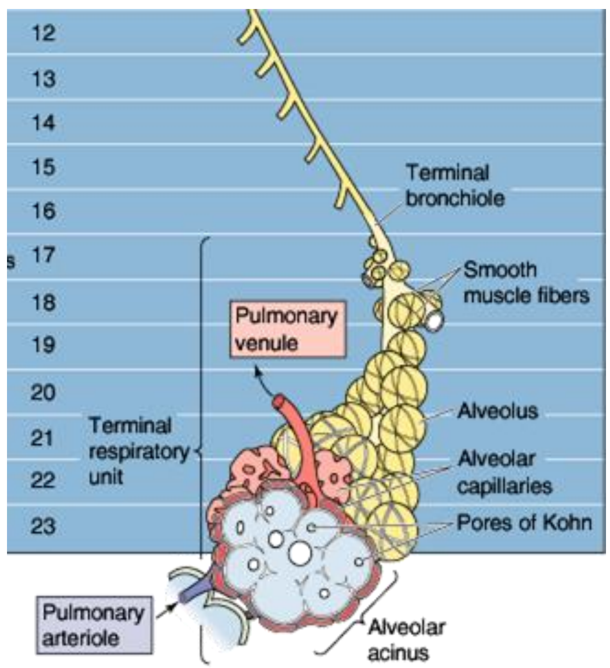


R (reservoir)

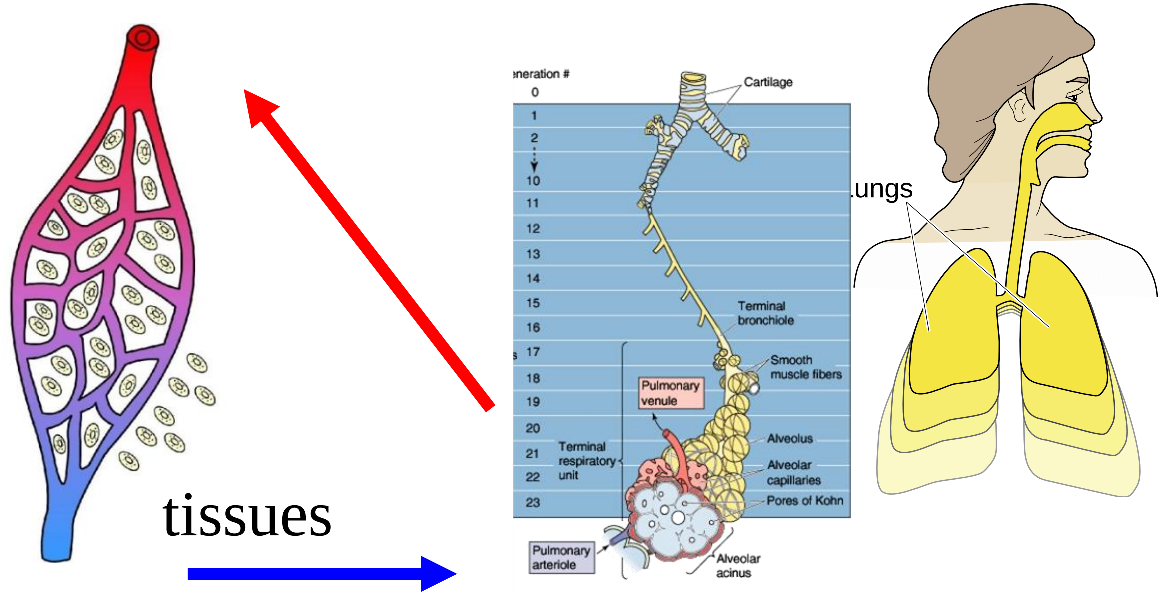
P (prot. layer)

skin

bloodstream

Oxygen transfer in lungs

$$J = \frac{DA}{L}(C_a - C_b)$$



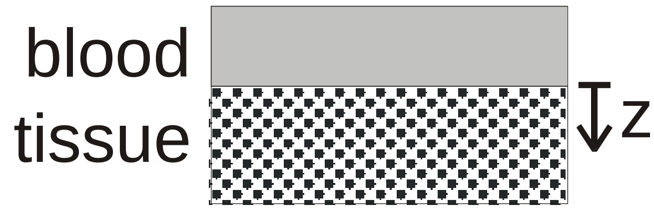
- Driven by O_2 gradient.
  - P_{O2} : in lungs = 100 mm Hg; in tissues 40 mm Hg
  - Assume an average difference of 30 mm Hg
- With solubility, σ_{O2}, of 1.4×10^{-6} M/mm Hg, C_a-C_b = 4.2×10^{-5} M
- Assume lung lining: L – 10 μm, D = 1 μm^2/msec
- Need 11 mmol/min O_2.
- Solve for A, plug in numbers, A = 43 m^2, compare to 30 – 100 m^2

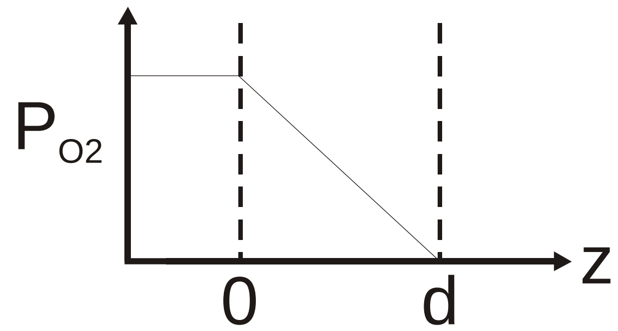
Capillary architecture

- How deep into tissues can O_2 be delivered?
- Assume:
  - 1-D diffusion system
  - P_{O2} = 40 mm Hg at z = 0
    P_{O2} = 0 mm Hg at z = d
  - All oxygen demand is localized to z = d.
- Total demand (d) = $A*d*j_{O2}$;
  j_{O2} = demand per volume of tissue,
  A = cross sectional area.
- Delivery (d) = J = (D*A/L)*ΔC

$$d = \sqrt{\frac{D_{O2} * \sigma_{O2} * P_{O2,blood}}{j_{O2}}}$$

$$d = 118\ \mu m$$

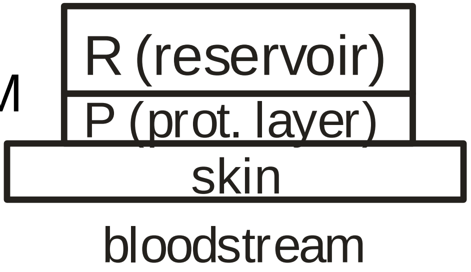




Drug delivery patch design

Layer	***Thickness***	***D*** ***(μm^2/sec)***	***β***
Reservoir	∞	1	1
Protective layer	100 um	500	0.1
Skin	100 um	200	1

- Drug A
- Reservoir, [A] = 10 mM; Bloodstream, [A] = 0 mM assumption for maximum delivery
- Consider as 1-D diffusion



- This patch must deliver a flux of 1 x 10^{-10} mol/sec of A to the individual. What is the patch size that will provide this flux?

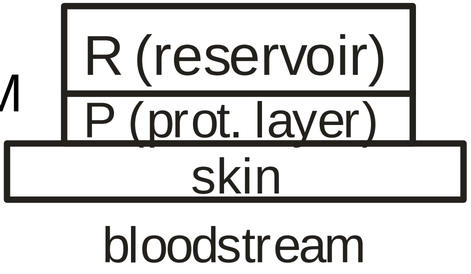
$$J = \frac{1}{(R_a + R_b)} * \Delta C = \frac{1}{R_{ser}} \Delta C; R_{ser} = R_a + R_b$$

$$R_{ser} = \frac{L_a}{D_a A_a \beta_a} + \frac{L_b}{D_b A_b \beta_b} \text{ which for equal areas } = \frac{1}{A}\left(\frac{L_a}{D_a \beta_a} + \frac{L_b}{D_b \beta_b}\right)$$

plug in for variables, A = 25 mm^2

Drug delivery patch design

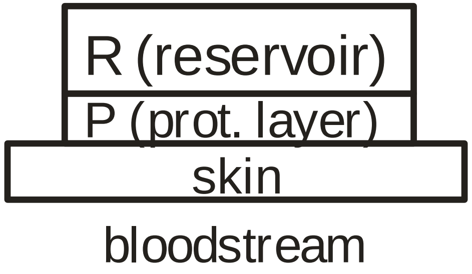
Layer	***Thickness***	***D*** ***(μm^2/sec)***	***β***
Reservoir	∞	1	1
Protective layer	100 um	500	0.1
Skin	100 um	200	1



- Drug A
- Reservoir, [A] = 10 mM; Bloodstream, [A] = 0 mM assumption for maximum delivery
- Consider as 1-D diffusion
- New guidelines dictate that the concentration of A must not exceed 1 mM at any point in the individual (skin & bloodstream). Does the patch meet this requirement? Start by finding concentration drop across each component, predict profile, account for β.

Drug delivery patch design

Layer	*Thickness*	*D* (μm^2/sec)	β
Reservoir	∞	1	1
Protective layer	100 um	500	0.1
Skin	100 um	200	1



- Find the concentration drop expected across each layer
  - Use the flux times equivalent resistance for each layer. J*R = ΔC; R = L/(β*A*D)
    - ΔCa = J * Ra = 8 mM
    - ΔCb = J * Rb = 2 mM
  - Use these drops in concentration to predict profile at interfaces. Then, account for changes in beta along the system. That is, if the outer sections are exposed to water, then just multiply the predicted profile by β in each region.

$$\mathrm{A}(x) = f(x) = \begin{cases} 10mM,\ x < 0 \\ 0.1 * \left(10mM - \frac{8mM}{100\mu m}(x)\right),\ 0 \le x < 100\mu m \\ 2mM - \frac{2mM}{100\mu m}(x - 100),\ 100\mu m \le x < 200\mu m \\ 0,\ 200\mu m \le x \end{cases}$$

Does this meet the guidelines?

R (reservoir)

P (prot. layer)

skin

bloodstream