

- 1.28 We estimate that the length of a step for an average person is about 18 inches, or roughly 0.5 m.

Then, an estimate for the number of steps required to travel a distance equal to the circumference of the Earth would be

$$N = \frac{\text{Circumference}}{\text{Step Length}} = \frac{2\pi R_e}{\text{Step Length}} = \frac{2\pi(6.38 \times 10^6 \text{ m})}{0.5 \text{ m/step}} = 8 \times 10^7 \text{ steps}$$

or $\boxed{N = 10^8 \text{ steps}}$

- 1.29 We assume an average respiration rate of about 10 breaths/minute and a typical life span of 70 years. Then, an estimate of the number of breaths an average person would take in a lifetime is

$$n = \left(10 \frac{\text{breaths}}{\text{min}}\right) (70 \text{ yr}) \left(\frac{3.156 \times 10^7 \text{ s}}{1 \text{ yr}}\right) \left(\frac{1 \text{ min}}{60 \text{ s}}\right) = 4 \times 10^8 \text{ breaths}$$

or $\boxed{n = 10^9 \text{ breaths}}$

- 1.30 We assume that the average person catches a cold twice a year and is sick an average of 7 days (or 1 week) each time. Thus, on average, each person is sick for 2 weeks out of each year (52 weeks). The probability that a particular person will be sick at any given time equals the percentage of time that person is sick, or

$$\text{probability of sickness} = \frac{2 \text{ weeks}}{52 \text{ weeks}} = \frac{1}{26}$$

The population of the Earth is approximately 7 billion. The number of people expected to have a cold on any given day is then

$$\text{Number sick} = (\text{population})(\text{probability of sickness}) = (7 \times 10^9) \left(\frac{1}{26}\right) = 3 \times 10^8 \text{ or } \boxed{10^9}$$

- 1.31 (a) Assume that a typical intestinal tract has a length of about 7 m and average diameter of 4 cm. The estimated total intestinal volume is then

$$V_{\text{int}} = A\ell = \left(\frac{\pi d^2}{4}\right)\ell = \frac{\pi(0.04 \text{ m})^2}{4}(7 \text{ m}) = 0.009 \text{ m}^3$$

The approximate volume occupied by a single bacterium is

$$V_{\text{bacterium}} = (\text{typical length scale})^3 = (10^{-6} \text{ m})^3 = 10^{-18} \text{ m}^3$$

If it is assumed that bacteria occupy one hundredth of the total intestinal volume, the estimate of the number of microorganisms in the human intestinal tract is

$$n = \frac{V_{\text{int}}/100}{V_{\text{bacterium}}} = \frac{(0.009 \text{ m}^3)/100}{10^{-18} \text{ m}^3} = 9 \times 10^{17} \text{ or } n = \boxed{10^{18}}$$

- (b) The large value of the number of bacteria estimated to exist in the intestinal tract means that they are probably not dangerous. Intestinal bacteria help digest food and provide important nutrients. Humans and bacteria enjoy a mutually beneficial symbiotic relationship.

- 1.32 (a) $V_{\text{int}} = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi(1.0 \times 10^{-6} \text{ m})^3 = \boxed{4.2 \times 10^{-17} \text{ m}^3}$

- (b) Consider your body to be a cylinder having a radius of about 6 inches (or 0.15 m) and a height of about 1.5 meters. Then, its volume is

$$V_{\text{body}} = Ah = (\pi r^2)h = \pi(0.15 \text{ m})^2(1.5 \text{ m}) = 0.11 \text{ m}^3 \text{ or } \boxed{10^{-1} \text{ m}^3}$$

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