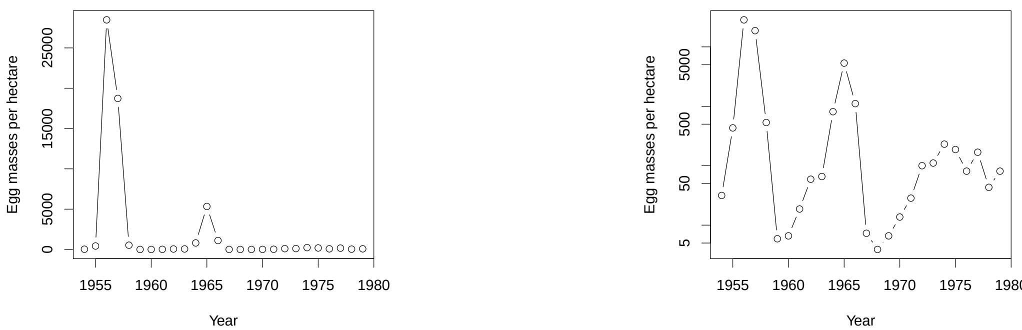
1. If I say a population is changing exponentially, I mean that

   A. It is changing faster and faster
   B. It is changing at a constant rate
   C. **It is changing at a rate proportional to its own size**
   D. It is changing at a rate proportional to the time that has elapsed



2. The picture above on the __________ shows population on a log scale. Compared to the other picture, it shows __________.

   A. left; individual density instead of total density
   B. left; the same numbers, but from a different perspective
   C. right; individual density instead of total density
   D. **right; the same numbers, but from a different perspective**

Use this information for the next three questions. A different population of phytoplankton reproduces on a strict daily cycle. They survive each day with probability 1/2 (so their average life span is 2 days). Surviving phytoplankton produce an average of 0.8 offspring that will survive to be counted the next day.

3. What is the reproductive number $\mathcal{R}$ for this population?

   A. 0.4
   B. 0.8
   C. 1.3
   D. **1.6**
   E. 2.4

4. What is the finite rate of increase reproductive number λ for this population?

   A. 0.4
   B. 0.8
   C. **1.3**
   D. 1.6
   E. 2.4

5. What can you say about the units of the quantities above?

   A. $\mathcal{R}$ is unitless, while λ has units [1/day]
   B. λ is unitless, while $\mathcal{R}$ has units [1/day]
   C. **Both are unitless, but λ is "associated" with the time step of 1 day**
   D. Both are unitless, but $\mathcal{R}$ is "associated" with the time step of 1 day

6. Which of the following is *not* a possible scenario for density-dependent population regulation?

   A. The birth rate decreases with density and the death rate increases
   B. The birth rate and death rate both increase, but the death rate increases faster
   C. The birth rate and death rate both decrease, but the birth rate decreases faster
   D. **The death rate decreases with density and the birth rate increases**

7. A population is regulated with a time delay, following the equation:

$$\frac{dN(t)}{dt} = (b(N(t-\tau)) - d(N(t-\tau)))N(t)$$

We expect it to show __________ oscillations when the unitless delay (τ/t_c) is short, and __________ oscillations when the unitless delay is long

   A. no; damped
   B. no; persistent
   C. damped; damped
   D. **damped; persistent**

8. Compared to the instantaneous rate 0.05/day, the instantaneous rate 1.2/hr:

   A. Means exactly the same thing
   B. Is not directly comparable, because they refer to different time steps
   C. **Is comparable, and refers to a larger (faster) rate**
   D. Is comparable, and refers to a smaller (slower) rate

9. Which of the following best illustrates resource *depletion* as opposed to simple competition?

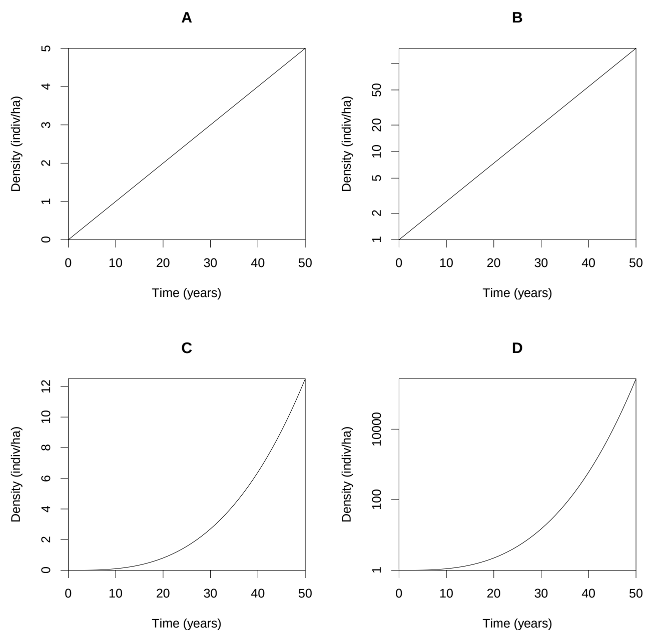
A. Swallows using up all of the available holes in a cliff site for breeding so that no space is left

B. **Swallows eating so many insects that insect population numbers decline**

C. Trees in a forest canopy growing so close together that no light gets through to the lower level

D. Introduced desert weeds using rainwater so efficiently that trees in the area have no access to water

10. *One* of the four pictures below shows a population growing exponentially – which one?



ANS: B

11. In a linear population model, we expect:

A. The reproductive number $\mathcal{R}$ is always > 1

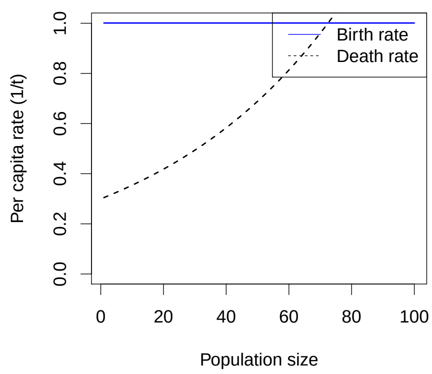
B. The instantaneous growth rate r is always > 1

C. The finite growth rate λ is always > 1

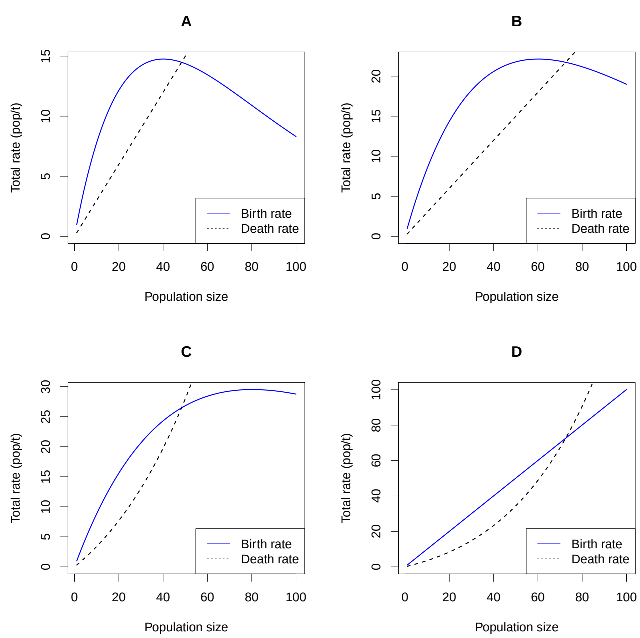
D. $\mathcal{R} > 1$ exactly when $r > 1$

E. $\mathcal{R} > 1$ **exactly when** $\lambda > 1$

Use the picture below for the next four questions. It shows the assumptions made for a continuous-time birth-death model.



12. Which of the four pictures below could be generated by the same model as the picture above?



ANS: D

13. This model has:

A. A stable equilibrium at zero and another stable equilibrium
B. A stable equilibrium at zero and another, unstable equilibrium
C. **An unstable equilibrium at zero and another, stable equilibrium**
D. An unstable equilibrium at zero and another unstable equilibrium

14. The highest *total population* net growth rate (dN/dt) in this model is seen:

A. When the population is very small
B. **When the population is between the two equilibria**
C. When the population is at the nonzero equilibrium
D. When the population is very large

15. The model illustrated above predicts that the population will decrease:

A. When the population is very small (only)
B. **When the population is very large (only)**
C. When the population is very small or very large
D. When the population is between the two equilibria
E. When the population is at the nonzero equilibrium

16. Consider your test paper, the province of Ontario, and the country of Canada. Which two are most similar in area, when considered by absolute difference (linear scale), or by proportional difference (log scale)?

A. The paper is the most different from the other two, on either scale
B. The province is the most different from the other two, on either scale
C. The country is the most different from the other two, on either scale
D. The paper is the most different on the linear scale, and the country is most different on the log scale
E. **The country is the most different on the linear scale, and the paper is most different on the log scale**

17. A pile of radioactive material is decaying *continuously* at an instantaneous rate of 1% per minute. After two minutes, what proportion is left?

A. **A little more than 98%**
B. Exactly 98%
C. A little less than 98%
D. About 30%
E. None

18. (4 points). A population of perennial plants has reproductive adults which produce seeds. Some of these seeds survive the winter and sprout. In addition to producing seeds, the adults pass the winter as root systems underground, and some of these resprout in the spring. We estimate the following. Each reproductive plant produces an average of 60 seeds. Each seed has a 5% probability of sprouting. Each reproducing adult has a 80% probability of resprouting. Each sprout (whether from a seed, or a surviving adult) has a 20% probability of surviving to reproduce at the end of the year. We wish to estimate the growth rate using the formula $\lambda = f + p$. Estimate the value of p, f and λ for this population. Show your work *briefly*. Will the population grow or decline; how do you know?

f is the expected number of new individuals per existing individual: $60\,\text{seeds/ adults} \times 5\,\text{sprouts}/100\,\text{seeds} \times 0.2\,\text{adults/ sprouts} = 0.6$ (the units all cancel). (1 point)

p is the expected probability that an existing individual will be seen again: $0.8\,\text{resprouts/ adults} \times 0.2\,\text{adults/ resprouts} = 0.16$ (1 point)

$\lambda = p + f = 0.76$ (1 point).

If $\lambda > 1$, the population will grow; if $\lambda < 1$ it will decline. Your answer may vary depending on version (1 point).

19. (4 points) Imagine some bacteria in a favorable environment. They are not dying, and are continuously reproducing at a constant per-capita rate of 0.5 new indiv per indiv per day. We start with a density of 1 indiv/ml.

a) Write an equation describing our *assumptions* about how this population changes through time (not the result).

$dN/dt = rN$ or $dN/dt = (b - d)N$

b) What are the birth rate b, death rate d and growth rate r?

$b = 0.5/\,\text{day}$, $d = 0$ (no units required for 0!), $r = 0.5/\,\text{day}$.

c) How many bacteria do we expect to see after a day?

$1\,\text{indiv/ ml}\,\exp(0.5) = 1.65\,\text{indiv/ ml}$.

d) How many bacteria do we expect to see after a week?

$1\,\text{indiv/ ml}\,\exp(3.5) = 33.1\,\text{indiv/ ml}$.