# POPULATION GROWTH

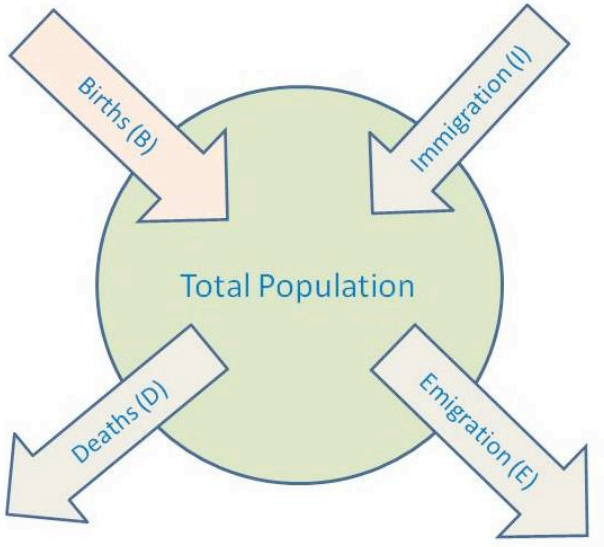
**(How is population growth naturally regulated?)**

## Why?

The current world population is estimated to be over 6.8 billion. At present the number of births annually exceeds the number of deaths, which means that the population is increasing, and is estimated to reach 9 billion by 2040. Back in 1750 the world population was estimated at less than 800 million.

How are growing populations such as ours, controlled and supported and can they continue to grow indefinitely?

## Model 1: Population Growth




1. What is the term used for populations moving into an area?
2. What is the term used for populations leaving an area?
3. What two factors cause an increase in the population size?
4. Name two factors that cause a decrease in population size.

5. Using the diagram and the letters B, D, E & I, write mathematical expressions to show the following:

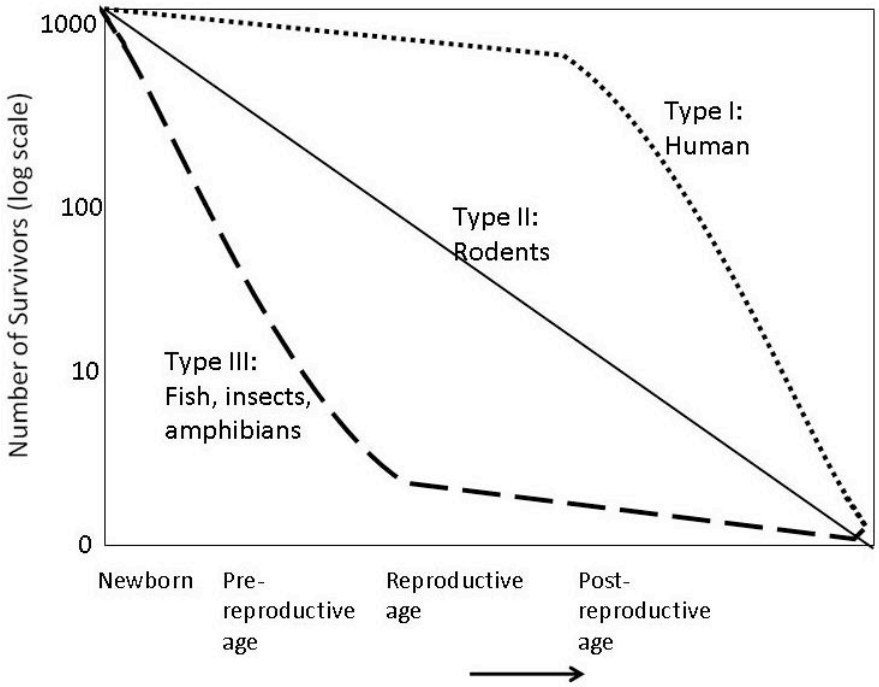
    a. A stable population:

    b. A declining population:

    c. A growing population:

    d. Population growth:

## Model 2: Survivorship Curves




6. What does the x-axis on the graph represent?

7. Which type of organism shows a steady decline at all life stages?

8. Which type of organism loses most of their individuals at an early life stage?

9. What survivor type are humans?

10. Using complete grammatical sentences, with your group describe the pattern of survivorship for type I individuals.

11. When the number of survivors is 100, at what life stage is each survivor type?

    a. Type I –

    b. Type II -

    c. Type III –

12. Which of the three groups/types have the highest number of individuals that reach reproductive age?

13. What is the difference in the average number of offspring that can potentially be produced by each of the three survivorship types?

14. How do populations with type II or III survivorship compensate for the high pre-reproductive mortality?

15. Considering the evolutionary strategies that each survivorship type has developed for producing and rearing their young, can you develop a hypothesis as to why type I survivors have the highest relative number of individuals/1000 births that survive until post-reproductive age?

16. Under what circumstances might human populations not show type I survivorship.

## Model 3: Growth Curves

Diagram A – Exponential Growth Curve

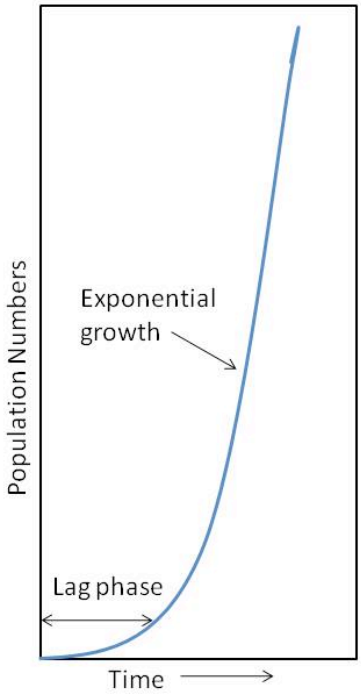
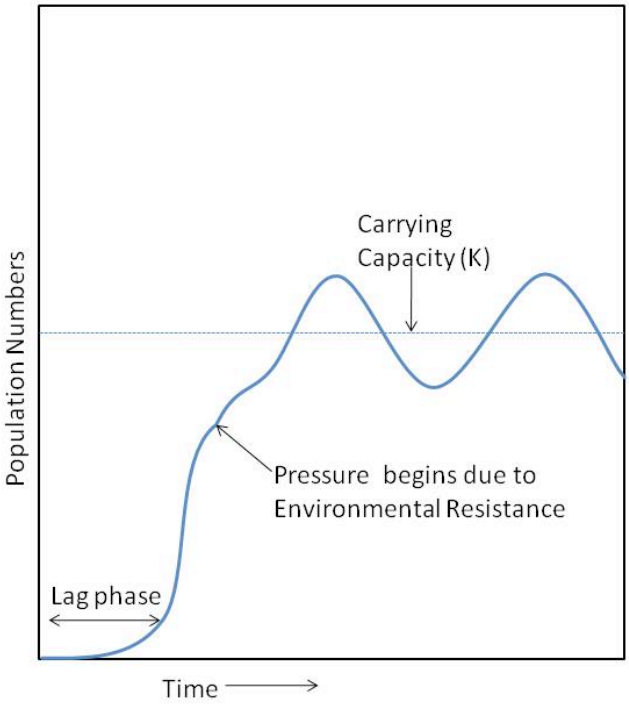



Diagram B – Logistic Growth Curve




17. During what phase of the growth curves is the population just beginning to colonize an area?

18. In which graph does the population growth appear to continue unchecked?

19. How is this type of growth described?

20. These types of growth curves are often referred to using the letter of the alphabet that they resemble. The logistic growth curve is sometimes referred to as an **S- curve**. What letter would you use to describe the exponential growth curve?

21. In diagram B what causes the population growth to slow down?

22. What term is used to describe the steady population that the environment can sustain in diagram B?

23. What factor(s) allow both population curves to show a period of rapid growth immediately after the lag phase?

24. Exponential growth (diagram A) refers to the phenomena of populations that double in size every generation. If you start with a single bacterium capable of dividing every 20 minutes, how many bacteria would you have after just 2 hours?


25. In most natural populations (diagram B) rapid exponential growth is unsustainable. As populations increase **environmental resistance** causes the growth rate to slow down, until a stable and sustainable population size is reached. With your group discuss and define the term environmental resistance, giving examples.

26. Diagram B shows that the population size fluctuates around the carrying capacity. Considering what you know about interactions in the environment, discuss with your group some of the factors that could cause these fluctuations. In your answer you should relate these factors to the information from model 1.

## Extension Questions

## Read This!

Invasive species are ones that are introduced into an environment but are not naturally found in that environment. One example of an introduced invasive species is the American gray squirrel, introduced into Britain at the end of the 18th century. Until 1876 the only native squirrel in Britain was the European red squirrel, which was found in deciduous and coniferous forests. By 1940 the gray squirrel had displaced the red squirrel across most of the British Isles, and by 1984 the red squirrel was only found in isolated coniferous woodland areas. After its initial introduction the gray squirrel population increased rapidly however in recent year's population sizes within specific environments have become stable.

27. Explain why the newly introduced gray squirrel initially showed rapid population growth and why the native red squirrel showed a population decline. Use ecological terms from the previous models in your answer.

28. Why has the population size of the gray squirrel become stable in recent years?

**Teacher's Resources**

## Learning Objectives

- Describe how population size and growth is affected by a variety of factors which may be expressed as a mathematical expression.
- Distinguish between exponential and logistic growth; understand and describe some of the many factors that affect population size and growth.
- Understand that ecosystems have finite resources and so can only sustain a limited population (carrying capacity)

## Prerequisites

This is an introductory biology activity and there are no specific prerequisites, however some basic exposure to species interactions such as mutualism, commensalism, parasitism and predator-prey cycles would be beneficial.

## Assessment Questions

1. A population started with 100 individuals. Over the following year there were 14 births, 20 deaths and a net migration of +2. Calculate the birth rate and death rate and using the equation below calculate the rate of population change. State whether the population is increasing or declining.

   **Rate of population change = (birth rate – death rate) + net migration rate.**

   Birth rate = 14%  Death rate = 20%

   Rate of population change = (14-20) + 2
   = (-6) + 2
   = -4

   Population is declining.

2. Exponential growth is represented by a

   a. *J curve*

   b. K curve

   c. S curve

   d. Y curve

3. List some of the strategies used by Type I survivors that ensure they have the highest post-reproductive age survival rate. *Low # births/individual; long gestation periods; late onset of reproductive capacity; nurture young for longer time periods*;

## Target Answers:

1. What is the term used for populations moving into an area? *Immigration*

2. What is the term used for populations leaving an area? *Emigration.*

3. What two factors cause an increase in the population size? *Births & immigration*

4. Name two factors that cause a decrease in population size. *Deaths & emigration*.

5. Using the diagram and the letters B, D, E & I, write mathematical expressions to show the following:

    a. A stable population: $B + I = D + E$

    b. A declining population: $B + I < D + E$

    c. A growing population: $B + I > D + E$

    d. Population growth: $(B-D) + (I-E) > 0$

6. What does the x-axis on the graph represent? *Relative age from birth to death*.

7. Which type of survivor shows a steady decline at all life stages? **Type II**

8. Which type of organism loses most of their individuals at an early life stage? *Type III*

9. What survivor type are humans? *Type I*

10. Using complete grammatical sentences, with your group describe the pattern of survivorship for type I individuals. *Most offspring survive through their early years so the population remains high until post reproductive age, and then shows a rapid decline.*

11. When the number of survivors is 100, at what life stage is each survivor type?

    a. Type I – *Post reproductive*

    b. Type II - *Reproductive*

    c. Type III – *Pre reproductive*

12. Which of the three groups/types have the highest number of individuals that reach reproductive age? *Type I*

13. What is the difference in the average number of offspring that can potentially be produced by each of the three survivorship types? *Fish, insects etc produce huge numbers of eggs and larvae; rodents can produce litters of 8-12 young every 30 days; humans typically only produce 1 child at a time and their pregnancy lasts for 9 months.*

14. How do populations with type II or III survivorship compensate for the high pre-reproductive mortality? *Produce large numbers of offspring.*

15. Considering the evolutionary strategies that each survivorship type has developed for producing and rearing their young, can you develop a theory as to why type I survivors have the highest relative number of individuals/1000 births that survive until post-reproductive age? *Type I survivors put a lot of energy into giving birth and rearing low numbers of individuals. This strategy ensures that most survive, whereas the other types (II & III) produce large numbers of individuals but do not spend much time in rearing these young so many die at an early stage.*

16. Under what circumstances might human populations not show type I survivorship. *Third world populations typically have high infant mortality and due to other environmental stresses show population decline at all life stages.*
17. During what phase of the growth curves is the population just beginning to colonize an area? *Lag phase*
18. In which graph does the population growth appear to continue unchecked? *Graph A*
19. How is this type of growth described? *Exponential*
20. These types of growth curves are often referred to using the letter of the alphabet that they resemble. The logistic growth curve is sometimes referred to as an **S- curve**. What letter would you use to describe the exponential growth curve? *J*
21. In diagram B what causes the population growth to slow down? *Environmental resistance.*
22. What term is used to describe the steady population that the environment can sustain in diagram B? *Carrying capacity.*

23. What factor(s) allow both population curves to show a period of rapid growth immediately after the lag phase? *Population numbers have increased so it becomes easier to reproduce. Still no competition and resources are readily available.*

24. Exponential growth (diagram A) refers to the phenomena of populations that double in size every generation. If you start with a single bacterium capable of dividing every 20 minutes, how many bacteria would you have after just 2 hours? *16777216*

25. In most natural populations (diagram B) rapid exponential growth is unsustainable. As populations increase environmental resistance causes the growth rate to slow down, until a stable and sustainable population size is reached. With your group discuss and define the term environmental resistance, giving examples. *All of the inhibitory factors that regulate a population. Examples could include natural disasters such as disease outbreak, drought, famine, flood, or they can be man-made such as wars and riots.*

26. Diagram B shows that the population size fluctuates around the carrying capacity. Considering what you know about interactions in the environment, discuss with your group some of the factors that could cause these fluctuations. In your answer you should relate these factors to the information from model 1. *Population varies due to changes in birth & death rate, immigration and emigration. This can be due to changes in the environment, increased competition, and changes in available resources, such as food or space.*
27. Explain why the newly introduced gray squirrel initially showed rapid population growth and why the native red squirrel showed a population decline. Use ecological terms from the previous models in your answer. *The gray squirrel was a better competitor so it could out-compete the smaller red squirrel. With little competition and limitless resources population growth of the gray squirrel would be exponential and rapid. The lack of density dependent factors allowed population growth to continue. The red squirrel was subject to density dependent factors such as increased competition for limited resources. Because it could not compete it was forced to move into areas it was less adapted for and as a result its population declined.*

28. Why has the population size of the gray squirrel become stable in recent years? *As the population size increased the competition for resources within the gray squirrel population has also increased. The population has reached carrying capacity in the environment. High levels of intraspecific competition created environmental resistance and so helped regulate the population size.*