

The Foundations of Biochemistry

1

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 50 μm .
- (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 μm .
- (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 nonionized 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 20 mM, how many glucose molecules are present per hexokinase molecule?

Answer

- (a) The magnified cell would have a diameter of $50 \times 10^4 \mu\text{m} = 500 \times 10^3 \mu\text{m} = 500 \text{ mm}$, 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 $(4/3)(3.14)(1.8 \times 10^{-9} \text{ m})^3 = 2.4 \times 10^{-26} \text{ m}^3$.
The number of actin molecules that could fit inside the cell is found by dividing the cell volume (radius = 25 μm) by the actin molecule volume. Cell volume = $(4/3)(3.14)(25 \times 10^{-6} \text{ m})^3 = 6.5 \times 10^{-14} \text{ m}^3$. 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.

**Significant 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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1. Understanding the eBook Biochemistry Lehninger Solution Manual
 - The Rise of Digital Reading Biochemistry Lehninger Solution Manual
 - Advantages of eBooks Over Traditional Books
2. Identifying Biochemistry Lehninger Solution Manual
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Biochemistry Lehninger Solution Manual
 - User-Friendly Interface
4. Exploring eBook Recommendations from Biochemistry Lehninger Solution Manual
 - Personalized Recommendations
 - Biochemistry Lehninger Solution Manual User Reviews and Ratings
 - Biochemistry Lehninger Solution Manual and Bestseller Lists
5. Accessing Biochemistry Lehninger Solution Manual Free and Paid eBooks
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 - Biochemistry Lehninger Solution Manual Enhanced eBook Features
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 - Adjustable Fonts and Text Sizes of Biochemistry Lehninger Solution Manual
 - Highlighting and Note-Taking Biochemistry Lehninger Solution Manual
 - Interactive Elements Biochemistry Lehninger Solution Manual
- 8. Staying Engaged with Biochemistry Lehninger Solution Manual
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Biochemistry Lehninger Solution Manual
- 9. Balancing eBooks and Physical Books Biochemistry Lehninger Solution Manual
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Biochemistry Lehninger Solution Manual
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Biochemistry Lehninger Solution Manual
 - Setting Reading Goals Biochemistry Lehninger Solution Manual
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Biochemistry Lehninger Solution Manual
 - Fact-Checking eBook Content of Biochemistry Lehninger Solution Manual
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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