1. Binding

a) [L] = 1.00 nM $\quad$ s_L = 0.05 nM

Kd = 12.7 nM $\quad$ s_{Kd} = 0.7 nM

We know that $f_{bnd} = \frac{[PL]}{Pt} = \frac{[L]}{K_d + [L]}$

Thus, $\frac{\partial f}{\partial [L]} = \frac{1}{K_d + [L]} - \frac{L}{(K_d + [L])^2}$ and $\frac{\partial f}{\partial K_d} = -\frac{[L]}{(K_d + [L])^2}$

Plugging in given values for K_d and [L] we find that:

$\frac{\partial f}{\partial [L]} = 0.0676648$ and $\frac{\partial f}{\partial K_d} = -0.00532793 = 0.00532793$

Now we apply the standard deviation formula:

$$s_{f_{bnd}} = \sqrt{\left(\frac{\partial f}{\partial [L]} * s_L\right)^2 + \left(\frac{\partial f}{\partial [K_d]} * s_{Kd}\right)^2} = 0.00503546$$

And using the above equations and values we find that f_{bnd} is: 0.0729927. So with proper significant figures, f_{bnd} is = 0.073 ± 0.005 for one standard deviation.

For [L] = 100 ± 5nM we go through the same procedure outlined above, and we find that f_{bnd} = 0.89 ± 0.01 for one standard deviation.

b) Can we distinguish between 20 μM and 50 μM concentrations? First calculate f_{bnd} for [L] = 20 μM:

$f_{bnd} = \frac{20000}{12.7 + 20000} = 0.999365$, remember that $20\mu M * \frac{1000nM}{\mu M} = 20000nM$

The standard deviation is:

$$\frac{\partial f}{\partial K_d} = -\frac{[L]}{(K_d + [L])^2}$$

$$s_{f_{bnd}} = \sqrt{\left(\frac{\partial f}{\partial K_d} * s_{Kd}\right)^2} = 0.0000349556$$

So f_{bnd}= 0.999365 ± 0.00003 for one standard deviation. But with two significant figures this becomes 1.0 ± 0.0.

We use the same procedure to get f_{bnd} at [L] = 50 μM: 0.999746 ± 0.00001, or 1.0 ± 0.0 with two significant figures. Now we compare the results:

$| f_{bnd,20} - f_{bnd,50} | = | 1.0 - 1.0 | = 0$

$s_{fbnd,20} + s_{fbnd,50} = 0.00003 + 0.00001 = 0.00004$

Since the sum of the errors is greater than the difference of the f_{bnd} values, there is overlap and the results cannot be distinguished from one another. This makes sense because we are way up in the saturation part of the enzyme kinetics curve, where $[L] \gg K_d$.

2. Organs and Function, MMD – 9.2

From the problem definition, we are told that fat and protein are 50% carbon by weight. A water-free mass of the human body consists only of the mass of fat and protein, which is 50% carbon as we said above. So we estimate the fraction of carbon in this water-free mass to be 0.5

From MMD p. 19, we know that the mass of a cell is 50% carbon-mass on a water-free basis, which means the cell has a mass carbon fraction of 0.5.

Thus, the water-free carbon mass fraction is the same for the cell and body.

3. Organs and Function, MMD – 9.5

a) The percentage of blood entering kidneys that is filtered is: =

$$\frac{125\frac{ml}{\min}}{1200\frac{ml}{\min}} = 0.10416 = 10.4\%$$

b) The average human holds 5 liters of blood (MMD p. 142). We assume the person is at rest, so this person's resting heart output is 5 liters/min. Thus, the total blood flow is 5 liters/min, and we find that:

$\frac{125\frac{ml}{\min}}{5000\frac{ml}{\min}} = 0.025$ is the fraction of total blood flow that is filtered every minute.