EXERCISE SET 1 SOLUTIONS

BIOPHYSICS I

1(a) By averaging all the side chains of the 20 amino acids, we can get the number of C, H, O, N atoms. The result is C$\simeq$ 3, H$\simeq$ 6, N$\simeq$ 1/2 and O$\simeq$ 1/2. The main chain has C=2, H=2 (lose 2 in forming peptide), N=1, O=1 (lose 1 in forming peptide).

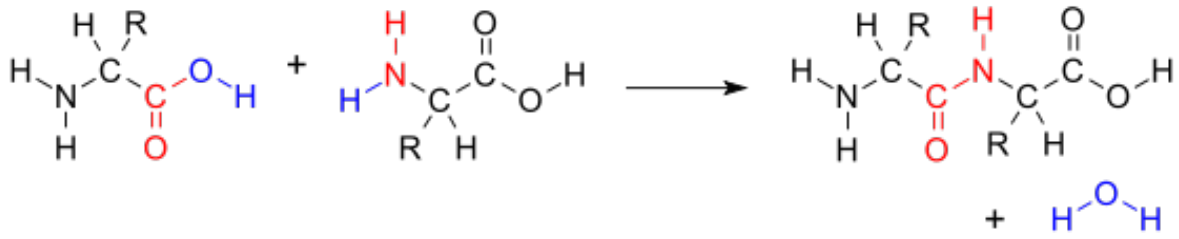

FIGURE 1. The condensation of two amino acids to form a peptide bond (red) with expulsion of water (blue)

There are two choices for calculating the typical size of an amino acid: C=5, H=8, N=2, O=1 (112 Da) or C=5, H=10, N=2, O=2 (120Da). Either way gives us a mass of roughly 110 Daltons.

Amino Acid	glycine	proline	arginine	tryptophan
Mass (Da)	57	98	157	186

(b) The rule: $M_{protein}(Da)$ = number of amino acids ·110Da.

Name	number of aa	Est. Mass (kDa)	Actual Mass (kDa)	% error
Myosin	3530	388.3	480	19
G-actin	375	41.3	42	1.7

(c) The rule: $M_{protein}(Da) = (\frac{R_g - 7.257}{0.395})^{\frac{5}{3}} \cdot 110Da$.

Name	amino acids	$R_{protein}$ aa
Myosin	3500	$\sim 60\mathring{A}$
G-actin	375	$\sim 21\mathring{A}$

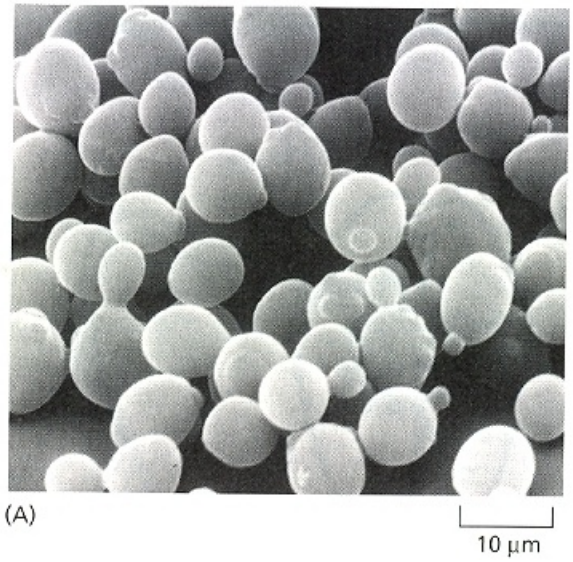

FIGURE 2

2(a) Each "cross", the unit that gets repeated in this structure, can be approximated by three cylinders of length $a \approx 400$ nm and diameter $d \approx 100$ nm. Therefore, its surface area is $3 \times \pi \times 100$ nm $\times$ 400 nm $\approx 3.8 \times 10^5$ nm^2. Now, each one of these units occupies a volume $a^3 \approx 9.4 \times 10^{-3}$ μm^3.

If we assume a volume of 500 μm^3 we can fit 500 μm^3/(9.4×10^{-3} μm^3) $\approx 5 \times 10^4$ such units. This in turn corresponds to a total surface area of $5 \times 10^4 \times 3.8 \times 10^5$ nm^2 = 2×10^3 μm^2.

(b) The mitochondria in this yeast are shaped like a cylinder with a diameter of 400 nm approximately (which could be the resolution limit of the microscope). The total extension of this cylinder is about 20 μm (this is only a rough estimate). This results in a total mitochondrial volume of $\pi(0.2\ \mu\text{m})^2 \times 20\ \mu\text{m} \approx 2.5\ \mu\text{m}^3$. The total area is $2\pi \times 0.2\ \mu\text{m} \times 20\ \mu\text{m} \approx 25\ \mu\text{m}^2$.

Mitochondria are thus just a small fraction of the total yeast volume, which is around 270 μm^3. (We estimate a radius of 4μm based on Figure 2)