

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 hands you 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 becomes when nothing is limiting the population — a special case, and a temporary one. The next topic supplies the term that is missing here, so it is worth finishing this handout knowing exactly what is missing and roughly what it has to do.

Part 1 • $dN/dt = B - D$

Three populations, each starting at **1,000**, each run for **30** steps. Fill in the difference for each and predict the direction before you read off the final column.

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. State what a population is.

2. Write the equation for population growth in terms of births and deaths, and explain what each symbol means.

3. In the scenario where births equal deaths the population does not change at all. Explain why this is not the same as nothing happening.

Part 2 · The trap

Two populations. One has a birth rate **6 times** higher than the other. **Write your prediction in the margin** for which one survives, before you fill in the last column.

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 you cannot say from that which one is growing faster.

5. Explain what would have to change for the shrinking population in your table to start growing, without altering its birth rate at all.

Part 3 · $dN/dt = r(\text{max}) N$

Four growth rates, each starting from $N = 10$ and run for **60** steps. The important column is the last one. Measure the gap between successive doublings and see whether it changes as the population gets larger.

$r(\text{max})$	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. Write the equation for exponential growth and explain what $r(\text{max})$ represents.

7. Explain what makes growth exponential rather than merely fast.

8. In every row, the number added in the last step is far larger than the number added in the first. Explain why, in terms of the equation.

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. Find the step at which the exponential population overtakes it, and compare them at the end.

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

9. Explain why a population growing exponentially is often not recognized as a problem until suddenly it is.

10. At the crossover, does anything about how the exponential population is growing change? Explain your answer.

Part 5 · Taking “without constraints” literally

The exponential model assumes reproduction **without constraints**. Those three words are carrying the whole model, so it is worth finding out what they imply. One bacterium, mass **1e-12 g**, dividing every **20 minutes**, with nothing whatever limiting it.

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

11. Explain why the assumption of unlimited reproduction is never true for long.

12. Describe three situations in which exponential growth actually is observed, and state what they have in common.

13. The next topic adds one factor to this equation. Predict what that factor has to do, and when it has to start doing it.

Part 6 · Factors and adaptations

Between them, four quantities make up both equations in this topic. Fill in what each one does, and then sort the adaptations by **which term of $dN/dt = B - D$ they act on** — some raise B and some lower D, and both are worth exactly the same.

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. Describe two adaptations that raise population growth, one acting through the birth rate and one through the death rate.

15. List 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 here is $\log 2 / \log(1 + r)$ rather than $\log 2 / r$ — and the tool reports the discrete figure because that is what its own numbers do.

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.