

The Foundations of Biochemistry

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1. The Size of Cells and Their Components

(a) If you were to magnify a cell 10,000-fold (typical of the magnification achieved using an electron microscope), how big would it appear? Assume you are viewing a "typical" eukaryotic cell with a cellular diameter of 5.0 mm.

(b) If this cell were a muscle cell (myocyte), how many molecules of actin could it hold? Assume the cell is spherical and no other cellular components are present; actin molecules are spherical, with a diameter of 3.6 nm. (The volume of a sphere is $4/3 \pi r^3$.)

(c) If this were a liver cell (hepatocyte) of the same dimensions, how many mitochondria could it hold? Assume the cell is spherical; no other cellular components are present; and the mitochondria are spherical, with a diameter of 1.5 mm.

(d) Glucose is the major energy-yielding nutrient for most cells. Assuming a cellular concentration of 1 mM (i.e., 1 millimole/L), calculate how many molecules of glucose would be present in our hypothetical (and spherical) eukaryotic cell. (Avogadro's number, the number of molecules in 1 mol of a monoisotopic substance, is 6.02×10^{23} .)

(e) Hexokinase is an important enzyme in the metabolism of glucose. If the concentration of hexokinase in our eukaryotic cell is 2.0 mM, how many glucose molecules are present per hexokinase molecule?

Answer

(a) The magnified cell would have a diameter of 5.0×10^{-3} mm = 5.0×10^{-3} mm = 5.0 mm, or 20 inches—about the diameter of a large pizza.

(b) The radius of a globular actin molecule is $3.6 \text{ nm}/2 = 1.8 \text{ nm}$; the volume of the molecule, in cubic meters, is $(4/3)(3.14)(1.8 \times 10^{-9} \text{ m})^3 = 2.4 \times 10^{-26} \text{ m}^3$.¹ The number of actin molecules that could fit inside the cell is found by dividing the cell volume (radius = 2.5 mm) by the actin molecule volume. Cell volume = $(4/3)(3.14)(2.5 \times 10^{-6} \text{ m})^3 = 6.5 \times 10^{-14} \text{ m}^3$. Thus, the number of actin molecules in the hypothetical muscle cell is

$$(6.5 \times 10^{-14} \text{ m}^3)/(2.4 \times 10^{-26} \text{ m}^3) = 2.7 \times 10^{12} \text{ molecules}$$

or 2.7 trillion actin molecules.

¹Significant figures: In multiplication and division, the answer can be expressed with no more significant figures than the least precise value in the calculation. Because some of the data in these problems are derived from measured values, we must round off the calculated answer to reflect this. In this first example, the radius of the actin (1.8 nm) has two significant figures, so the answer (volume of actin = $2.4 \times 10^{-26} \text{ m}^3$) can be expressed with no more than two significant figures. It will be standard practice in these expanded answers to round off answers to the proper number of significant figures.

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Joacim Rocklöv

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Complete Solutions Manual for Biochemistry, 4/e Christopher K. Mathews,2013-10-10 Solutions Manual to Accompany Lehninger, Nelson, Cox Principles of Biochemistry, Second Edition Albert L. Lehninger, Frederick Wedler,1993-12-01

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