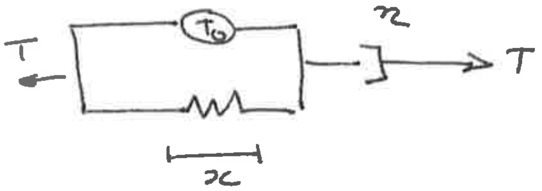
Crib 4G6 (2013)

1

(a)



$$T_0 + kx = -\eta\dot{x}$$

$$\frac{-\eta\dot{x}}{T_0+kx} = 1$$

(20%)

(b)

$$\frac{-\eta\,dx}{T_0+kx} = dt$$

$$-\frac{\eta}{k}\ln\left(\frac{T_0+kx}{C}\right) = t$$

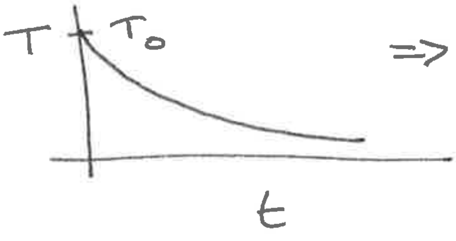
$$kx = Ce^{-\frac{kt}{\eta}} - T_0$$

$$kx = 0 \quad @ \quad t = 0 \Rightarrow C = T_0$$

$$kx = T_0\left[e^{-\frac{kt}{\eta}} - 1\right]$$

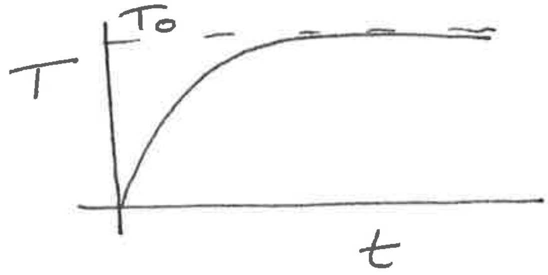
$$T = T_0 + kx = T_0e^{-\frac{kt}{\eta}}$$

(c)

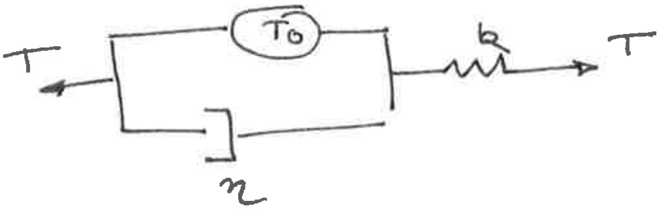


⇒ model predicts tension rises instantaneously to T_0 & then decays away

We would anticipate that the response of a muscle under isometric conditions to be



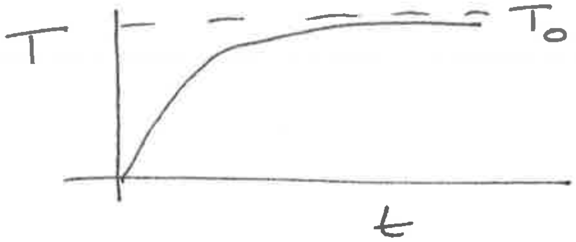
(d)



$$T_0 + \eta \dot{x} = kx$$

$$\Rightarrow \quad \frac{\eta \, dx}{T_0 - kx} = dt$$

$$kx = T_0\left[1 - e^{-\frac{kt}{\eta}}\right] = T$$



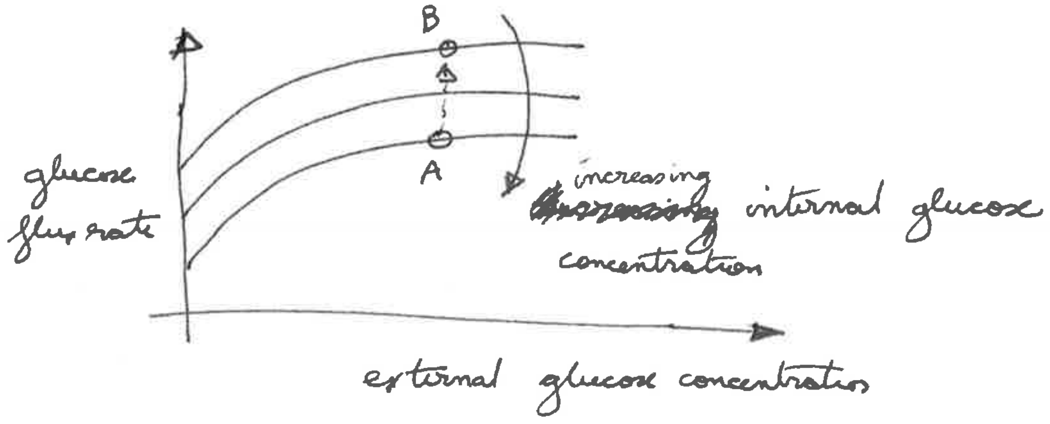
as anticipated for a muscle under isometric conditions.

2

(a) Glucose transport across the cell membrane occurs by carrier mediated transport (Uniports). The carrier molecule alternately exposes ~~the~~ its binding site first on one side & then the other side of the membrane first capturing glucose on one side & then releasing it on the other side

(b) Insulin affects the binding affinity of the glucose to the carrier molecule & thus controls the flux rate of glucose

(c)



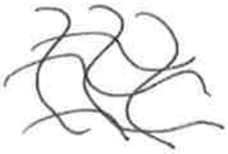
(d) The phosphorylation of glucose decrease the internal glucose concentration & thereby results in the operating point moving from A to B on the graph above resulting in an increased flux rate.

(e) ~~[illegible]~~ Carrier mediated transport is a passive transport mechanism & is ~~not~~ thus not affected by ATP concentration.

3

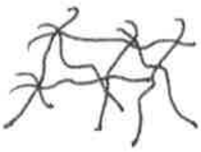
(a) Animal cells have a semi-permeable cell ~~wall~~ membrane which results in loss of water from the cell by Osmosis when there is a high external concentration of a salt or sugar solution. On the other hand, plant cells ~~walls do~~ have a non semi-permeable cell wall which prevents loss of water by osmosis.

(b) The collagen fibres within skin are in a wavy network.



This ~~[illegible]~~ means that the effective modulus of skin is not governed by the stretching of the ~~collagen~~ collagen fibres but rather by the bending of the fibres. Hence the modulus of skin is much less than that of the collagen fibres.

(c) ~~the~~ The cell membrane of red blood cells comprises a triangulated network of spectrin.

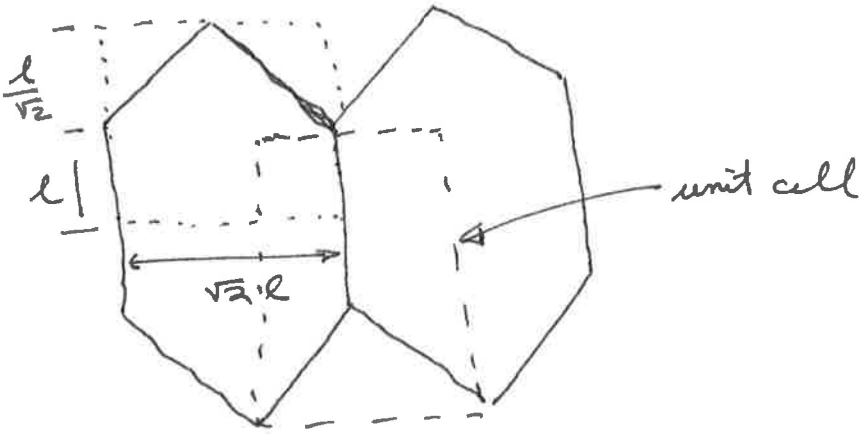


However, the spectrin fibres are wavy & thus even though they form a stretching governed triangulated lattice, they deform by bending due to their wavy nature & hence the cell membrane of red blood cells is very compliant.

(d) Animal cells have a semi-permeable cell membrane which case loose water by osmosis & thus ion pumps are required to maintain ion concentrations & thus control osmosis. Plant cells have a cell wall which prevents osmosis & hence ion pumps are not required to maintain ion concentrations.

4

(a)



$$\cancel{\bar{\rho} = \frac{\quad}{\sqrt{2}l\left(l+\frac{l}{\sqrt{2}}\right)}}$$

$$\bar{\rho} = \frac{2lt + 2lt}{\sqrt{2}l\left(2l + \frac{l}{\sqrt{2}}\right)}$$

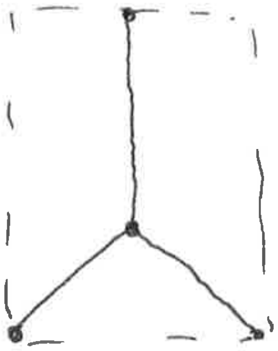
$$= \frac{4t}{l\left(2\sqrt{2}+1\right)}$$

(b)
(i)

$$\Sigma_{3Y}\,\sqrt{2}l\left(2l + \frac{l}{\sqrt{2}}\right) = \sigma_Y\left[2lt + 2lt\right]$$

$$\frac{\Sigma_{3Y}}{\sigma_Y} = \bar{\rho}$$

b
(ii)



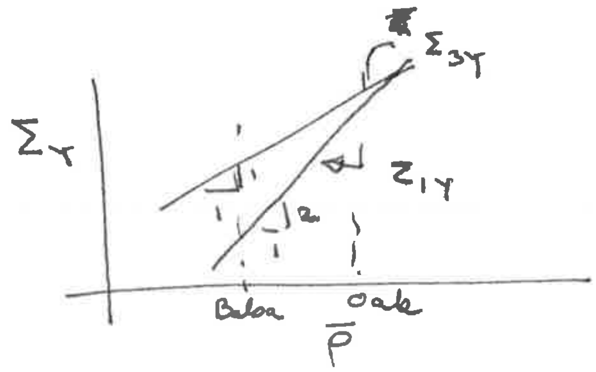
$$\Sigma_{1Y}\left(2l + \frac{l}{\sqrt{2}}\right)u = M_p\theta + \frac{M_p\theta}{3} + \frac{M_p\theta}{3}$$

$$= \frac{5M_p\theta}{3}$$

$$\theta = \frac{\sqrt{2}u}{l}$$

$$\Rightarrow \quad \frac{\Sigma_{1Y}}{\sigma_Y} = \frac{5}{12(\sqrt{2}+1)}\,\frac{(2\sqrt{2}+1)^2}{16}\,\bar{\rho}^2$$

(c)



Balsa has a much lower density compared to oak & hence based on the above graph will have $\Sigma_{1Y} << \Sigma_{3Y}$ while the 2 strengths converge at higher densities as in oak.