

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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Recursos para la enseñanza/aprendizaje del metabolismo Miguel Ángel Medina Torres, Fernanda Suárez Marín, Francisco José Alonso Carrión, 2019-10-16 Recursos para la enseñanza aprendizaje del metabolismo es producto de la experiencia de más de treinta años de docencia universitaria y de proyectos de innovación educativa. Contiene información relevante sobre la bibliografía disponible prácticas de laboratorio recursos TIC y de otros tipos para el estudio del metabolismo así como una experiencia singular desarrollada por nuestros propios estudiantes el programa de radio La bicicleta de Krebs. En sus contenidos han colaborado un nutrido grupo de profesores y estudiantes. Confiamos en que esta obra sea una valiosa aunque modesta aportación para cuantos interesados en la docencia del metabolismo se acerquen a su lectura o consulta. Este libro es uno de los productos derivados del Proyecto de Innovación Educativa PIE17/145 de la Universidad de Málaga.

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Table of Contents Biochemistry Lehninger Solution Manual Garrett

1. Understanding the eBook Biochemistry Lehninger Solution Manual Garrett
 - The Rise of Digital Reading Biochemistry Lehninger Solution Manual Garrett
 - Advantages of eBooks Over Traditional Books
2. Identifying Biochemistry Lehninger Solution Manual Garrett
 - 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 Garrett
 - User-Friendly Interface
4. Exploring eBook Recommendations from Biochemistry Lehninger Solution Manual Garrett
 - Personalized Recommendations
 - Biochemistry Lehninger Solution Manual Garrett User Reviews and Ratings
 - Biochemistry Lehninger Solution Manual Garrett and Bestseller Lists

5. Accessing Biochemistry Lehninger Solution Manual Garrett Free and Paid eBooks
 - Biochemistry Lehninger Solution Manual Garrett Public Domain eBooks
 - Biochemistry Lehninger Solution Manual Garrett eBook Subscription Services
 - Biochemistry Lehninger Solution Manual Garrett Budget-Friendly Options
6. Navigating Biochemistry Lehninger Solution Manual Garrett eBook Formats
 - ePub, PDF, MOBI, and More
 - Biochemistry Lehninger Solution Manual Garrett Compatibility with Devices
 - Biochemistry Lehninger Solution Manual Garrett Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Biochemistry Lehninger Solution Manual Garrett
 - Highlighting and Note-Taking Biochemistry Lehninger Solution Manual Garrett
 - Interactive Elements Biochemistry Lehninger Solution Manual Garrett
8. Staying Engaged with Biochemistry Lehninger Solution Manual Garrett
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Biochemistry Lehninger Solution Manual Garrett
9. Balancing eBooks and Physical Books Biochemistry Lehninger Solution Manual Garrett
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Biochemistry Lehninger Solution Manual Garrett
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Biochemistry Lehninger Solution Manual Garrett
 - Setting Reading Goals Biochemistry Lehninger Solution Manual Garrett
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Biochemistry Lehninger Solution Manual Garrett
 - Fact-Checking eBook Content of Biochemistry Lehninger Solution Manual Garrett
 - 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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