D\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial C}{\partial r}\right) = 0$

$$C(r) = C_0\left(1 - \frac{a}{r}\right)$$

(steady state)

$$J_r(a) = -D \bullet C_0 \bullet 4 \bullet \pi \bullet a = I_D$$ (diffusive current)

(mole cm^{-2} sec^{-1}) (units of mole sec^{-1})

$$P_e = \frac{2 \bullet a \bullet u}{D}$$

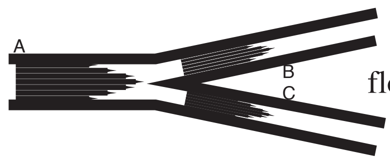
$$I_m = 4 \bullet \pi \bullet a^2 \bullet \beta$$ (metabolic current)

(cm^2) (units of mole sec^{-1})

$$\frac{\partial C}{\partial t} = u \bullet \frac{\partial C}{\partial r} \bullet C + D\frac{\partial^2 C}{\partial r^2}$$

flow velocity; concentration gradient; concentration

$$Q = \frac{\Delta p}{l}\frac{\pi a^4}{8\eta}$$



$$\mu_j^{liquid} = \mu_j^* + RT\ln a_j + \overline{V}_j P + z_j FE + m_j gh$$

fluid density; velocity

$$D = \frac{1}{2} \bullet \rho \bullet V^2 \bullet A \bullet C_D$$

frontal area; drag coefficient (shape-dependent)

$$m\left(-\frac{d\upsilon}{dt}\right) = 6 \bullet \pi \bullet \eta \bullet r \bullet \upsilon$$

$$\upsilon(t) = \upsilon_0 e^{\left(-\frac{6 \bullet \pi \bullet \eta \bullet r}{m} \bullet t\right)}$$

$$V_{\text{terminal}} = \sqrt{\frac{2mg}{\rho A C_D}}$$

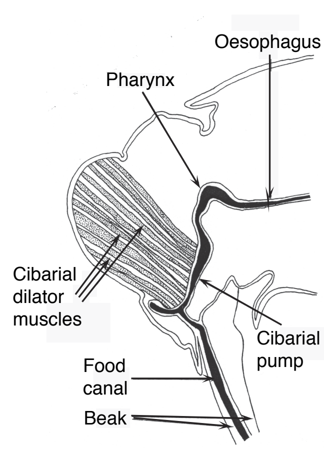
Frictional force

$$F_f = 6\pi\eta a v$$

Where the frictional and gravitational forces are balenced, the velocity reaches a steady state.

Gravitational pull

$$F_g = \tfrac{4}{3}\pi a^3 \Delta\rho g$$



The energetic details of the pumping mechanism are shown below for *Rhodnius* (a blood sucking insect) and spittlebugs (*Philaenus*)[1].

	Rhodnius	*Philaenus*
Muscle tension (maximum)	600 kPa	600 kPa
Pump stroke frequency	3 Hz	1.7 Hz
Muscle contraction rate (muscle lengths per second)	1 s^{-1}	0.5 s^{-1}
Ratio of muscle/piston	2.5	10.0
Maximum muscle tension	–300 kPa	–2400 kPa

Symbol	Value	Units	Comments
GAS CONSTANT			
R	8.314	J mol^{-1} K^{-1}	R is the Boltzmann constant times Avogadro's Number ($6.023 \bullet 10^{23}$)
	1.987	cal mol^{-1} K^{-1}	
	8.314	m^3 Pa mol^{-1} K^{-1}	
RT	$2.437 \bullet 10^3$	J mol^{-1}	At 20 ºC (293 ºK)
	$5.833 \bullet 10^2$	cal mol^{-1}	At 20 ºC (293 ºK)
	2.437	liter MPa mol^{-1}	At 20 ºC (293 ºK)
RT/F	25.3	mV	At 20 ºC (293 ºK)
2.303 • RT	5.612	kJ mol^{-1}	At 20 ºC (293 ºK)
	1.342	kcal mol^{-1}	At 20 ºC (293 ºK)
FARADAY CONSTANT			
F	$9.649 \bullet 10^4$	coulombs mol^{-1}	F is the electric charge times Avogadro's Number
	$9.649 \bullet 10^4$	J mol^{-1} V^{-1}	
	23.06	kcal mol^{-1} V^{-1}	
CONVERSIONS			
kcal	4.187	kJ (kiloJoules)	Joules is an energy unit (equal to 1 Newton•meter)
Watt	1	J sec^{-1}	
Volt	1	J $coulomb^{-1}$	
Amperes	1	coulomb sec^{-1}	
Pascal (Pa)	1	Newton $meter^{-2}$	Pascal is a pressure unit (equal to 10^{-5} bars)
Siemens	1	Ohm^{-1}	Siemens (S) is conductance, the inverse of resistance (Ohm)
PHYSICAL PROPERTIES			
η_w	$1.004 \bullet 10^{-3}$	Pa sec	viscosity of water at 20 ºC
ν_w	$1.004 \bullet 10^{-6}$	m^2 sec^{-1}	kinematic viscosity of water at 20 ºC (viscosity/density)
V_w	$1.805 \bullet 10^{-5}$	M^3 mol^{-1}	Partial molal volume of water at 20 ºC (viscosity/density)

Source: Nobel, Park S (1991) Physicochemical and Environmental Physiology