AP BIOLOGY · UNIT 8 · TOPIC 8.3

Population Ecology

Learning objective 8.3.A Describe factors that influence growth dynamics of populations.

Name: Date: Period:

Use the tool **Nothing Stopping It**. Parts 1 and 2 use **Births minus deaths**, Parts 3 and 4 use **What exponential means**, and Parts 5 and 6 use **Taking it literally**. The course framework gives two equations for this topic, and they are not two different laws. **dN/dt = B − D** is the definition of population change and is always true. **dN/dt = r(max)N** is what that equation becomes when nothing limits the population: a special case, and a temporary one. Topic 8.4 adds the term that is missing here.

Part 1 · dN/dt = B − D

Three populations, each starting at **1,000**, each run for **30** steps. Click each scenario in the tool and record B and D. Calculate B − D, then predict whether the population grows or shrinks before you read Population after 30 steps.

Scenario	Birth rate, B	Death rate, D	B − D	N after 30 steps	Growing or shrinking?
Births exceed deaths					
Births equal deaths					
Deaths exceed births					

1. Describe a population.

2. (a) Identify the equation for population growth in terms of births and deaths.

(b) Describe what each symbol in the equation represents.

3. In the scenario in which births equal deaths, the population size does not change. Explain how a population whose size does not change can still have births and deaths.

Part 2 · The trap

Two populations. One has a birth rate of 0.30 and the other a birth rate of 0.05, **6 times** lower. **Write your prediction in the margin** for which one grows. Then read The trap table in the tool and record the birth rate, the death rate, B − D and N after 30 steps for each population.

Population	Birth rate	Death rate	B − D	N after 30 steps
High birth rate, higher death rate				
Low birth rate, lower death rate				

4. Population A has a birth rate of 0.30 and population B has a birth rate of 0.05. Explain why the birth rates alone cannot be used to determine which population is growing faster.

5. The shrinking population in the Part 2 table has a birth rate of 0.30 and a death rate of 0.35. Describe the change in its death rate that would make the population grow if its birth rate did not change.

Part 3 · dN/dt = r(max) N

Four growth rates, each starting from N = **10** and run for **60** steps. Click each value of r in the tool and record its readouts. Steps per doubling is the average number of steps between successive doublings; the dashed marks on the graph show each doubling.

r(max)	N at the end	Added in step 1	Added in the last step	Steps per doubling
0.05				
0.10				
0.20				
0.50				

6. (a) Identify the equation for exponential growth.

(b) Describe what r(max) represents.

7. Using the Part 3 table, explain what makes growth exponential rather than merely fast.

8. In every row of the Part 3 table, the number added in the last step is far larger than the number added in step 1. Using the equation dN/dt = r(max)N, explain why.

Part 4 · Against a flat rival

The same starting size, and a rival that gains exactly **50** individuals every step no matter how large it is, and both start at 10. The tool marks the crossover step on its graph, and Population after 60 steps for r = 0.20 (Part 3) gives the exponential population at step 60. Calculate the other values: the rival has 10 + 50 × (step) individuals, and the exponential population has 10 × 1.2 raised to the power of the step, rounded to a whole number. Show each calculation in the margin beside the table.

	At step 10	At step 20	At the crossover	At step 60
Flat +50 per step				
Exponential, r = 0.20				
Which is ahead?				

9. Using the Part 4 table, explain why a population that is growing exponentially often goes unnoticed as a problem until it is very large.

10. Determine whether the way the exponential population grows changes at the crossover step. Provide reasoning to justify your determination.

Part 5 · Taking “without constraints” literally

The exponential model assumes reproduction **without constraints**. The tool takes these words literally: one bacterium, with a mass of **1e-12 g**, dividing every **20 minutes**, with nothing limiting it. Record the tool’s readouts, then complete the last two rows.

Quantity	Value
Doublings needed to outweigh the Earth	
Time that takes, in hours	
Time that takes, in days	
Has this ever happened?	
What must be true of every real population?	

11. Using the Part 5 table, explain why the assumption of unlimited reproduction can be true only for a short time.

12. (a) Describe three situations in which exponential growth is observed.

(b) Describe what the three situations have in common.

13. Topic 8.4 adds one factor to the equation dN/dt = r(max)N.
(a) Predict the effect that the factor must have on the growth rate when the population is small.

(b) Predict the effect that the factor must have on the growth rate when the population reaches the largest size the environment can support.

Part 6 · Factors and adaptations

The tool's factor table describes the four quantities in the two equations: B, D, N and r(max). Sort each adaptation below by **which term of dN/dt = B − D they act on**. Some raise B and some lower D, and an equal change in either has the same effect on dN/dt.

Adaptation	Resource it secures	Raises B or lowers D?	How it works
Deep root systems in arid plants			
Caching food for winter			
Nitrogen-fixing root nodules in legumes			
Migration			
Dormancy and seed banks			

14. (a) Describe one adaptation that increases population growth by raising the birth rate.

(b) Describe one adaptation that increases population growth by lowering the death rate.

15. Identify the factors that influence the growth dynamics of a population.

What the model simplifies

Both equations are run in discrete steps rather than as true differential equations, because a step-by-step version is what a student can follow and reproduce by hand. The continuous solutions differ slightly: the doubling time of the discrete model is log 2 / log(1 + r) rather than log 2 / r, and the tool reports the average doubling time measured from its own numbers.

Birth and death rates are treated as per-capita constants. Real populations have age structure, and the same overall birth rate means very different things in a population of juveniles and one of post-reproductive adults. Age structure is the largest thing left out.

The bacterium calculation uses a mass of one picogram and a twenty-minute division time, both round figures rather than measurements of a particular species. The conclusion is robust to a wide margin of error in either.

The comparison with a population adding a fixed number each step is a device rather than a biological claim. Nothing in nature adds exactly fifty individuals per interval regardless of its size; the comparison exists to separate “growing quickly” from “growing exponentially”, which are the two things students most often merge.