1. If a culture of bacteria doubles in two hours, how long will it take to increase to ten times its initial population?

2. Bacteria increase by a factor of ten in ten hours; how many hours to increase by a factor of 100?

3. How old is a skull that has $\frac{1}{5}$ as much radiocarbon as a modern skull?

4. The population of Cairo grew from 5 million to 10 million in 20 years. When was it 8 million?

5. The population of New York and LA are growing at 1% and 1.4% a year. Starting from 8 million (NY) and 6 million (LA), when will they be equal?

6. Suppose the value in $1 in Japanese yen decreases at 2% per year. Starting from $1 = Y240, when will one dollar equal one yen?

7. If $y = 1000$ at $t = 3$, and $y = 3000$ at $t = 4$, what was $y_0$ at $t = 0$ (assuming exponential growth)?

8. Atmospheric pressure decreases with height according to the differential equation $\frac{dp}{dh} = cp$.

   The pressure at $h = 0$ (sea level) is 1013 millibars while at $h = 20$ km the pressure is 50 millibars. Find $c$. Then explain why $p = \sqrt{1013 \cdot 50}$ half-way up at $h = 10$ km.

9. Most drugs in the bloodstream decay according to the differential equation $y' = cy$ (first-order kinetics).

   (a) The half-life of morphine is 3 hours. Find the decay constant $c$.

   (b) The half-life of nicotine is 2 hours. After a six-hour flight, what fraction remains?

10. The antiseizure drug dilantin has constant clearance rate $y' = -a$ until $y = y_1$. Then $y' = -\frac{a}{y_1} \cdot y$.

   Solve for $y(t)$ in two pieces from $y_0$. When does $y$ reach $y_1$?
11. If a bank offers an annual simple interest rate of $\frac{7}{2}\%$ or continuously compounded at $\frac{7}{4}\%$, which is better?

12. What continuous interest rate is equivalent to an annual rate of 9%?

In one year of simple interest, an initial amount $A_0$ grows to $A_0 + 0.09A_0 = 1.09A_0$.

13. You are a loan shark. What is $1$ worth after a year of continuous compounding at 1% per day?

14. At 10% interest, continuously compounded, the $24$ paid to the Indians for Manhattan would be worth how much after 365 years?

15. If Newton’s tea cools from 80° to 60° in 12 minutes (room temperature 20°), find $r$ in Newton’s cooling equation, $T(t) = T_a - (T_a - T_o)e^{-rt}$. When was his tea 100°?