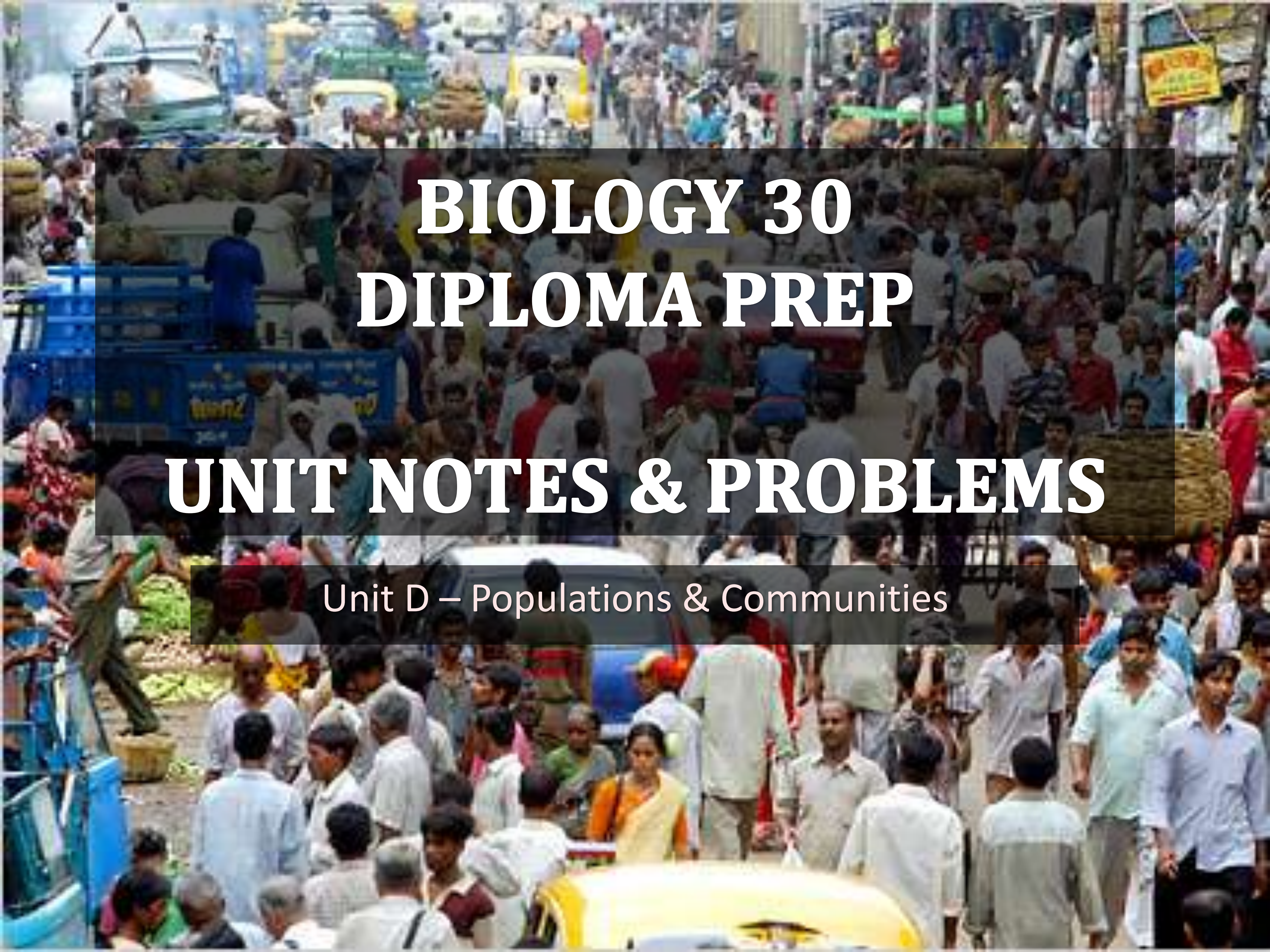


BIOLOGY 30
DIPLOMA PREP

UNIT NOTES & PROBLEMS

Unit D – Populations & Communities

POPULATIONS, COMMUNITIES & ECOSYSTEMS

- a **population** refers to all of the individuals of the same species living in the same place at the same time
- a **community** includes all the species that occupy a given area at a certain time
  - a study of a community only includes the study of living organisms
- a study of an ecosystem would include both living (**biotic**) and non-living (**abiotic**) components

ECOSYSTEMS, POPULATIONS, AND COMMUNITIES

- Review:
  - a study of an ecosystem includes all the living and non-living components of an area
  - a study of a community involves all the living components of an area
  - a study of a population only looks at the members of one particular species in the area

DENSITY & DISTRIBUTION OF POPULATIONS

- all populations can be described in terms of two basic qualities:
  - **population density (D_P)** is defined as the number of individual organisms (N) in a given area (A) or volume (V).
    - the equation one would use to calculate the density of a population is:

$$D_P = \frac{N}{A} \quad \text{or} \quad D_P = \frac{N}{V}$$

EXAMPLE:

- e.g. you wish to calculate the density of a gopher population. Based on several samples, you find an average of 12 gophers living in an area of $10.0m^2$. The density of that population would be:

  $D_P = N/A = 12 \text{ gophers} / 10.0m^2 = 1.2 \text{ gophers}/m^2$

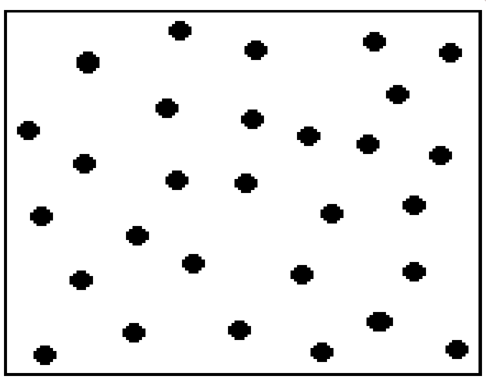
- if you know that the field in which the gophers live is $200.0m^2$, you can estimate the size of the population

  $(1.2 \text{ gophers}/m^2)(200.0m^2) = 240 \text{ gophers}$

- the assumption that you made in this example was that the gophers were evenly distributed throughout the entire field

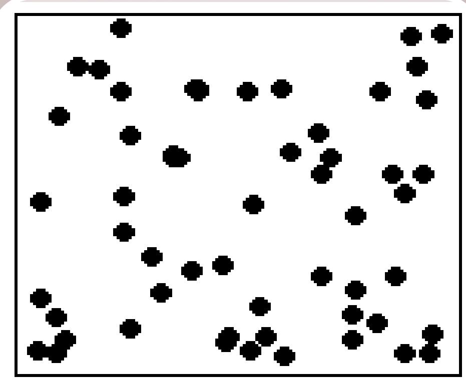
DISTRIBUTION (NOTE: MOST LIKELY WILL NOT BE TESTED ON THE DIP)

+ **distribution** refers to the arrangement of the population in a given area
  – there are three theoretical patterns for population distribution:



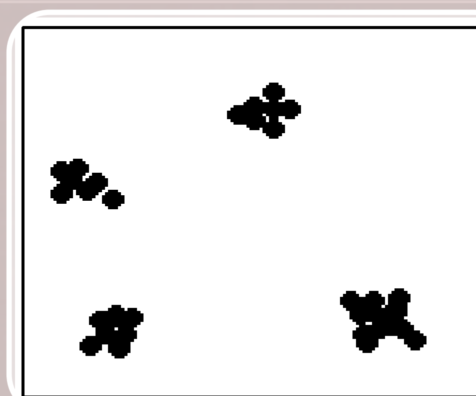
uniform

- individuals are evenly spaced over a defined area



random

- individuals or pairs of organisms are distributed unevenly throughout a suitable habitat, with no identifiable pattern



clumped

- when members of a population are found close together, in various groups within their habitat

DISTRIBUTION

- **uniform distribution** occurs when individuals are evenly spaced over a defined area
  - this pattern occurs often in agriculture and other artificial populations
  - also occurs in birds of prey, and other animals that behave territorially to defend resources or protect the young
  - e.g. golden eagles pair off and defend a particular piece of territory

DISTRIBUTION

+ **random distribution** occurs when individuals or pairs of organisms are distributed unevenly throughout a suitable habitat, with no identifiable pattern
  - occurs when resources are abundant
  - population members do not need to compete, or group together, for survival
  - the rarest form of distribution in nature
  - e.g. in summer female moose and their young tend to be distributed randomly over their habitat

DISTRIBUTION

- **clumped distribution** occurs when members of a population are found close together, in various groups within their habitat
  - most populations exhibit this pattern
  - e.g. humans exhibit this pattern of distribution, congregating where food, water and shelter are most abundant
  - e.g. aspen trees reproduce asexually by sprouting new trees from the roots of older trees, so they are found in groves

DISTRIBUTION

+ in nature, most populations do not fit exactly into one of these categories which is why these patterns are said to be theoretical
+ in some species, all three patterns may be demonstrated, at different parts in their life cycle or throughout the year
  – e.g. in the summer, mother moose and their fawns tend to be distributed randomly, but in the winter, they may tend to group around scarce food sources.
+ changes in distribution patterns of a species can give scientists information about the behaviour or ecology of the species

POPULATION GROWTH

- there are four processes that can change the size (number of individuals) of a population, ΔN
  - processes that increase population size
    - births (b) – also called ***natality***
    - **immigration** (i) – the movement of individuals into a population
  - processes that decrease population size
    - deaths (d) – also called ***mortality***
    - **emigration** (e) – the movement of individuals out of a population
- populations in which all four processes are in play are referred to as **open populations**, whereas when only birth and death occur with no immigration/emigration, it is referred to as a **closed population**

POPULATION GROWTH

$$\Delta N = [b + i] - [d + e]$$

change in population size = births + immigration − deaths + emigration

- in most populations, immigration and emigration often occur in very low amounts, and in equal amounts, so they do not significantly alter the sizes of the populations
- the migration of an entire population (e.g. flying south for the winter) does not change the size of the population.

GROWTH RATE

- not only does the amount of change matter, also the rate at which that change occurs
  - **population explosions** occur when a population increases in size so quickly that it spreads before it can be contained
    - e.g. weeds in a garden
  - **population crashes** occur when a population decreases very rapidly and by a significant amount
  - the growth rate (*gr*) of a population can be calculated by dividing the change in population (ΔN) by a specific time frame (Δt)

GROWTH RATE

$$gr = \frac{\Delta N}{\Delta t}$$

- the timeframe will depend on the context of the question (e.g. “per month” or “per year”)
- a positive number for *gr* will indicate the population is getting larger, while a negative number will indicate it’s shrinking
- the calculation of growth rate does not take the initial size of the population into account
  - comparison of growth rates cannot be made between two populations if their initial size was different
  - e.g. if two school populations increased by 100 students, it would have a bigger impact on Oscar Romero than on Ross Sheppard

PER CAPITA GROWTH RATE

$$cgr = \frac{\Delta N}{N} = \frac{N_{final} - N}{N}$$

- in order to compare the growth rate of two different-sized populations of the same species, the change has to be expressed in terms of rate of change per individual – the **per capita growth rate** (*cgr)*
  - compares the change in the number of individuals (ΔN) with the original number of individuals (N):
  - as with growth rate, for per capita growth rate, a positive number will indicate the population is getting larger, while a negative number will indicate it's shrinking

DIPLOMA PRACTICE QUESTIONS

Use the following information to answer the next two questions.

A team of scientists recommends moving grizzly bears into the North Cascades area of British Columbia in order to save the resident population, which has been classified as threatened. The grizzly population in the North Cascades was estimated to be only 23 bears in 2001. The goal of the recovery plan is to increase the number of grizzlies in the 9 810 km^2 area to 150 bears by 2050.

North Cascades Grizzly Bear Recovery Team. 2001. *Recovery Plan for Grizzly Bears in the North Cascades of British Columbia*. Ministry of Environment, Government of British Columbia. http://wlapwww.gov.ba.ca/wld/documents/recovery/ncgbrt_final.pdf.

DIPLOMA PRACTICE QUESTIONS

+ Numerical Response #1

In the North Cascades of British Columbia in 2001, what was the density of the grizzly bear population per 1 000 square kilometres?

Answer: __________ grizzly bears/1 000 km^2

+ Numerical Response #2

What is the projected per capita growth rate of the grizzly bear population in the North Cascades of British Columbia from 2001 to 2050?

Answer: __________

FACTORS THAT AFFECT POPULATION GROWTH

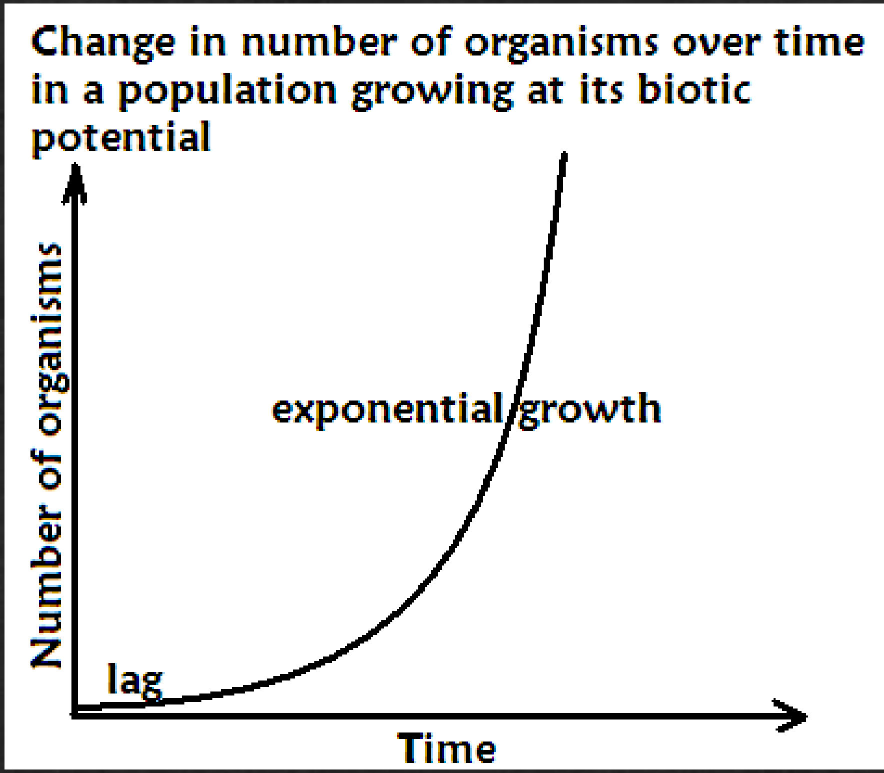
- the factors that affect the rate of population growth of a species are grouped into two broad categories: biotic, and abiotic
- biotic factors – e.g. physiological and physical characteristics of a species
  - **biotic potential (*r*)** – the highest possible per capita growth rate for a population, affected by:
    - the number of offspring per reproductive cycle
    - the number of offspring that survive long enough to reproduce
    - the age of reproductive maturity
    - the number of times that the individuals reproduce in a life span
    - the life span of individuals

J-CURVES (EXPONENTIAL GROWTH)

- a population that is growing at its biotic potential is growing **exponentially** – there is a brief lag phase, followed by a steep upward curve – called a **J-shaped curve**
- only occurs in some organisms, and only under ideal conditions
- exponential growth is seen most often in
  - micro-organisms, (e.g. bacteria)
  - small animals (e.g. fruit flies)
  - certain plants (e.g. dandelions)

J-CURVES (EXPONENTIAL GROWTH)

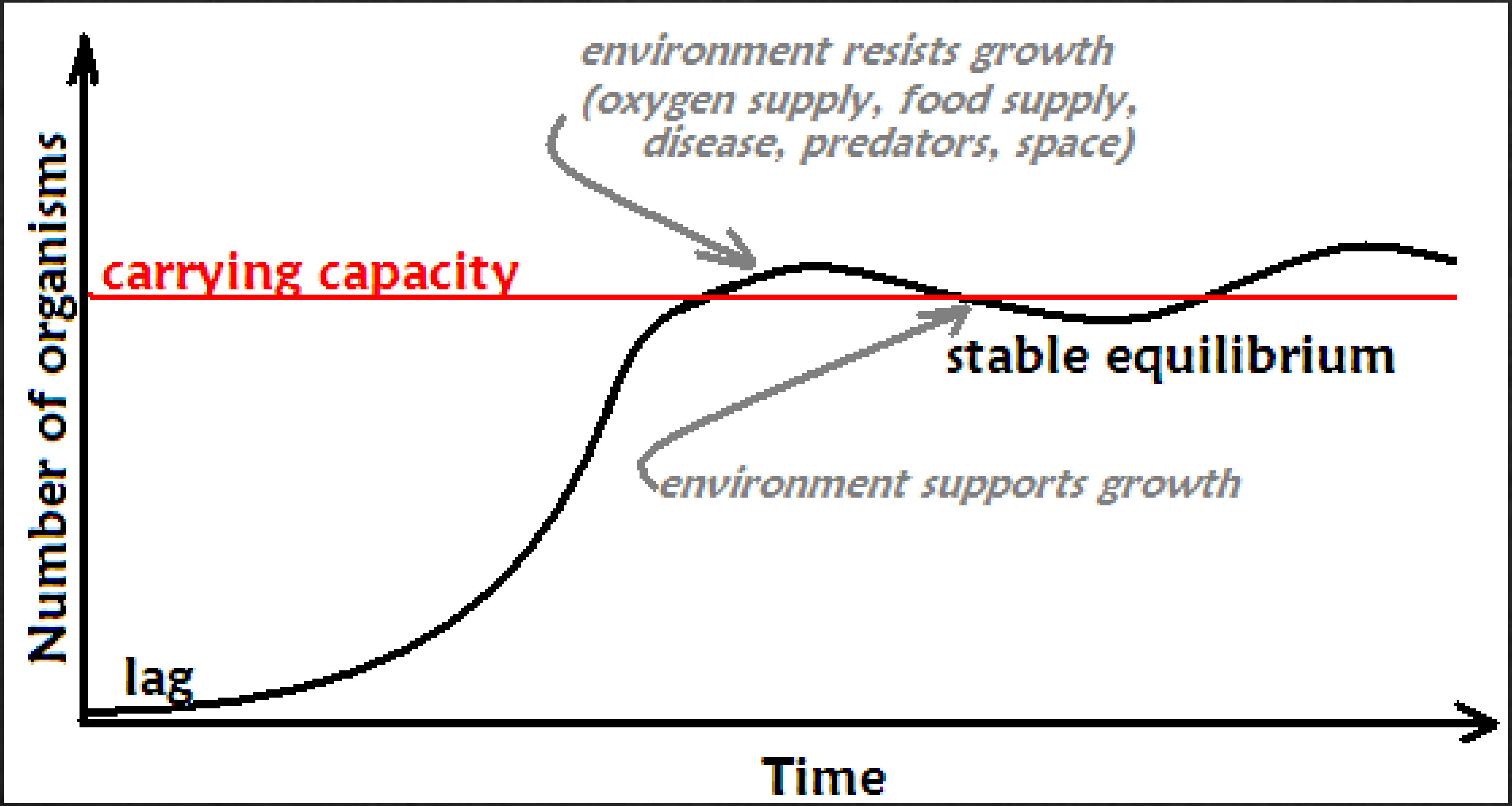
- the **lag phase** of population growth occurs in the initial stages of growth, when there are only a few individuals to reproduce
- as the number of individuals in the population increase, the population will grow at an increasing rate
  - during the exponential phase, the birth rate is much greater than the death rate
  - under natural conditions, exponential growth cannot continue indefinitely
    - limiting factors, such as competition for food will slow the rate of growth
- the **stationary phase** of population growth occurs when the birth and death rates are equal



S-CURVES (DYNAMIC EQUILIBRIUM)

- the carrying capacity *(K)* of a habitat is the theoretical maximum population size that the environment can sustain in the long-term.
  - the carrying capacity of a habitat can fluctuate (vary slightly) from year to year, or from season to season
  - when a population size stays around the carrying capacity for awhile, it is considered to be in **stable (dynamic) equilibrium**
- this curve is referred to as an **S-shaped curve**

S-CURVES (DYNAMIC EQUILIBRIUM)



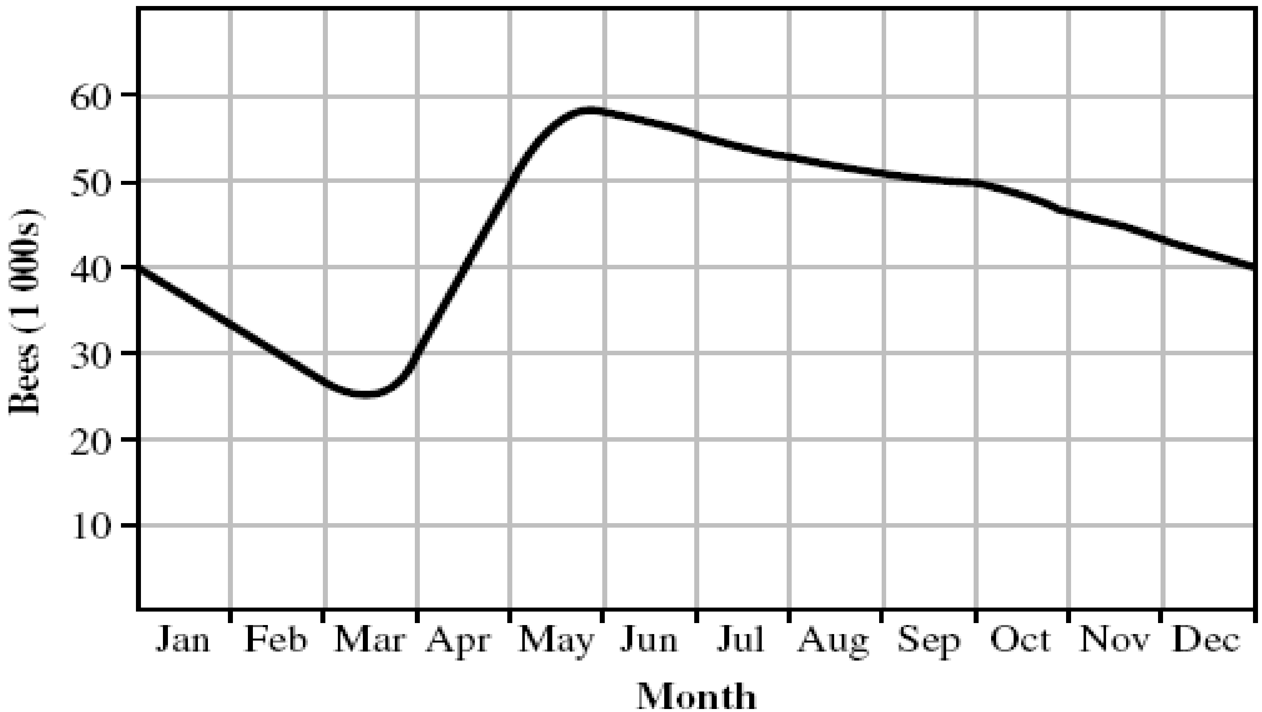
DENSITY-DEPENDENT & INDEPENDENT FACTORS

- carrying capacity can be limited by two categories of factors:
  - density-dependent factors
    - biotic factors, their effect depend on the density and size of the population
    - e.g. parasites, predators
  - density-independent factors
    - abiotic
    - limit growth regardless of the size of the population
    - e.g. harsh weather, drought, forest fires, cold snaps
  - the combination of all limiting factors is referred to as **environmental resistance**
- when a factor changes, the carrying capacity could change and the population size will adjust accordingly

DIPLOMA PRACTICE QUESTIONS

Use the following information to answer the next question.

The population of a colony of honey bees (*Apis mellifera*) in Alberta varies seasonally as illustrated in the following graph.



DIPLOMA PRACTICE QUESTIONS

+ Multiple choice question #1

The portion of the graph for April **most likely** indicates the effect of

A. an increase in parasitism
B. a decrease in competition
C. a decrease in limiting factors
D. an increase in environmental resistance

LIFE STRATEGIES

life strategies are the methods used by a species to allow the species the best chance at survival

r-selected strategies

- species where individuals:
  - have short life spans,
  - reproduce often
  - produce numerous offspring
  - do little to care for young
- e.g. fruit flies and many other insects
- typically take advantage of favorable environmental conditions to reproduce quickly

K-selected strategies

- species where populations live close to their carrying capacity, and individuals:
  - have few offspring per reproductive cycle
  - one or both parents care for young offspring
  - offspring take a relatively long time to mature and reproduce
  - have a long life-span
  - tend to have large bodies, compared to r-selected organisms
- e.g. humans (and other mammals)

DIPLOMA PRACTICE QUESTION

Use the following information to answer the next three questions.

The 42 000 wild horses and donkeys that live in the American West are reproducing at such a high rate that they could severely damage range lands in the future. In an effort to prevent overpopulation, some mares (females) are rounded up and injected with porcine zona pellucida (PZP), a long-lasting contraceptive. U.S. Food and Drug Administration guidelines prohibit the use of PZP until after a wild mare has had at least one successful pregnancy.

—from *McInnis, 1996*

- Multiple choice #2

If the effect of PZP on horses is like the effect of the birth control pill on women, pregnancy is prevented because

A. ovulation does not occur
B. implantation does not occur
C. sperm cannot enter the uterus
D. sperm cannot enter the oviducts

DIPLOMA PRACTICE QUESTION

Use the following information to answer the next three questions.

The 42 000 wild horses and donkeys that live in the American West are reproducing at such a high rate that they could severely damage range lands in the future. In an effort to prevent overpopulation, some mares (females) are rounded up and injected with porcine zona pellucida (PZP), a long-lasting contraceptive. U.S. Food and Drug Administration guidelines prohibit the use of PZP until after a wild mare has had at least one successful pregnancy.

—from *McInnis, 1996*

+ Multiple choice #3

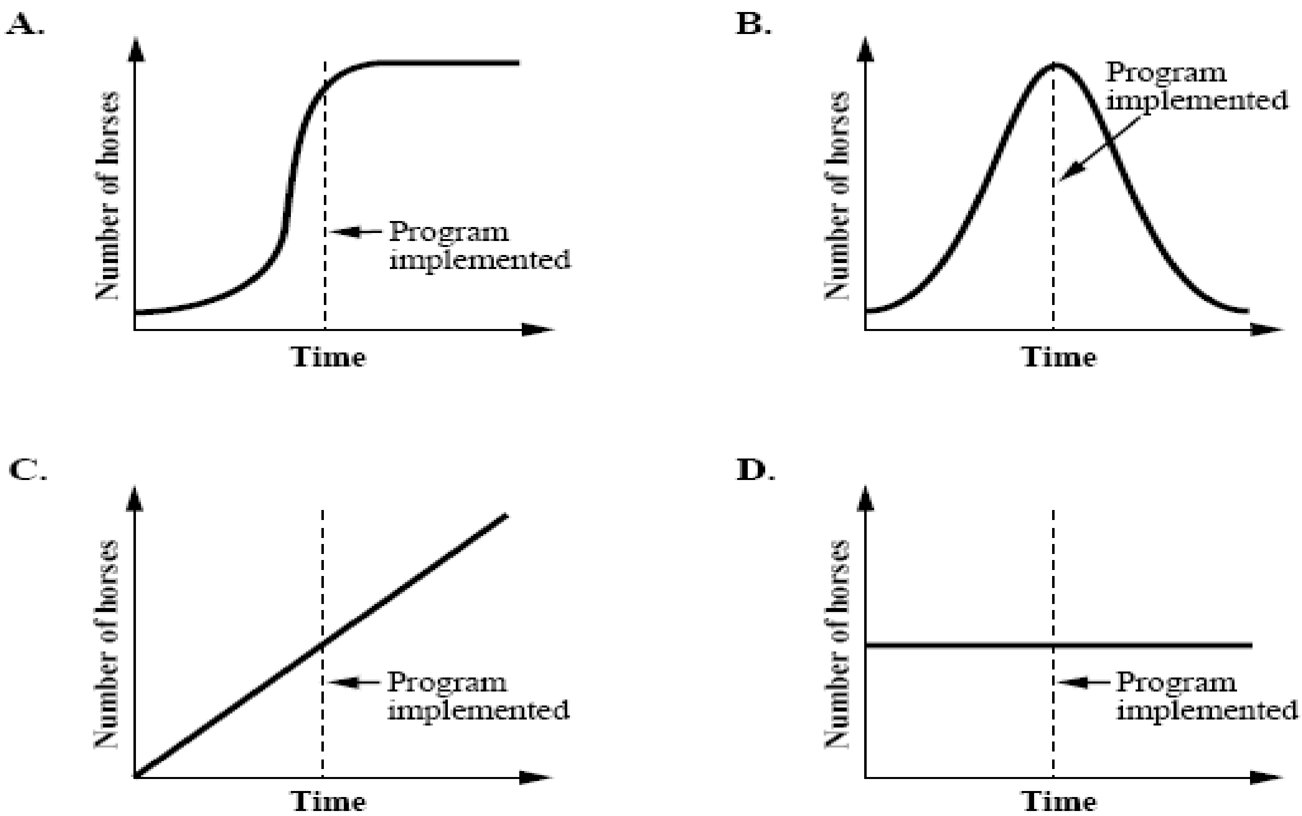
Wild horses are considered to be a relatively K-selected species; however, one characteristic exhibited by these wild horses that is similar to an *r*-selected species is

A. their large size
B. their relatively long lifespan
C. their relatively high reproductive potential
D. the large amount of parental care devoted to their offspring

DIPLOMA PRACTICE QUESTION

+ Multiple choice #4

Assuming that the contraceptive program manages the wild horse population successfully, which of the following graphs would **best** represent the wild horse population growth curve over time?



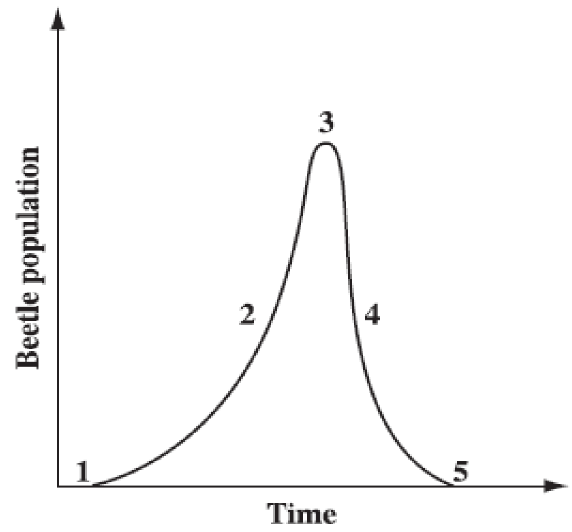
DIPLOMA PRACTICE QUESTION

+ Numerical Response #3

Use the following information to answer the next question.

The lodgepole pine forests of British Columbia are currently being threatened by infestations of insects called mountain pine beetles. An infested lodgepole pine becomes progressively damaged by the feeding activities of the rapidly growing beetle population in the tree. A secondary infection by fungi eventually kills the tree. Early detection of beetle-infested trees and their removal by selective logging would affect the population of both lodgepole pines and mountain pine beetles.

A Population of Mountain Pine Beetles on a Lodgepole Pine



Three Equations Representing Population Change

A (Immigration + Natality) = (Emigration + Mortality)
B (Immigration + Natality) < (Emigration + Mortality)
C (Immigration + Natality) > (Emigration + Mortality)

Match three of the regions numbered on the graph above with the letters of the equations representing population change.

Region on Graph:	_____	_____	_____
Equation:	**A**	**B**	**C**

LIFE STRATEGIES

+ "*r*-selected" or "*K*-selected" labels are only useful in relation to other species, because most species tend to be somewhere in the middle of the continuum
+ by labeling a species as "*r*-selected" or "*K*-selected", predictions can be made regarding the success of a population in a particular habitat

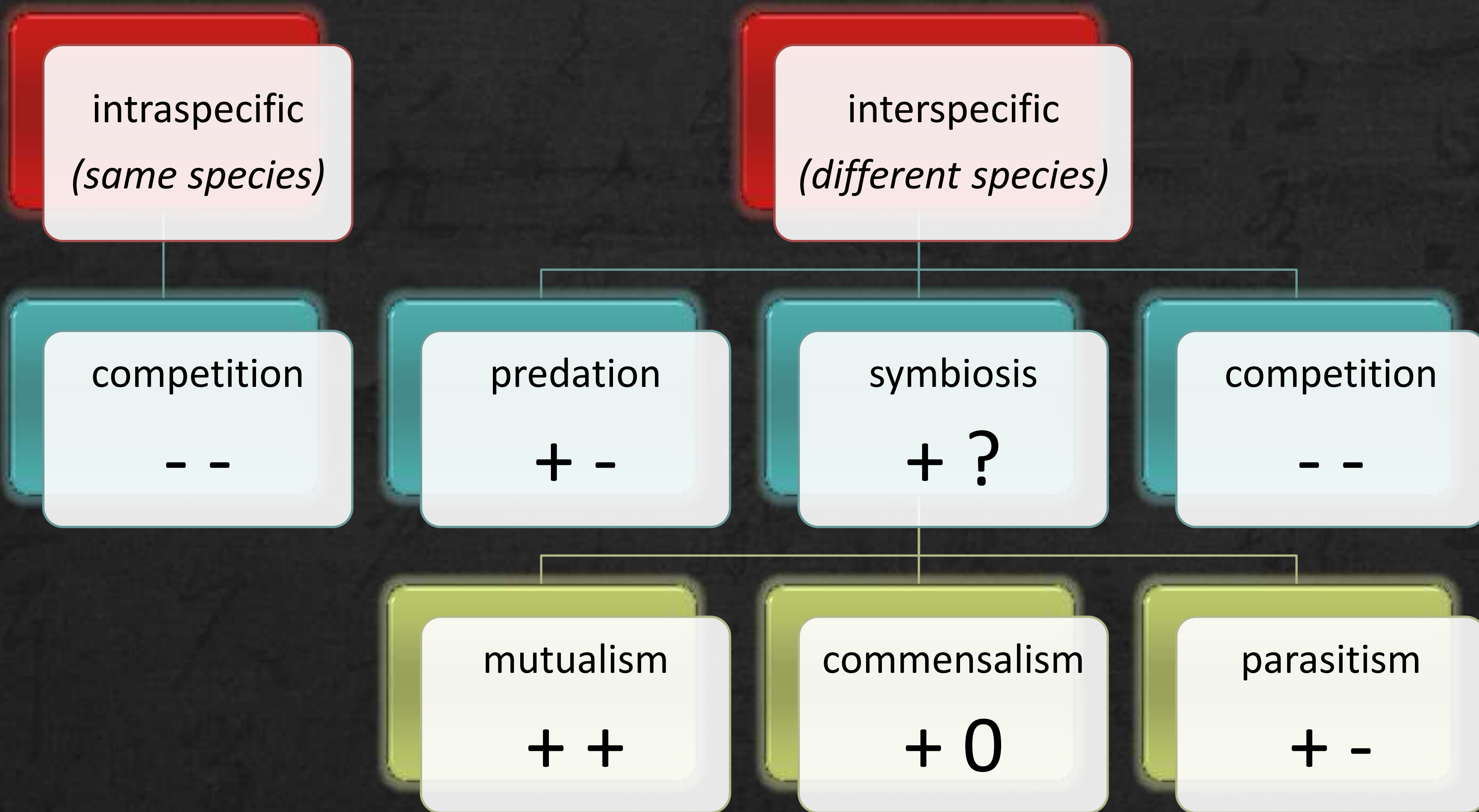
INTERACTIONS IN BIOLOGICAL COMMUNITIES

+ two major categories of interactions in biological communities:
  - **intraspecific interactions**
    - “intra” means “within” (e.g. intramurals)
    - intraspecific interactions occur between members of the same species
    - example: competition for mating partners
  - **interspecific interactions**
    - “inter” means “between” (e.g. international)
    - interspecific interactions occur between members of two different species
    - example: predator/prey relationships

INTRASPECIFIC COMPETITION

- ***intraspecific competition*** occurs between members of the same species
  - density-dependent, limits growth of a population
  - aids in natural selection
    - some individuals have a "competitive advantage" that makes them better able to survive, and therefore reproduce
  - in some species, offspring have to disperse away from their parents or they would be in direct competition with them for resources (most common in fungi and plants)

BIOLOGICAL RELATIONSHIPS



INTERSPECIFIC INTERACTIONS

- Three types, classified according to the benefit to each species
  - predator-prey relationships
    - one benefits, one is harmed
  - **interspecific competition**
    - both are harmed
  - symbiotic relationships
    - one benefits, the effect on the other varies

INTERSPECIFIC COMPETITION

- Interspecies competition occurs when members of two different species compete
- both species must rely on the same resources
  - food
  - land & shelter
- there must be limited access to resources
  - if two plants are growing and neither shades the other, they are not in competition for light
  - the two plants would be in competition, however, for access to water and for pollinators

PREDATOR – PREY RELATIONSHIPS

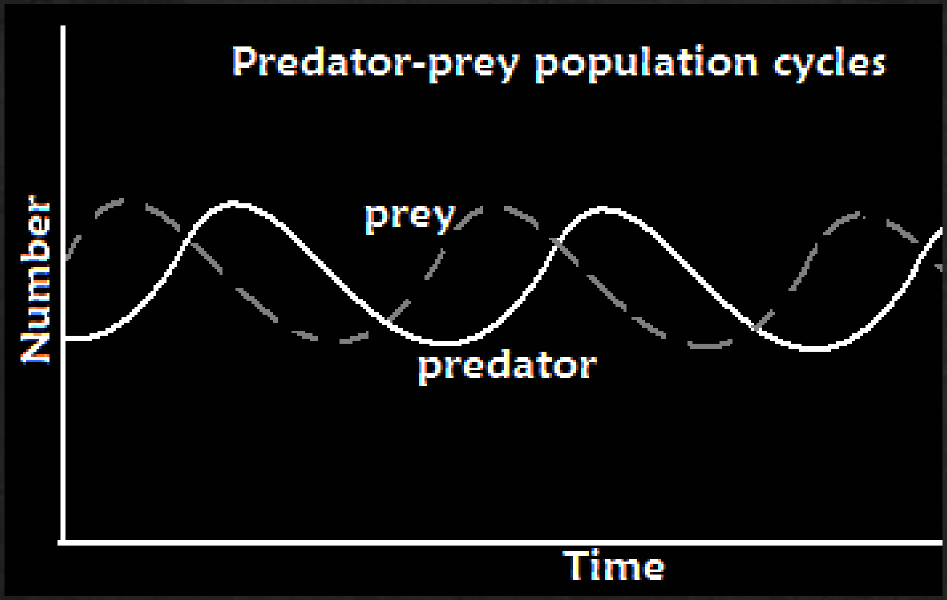
- Also known as **predation**
- One organism kills and feeds on another organism
- The organism doing the killing is the **predator**
- The organism being killed is the **prey**

PREDATOR – PREY RELATIONSHIPS

- both the producers (prey) and consumers (predators) are under selective pressure
  - the predator must be able to meet its own needs, but also be better at doing so than other predators
  - for the prey, it is in its best interests to be difficult to catch, or less desirable to consume
- defense mechanisms may also be useful
  - chemical defense (e.g. tasting bitter, being poisonous)
  - protective colouring/patterning to blend into surroundings
  - **mimicry**: when a harmless species takes on the same appearance as a poisonous or harmful species
    - e.g. the syrphid fly has the same yellow and black striped colouration of the yellow-jacket wasp, but no stinger

PREDATOR – PREY RELATIONSHIPS

- predator and prey populations tend to go in cycles
  - as prey populations increase, the number of predators increases shortly thereafter, and vice versa
  - as prey evolve, predators must evolve with them, or risk losing a food source



DIPLOMA PRACTICE QUESTION

+ Multiple choice #5

> In areas where moose and caribou share habitat, they are both preyed upon by wolves. The population cycle of the moose is affected by the presence of a second prey species, the caribou.
>
> —from *Mech, 1996*

A reasonable prediction based on these predator–prey relationships is that

A. predator species would not show population changes caused by density-dependent factors

B. low numbers of caribou would cause wolf starvation if the moose population was also low

C. wolf and prey populations would decline as the same diseases spread through the three populations

D. an area would have the same carrying capacity for moose as it has for caribou, even though each species has different food preferences

SYMBIOSIS

- **symbiotic relationships**
  - close relationship between individuals of different species that live together
- there are three types of symbiotic relationships
- classified according to the effect on the other species
  - **+ and + = mutualism**
  - **+ and - = parasitism**
  - **+ and 0 = commensalism**

MUTUALISM

+ **mutualism**
  - where both partners benefit from the relationship
  - example: the relationship between the flowering plants and their pollinators
    - × when pollination is carried out by bees, the bees benefit by getting nectar
    - × the plant benefits by getting its pollen dispersed to other plants

SYMBIOSIS

+ **commensalism**
  - when one partner benefits, and the other is unaffected
  - example: the clownfish lives in a type of coral called an anemone
    - × normally the anemone stings predators and digests it with enzymes it secretes from its tentacles
    - × the clownfish is immune to the anemone's sting because of a special mucus secreted by its skin
    - × the clownfish benefits from having the protection of the anemone, but the anemone is largely unaffected by the clownfish

SYMBIOSIS

+ parasitism
  - one partner benefits at the expense of the other
  - the partner who benefits is called the **parasite**, while its victim is referred to as the **host**
  - parasites are an important factor in limiting the growth of host populations
  - they will never completely wipe out a population, because that would also cause the parasite to become extinct

SYMBIOSIS

+ **parasitism**
  - parasites include all viruses, and some worms, bacteria, and insects
  - parasites affect almost all species of wild and domesticated plants and animals
  - the World Health Organization estimates that 1.4 billion people worldwide are infested with parasites
    - equivalent to about 1 in 5,
    - less developed areas are more susceptible due to contaminated drinking water, lower standard of living, and poorer nutrition

Tapeworms attached to stomach wall

DIPLOMA PRACTICE QUESTION

+ Multiple choice #6

Use the following information to answer the next question.

Harbour porpoises living off the northeast coast of Scotland have been found dead washed up on shore, the victims of violent, high-energy impacts. Zoologists have identified scratches on the dead porpoises that match the teeth of an unlikely killer, the bottle-nosed dolphin, long assumed to be playful and gentle. These two cetaceans (aquatic mammals), which share the same range and food supply, were thought to coexist peacefully.

—from *Discover, 1996*

What type of relationship do the bottle-nosed dolphin and the harbour porpoise exhibit?

A. Symbiotic
B. Predator–prey
C. Intraspecific competition
D. Interspecific competition

DIPLOMA PRACTICE QUESTION

- Multiple choice #7

Use the following information to answer the next question.

In winter, snowshoe hares found in Jasper National Park create pathways in the snow between feeding and resting sites. These travel lanes are then used by porcupines, making the porcupines' movement through deep snow easier.

What relationship exists between the snowshoe hare and the porcupine?

A. Mutualism
B. Predator–prey
C. Commensalism
D. Intraspecific competition

DIPLOMA PRACTICE QUESTION

+ Multiple choice #8

Use the following information to answer the next question.

Mites (*Acaropis woodii*) can live in the trachea of a bee. These mites obtain nutrients from bee tissue. Beekeepers worry when mite populations reach numbers that have the potential to destroy the bee colony.

The relationship between bees and mites is called

A. parasitism
B. commensalism
C. interspecific competition
D. intraspecific competition

PRIMARY SUCCESSION

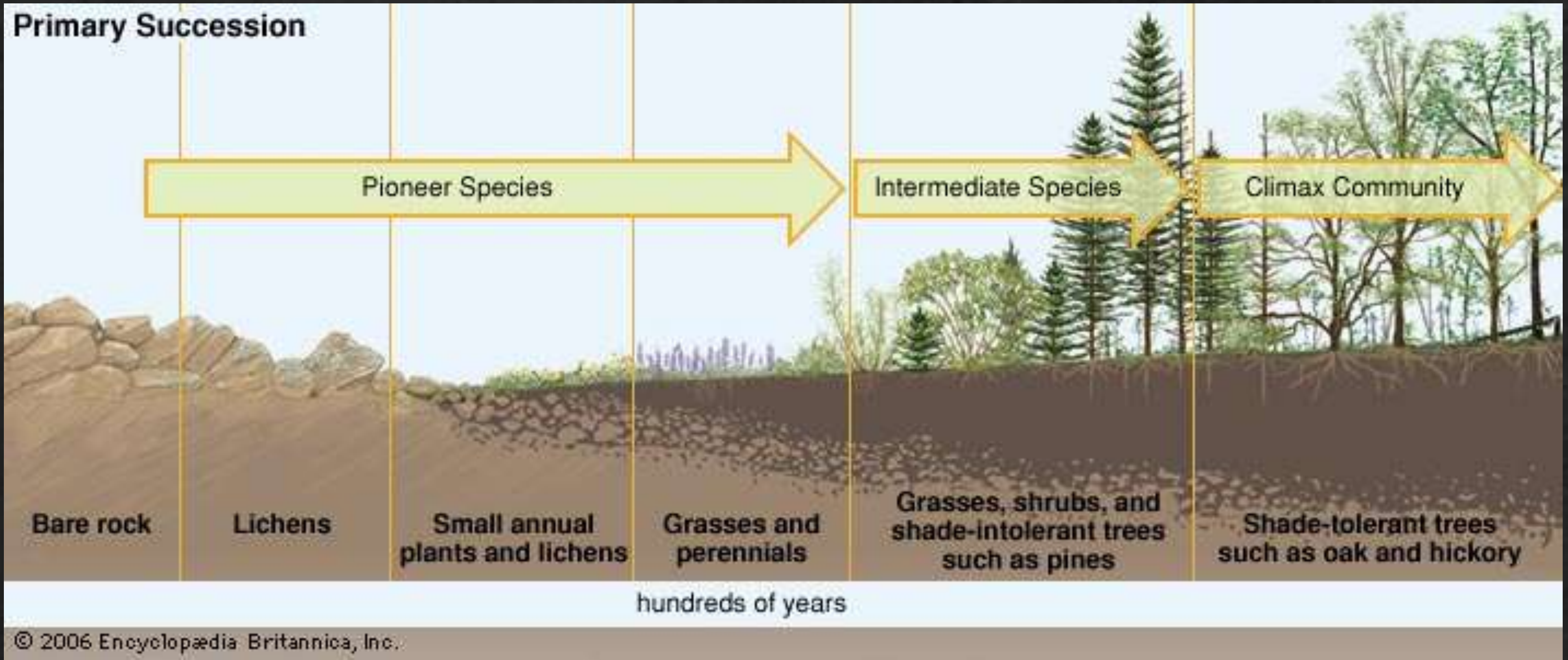
- Primary Succession:
  - the process of changing - in successive stages - an environment from an area of bare rock and few species to a complex community
  - It starts with a **pioneer species.**

THE PIONEER SPECIES

- usually this a simple, hardy plant that will invade a barren ground
  - often include fern, lichen, moss, bacteria
- pave the way for future life by changing the original habitat.
  - Bacteria and lichen produce acid which breaks down the rock
  - When these beginning species die and decay their remains add to the formation of **humus** (the organic component of soil)
- each new **seral community** that is added is increasingly complex, as are the relationships between species
- during the early stages of succession, the total number of species will increase dramatically

SUCCESSION CONTINUES

- Once there is a humus-rich soil, grasses can begin to grow.
- grass roots grow into small cracks, eroding away at the rock
  - it produces shade and so mosses and lichen die off
  - in this sense the grass has succeeded the moss



SUCCESSION IN ALBERTA

- Grass is succeeded by
  - broad-leaved shrubs,
  - deciduous trees
  - coniferous trees
- In Northern Alberta, the climax community includes a forest of mostly coniferous trees
- **Climax Community**: the stable community that results from the process of succession

SECONDARY SUCCESSION – THE DESTRUCTION

- Often times an ecosystem can be destroyed by <u>natural causes</u> such as severe storms, tornados, or even fires
- When a fire occurs, it may destroy the ecosystem, but the <u>soil that had developed during primary succession will remain</u>.

SECONDARY SUCCESSION

- With the remaining soil, and very few organisms left to survive, an ecosystem must develop again.
- But the process is <u>much faster then primary succession</u>, as humus rich soil already exists

SECONDARY SUCCESSION

- Secondary succession will lead to the climax community much faster then primary succession
- **Secondary Succession:** the return in stages to a stable climax community from an area that has had its vegetation - but not its soil - removed

DIPLOMA PRACTICE QUESTION

+ Multiple choice #9

Use the following information to answer the next question.

Large fishing vessels called trawlers use nets that are dragged along the seabed and often have catastrophic effects on the sea floor habitat. Prohibiting commercial fishing by trawlers could save not only the targeted fish species, but also many other marine species.

The recovery of the sea floor habitat after trawlers have been prohibited in a particular region is called

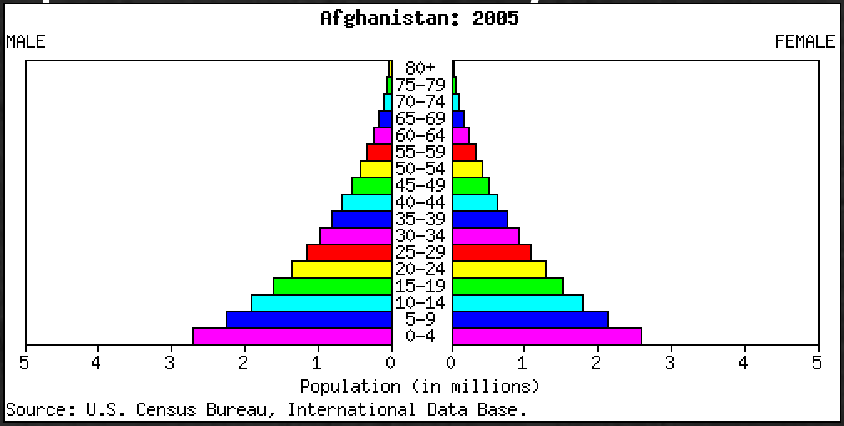
A. climax succession
B. pioneer succession
C. primary succession
D. secondary succession

POPULATION HISTOGRAMS

- population curves are useful for depicting how populations change over time, but do not give information about the age distribution of the members of that population
- a **population histogram** is a special type of bar graph that divides the population into age groups, and is particularly useful for populations in which individuals have a life span of more than a few years
- typically, the histogram is divided into males (on the left), and females (on the right)

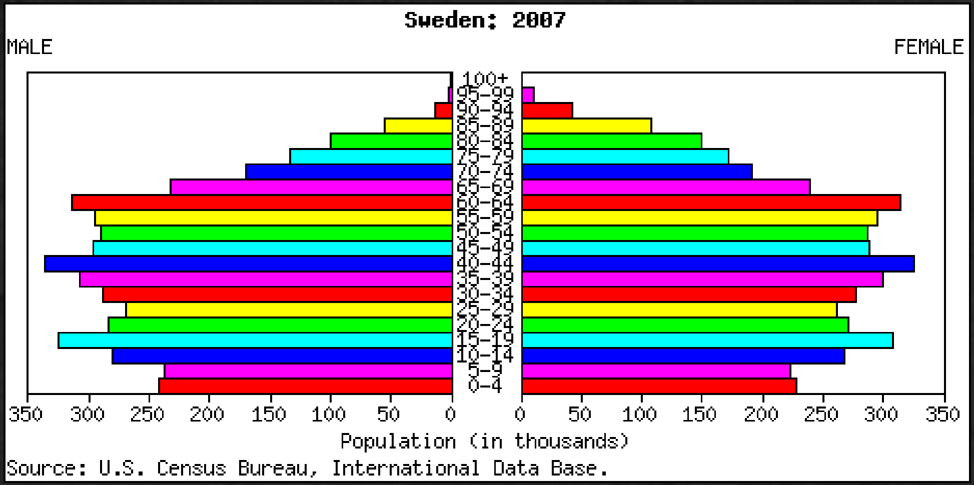
POPULATION HISTOGRAMS

- using the data from these graphs, it is possible to predict if a population is likely to



  - grow
    - occurs in a young populations
    - age pyramid will appear “bottom heavy”
    - in human populations, common in areas where birthrates are not controlled by the government
    - e.g. Afghanistan, Democratic Republic of Congo

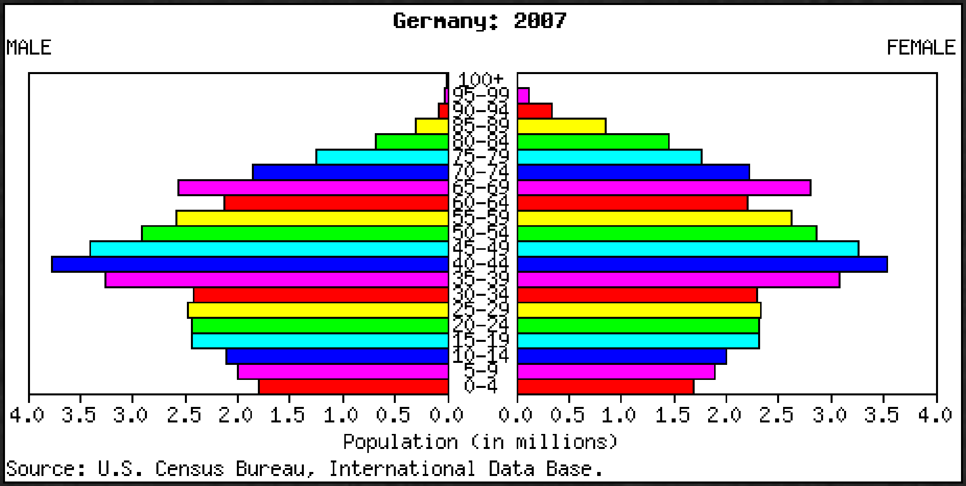
POPULATION HISTOGRAMS



– stabilize

- as in a population that is fairly evenly spread in age distribution
- in human populations, these countries will see slow growth
- e.g. Sweden, Canada

POPULATION HISTOGRAMS



- decline
  - seen in an aging population
  - histogram appears "top heavy"
  - example: like Canada and the United States, Germany experience a "baby boom" after WWII, and has a bulge in its pyramid in the 40-60 year-old range
- a histogram can predict the future growth (or lack of) of a population by examining the distribution of individuals within the age groups that are capable of reproduction

HUMAN POPULATION GROWTH

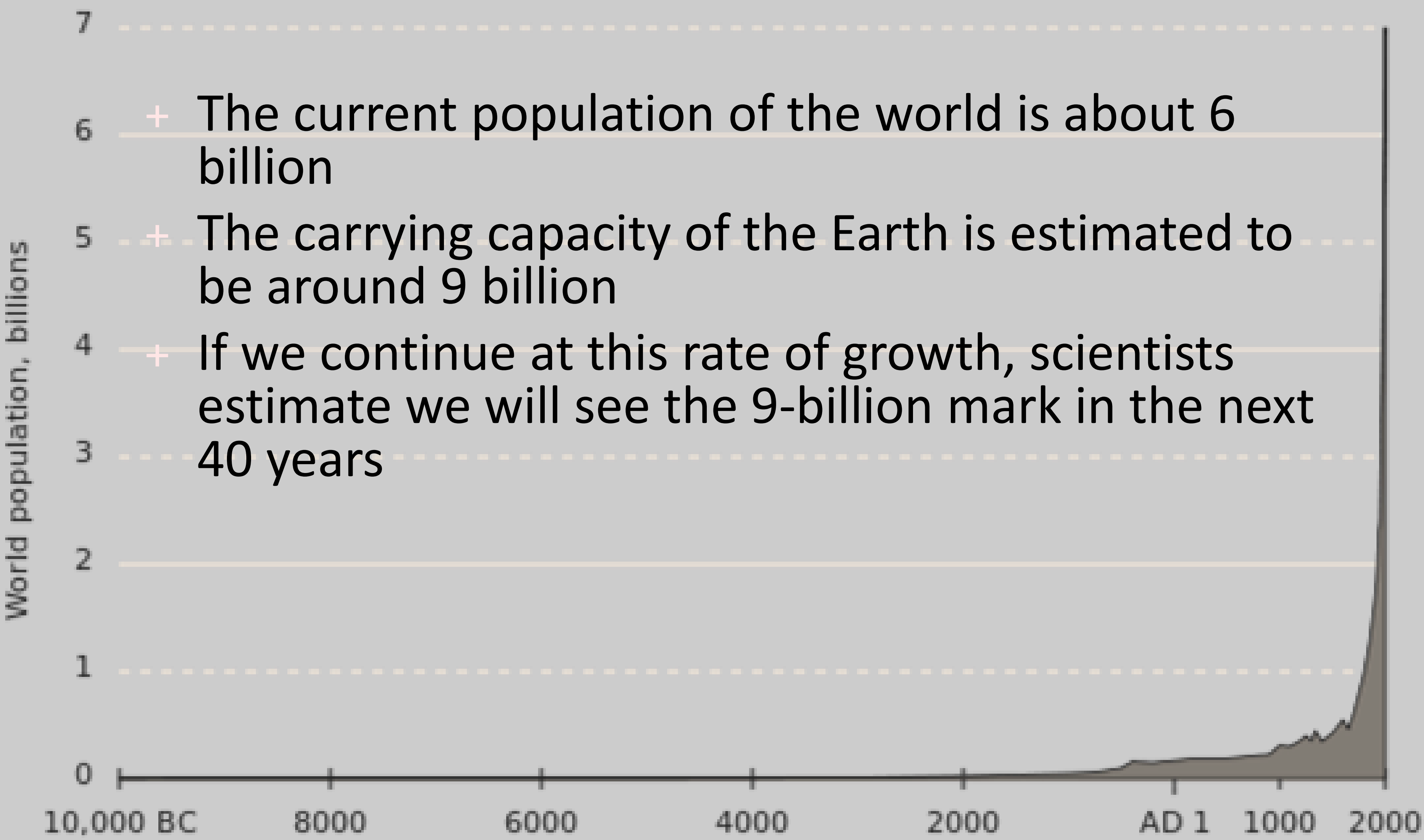
- for most of its history, the human population has been stable or grown very slowly
- explosive growth of the human population is linked with advancements in
  - agriculture, industry, and science/medicine,
- specifically the **Industrial Revolution** of the 18th century
  - living conditions improve (better hygiene linked with higher education)
  - death rate slowed due to advancements in medicine

HUMAN POPULATION GROWTH

- the 21st century is the first time in the world’s history that the elderly will outnumber the youth
- the carrying capacity of the Earth depends on many factors, including
  - food and resource supply,
  - waste disposal,
  - pollution,
  - access to clean water,
  - distribution of populations
- recall that **sustainability** is the ability to maintain the current standard of living without compromising future generations from meeting their needs
  - human population is not currently growing in a sustainable way

HUMAN POPULATION GROWTH

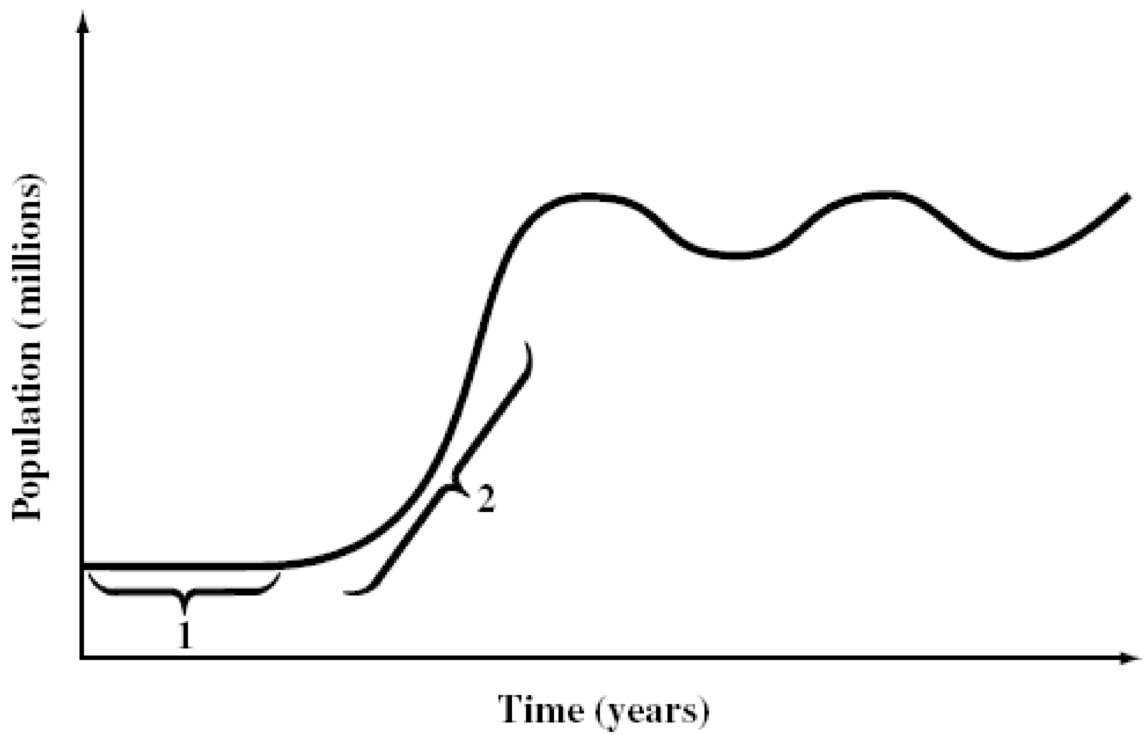
- The current population of the world is about 6 billion
- The carrying capacity of the Earth is estimated to be around 9 billion
- If we continue at this rate of growth, scientists estimate we will see the 9-billion mark in the next 40 years



DIPLOMA PRACTICE QUESTION

The phenomenal population growth in the American colonies impressed upon Malthus just how quickly humans could multiply.

Graph Illustrating Theoretical Human Population Growth



DIPLOMA PRACTICE QUESTION

+ Multiple choice #10

Which of the following rows identifies the region of the graph above that illustrates exponential growth of a population and the type of graph illustrated?

Row	Exponential growth	Type of graph
A.	1	S-shaped
B.	1	J-shaped
C.	2	S-shaped
D.	2	J-shaped

DIPLOMA PRACTICE QUESTION

- Multiple choice #11

Use the following information to answer the next question.

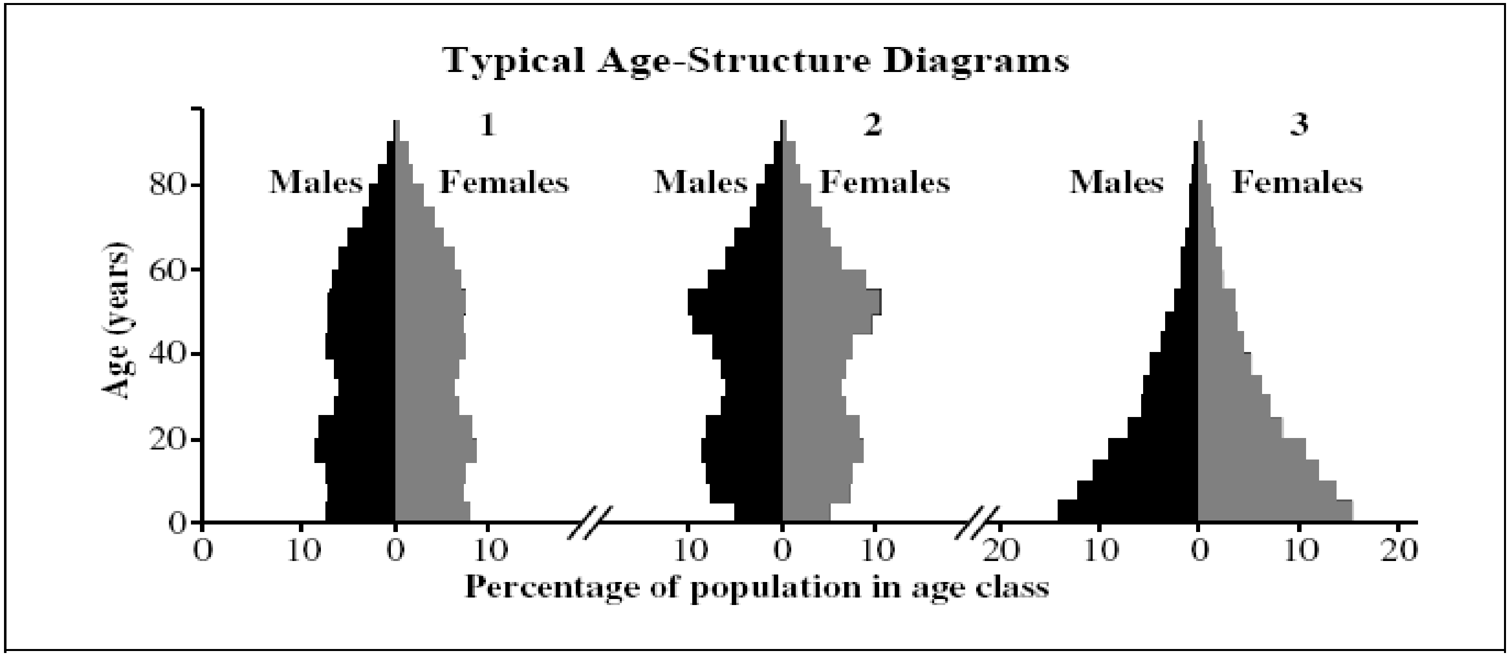
The human population is not expected to level off until after it passes the 10 billion mark, which will occur sometime in the middle of the 21^{st} century. This prediction is partially based on the fact that the population growth rate has slowed down as a result of the increased use of birth control and death from diseases such as AIDS.

The term that describes the expected levelling off of the human population is

A. J-shaped curve
B. biotic potential
C. carrying capacity
D. population density

DIPLOMA PRACTICE QUESTION

+ Numerical Response #4



At the end of the 20th century, Mexico's population could have been described as expanding, Sweden's as stabilized, and Canada's as declining. Match each of the diagrams numbered above with the country named below that the diagram could represent.

Diagram:	____________	____________	____________
Country:	Mexico	Sweden	Canada

GENE POOLS & GENETIC DIVERSITY

- a **gene pool** is the sum of all the alleles for all the genes in a population
  - a species' gene pool represents the degree of genetic variation
  - the more variety there is in the gene pool, the better the population can survive in a changing environment

GENOTYPE FREQUENCY

- a **genotype frequency** is the proportion of a population with a particular genotype, usually expressed as a decimal
  - it is calculated by dividing the number of offspring with that genotype by the total number of offspring
  - e.g. 200 mice are born, 72 are homozygous black, 96 are heterozygous black, and 32 are homozygous white
    - frequency of BB genotype = 72/200 = 0.36
    - frequency of Bb genotype = 96/200 = 0.48
    - frequency of bb genotype = 32/200 = 0.16
  - the sum of all possible genotypes is 1.00 (or 100%)

PHENOTYPE FREQUENCY

- a **phenotype frequency** is the proportion of a population with a particular phenotype, expressed as a decimal or percent
  - e.g. 200 mice are born, 72 are homozygous black, 96 are heterozygous black, and 32 are homozygous white
    - frequency of black phenotype = (72+96)/200 = 0.84
    - frequency of white phenotype = 32/300 = 0.16
  - for the recessive allele, the frequency of the genotype and the phenotype should be equal

ALLELE FREQUENCY

- an **allele frequency** is the rate of occurrence of a particular allele in a population
  - usually expressed as a decimal
  - since each diploid organism has two possible alleles, the total number of alleles in a population is twice the number of individuals
  - e.g. 200 mice are born, 72 are homozygous black, 96 are heterozygous black, and 32 are homozygous white
    - 72 mice have two B alleles, and 96 have one → [2(72) + 96]/400 = 240/400= 0.60
    - 96 mice have one b allele, and 32 have two → [2(32) + 96]/400 = 160/400 = 0.40
  - again, the allele frequencies should add up to 1.00 (100%)

HARDY-WEINBERG PRINCIPLE

- until the early 1900s, biologists thought that recessive alleles would eventually be eliminated from a population
- the evidence did not support that prediction; in fact in some cases the recessive alleles are more common than the dominant allele
  - e.g. in humans' ABO blood types, Type O (recessive) is the most common blood type
- in 1908 two scientists named Godfrey Hardy and Wilhelm Weinberg, each showed that allele frequencies in a population will remain constant in a population through generations as long as the following conditions are met:

5 CONDITIONS FOR HARDY-WEINBERG

1. the population is large enough that chance events will not alter allele frequencies
2. mates are chosen randomly (random mating)
3. there is no migration (ensures that no new genes enter or leave the population)
4. there are no new genetic mutations
5. there is no natural selection against any of the phenotypes

HARDY-WEINBERG

- the **Hardy-Weinberg principle**, as listed above, allows us to study one trait at a time and make predictions about the frequencies of the alleles that code for that trait
  - in Hardy-Weinberg equations, the following symbols are used:

    p = the frequency of the dominant allele

    q = the frequency of the recessive allele
  - since there are only two possible alleles,

    $p + q = 1.00$

HARDY-WEINBERG

- *p's* and *q's* also represent the probabilities of that allele appearing in a species gametes
  - if *p* is the probability of a gamete receiving the dominant allele, then the probability of an offspring being homozygous dominant is

    $p \times p = p^2$ ← ***genotype frequency***
  - if *q* is the probability of a gamete receiving the recessive allele, then the probability of an offspring being homozygous recessive is

    $q \times q = q^2$ ← ***genotype frequency***

HARDY-WEINBERG

- the probability of an offspring getting the dominant allele from its mother and the recessive allele from its father would be $p \times q = pq$,
- it is also just as likely the offspring gets the recessive allele from its mother and the dominant allele from its father, $q \times p = pq$,
- the probability of an offspring being heterozygous is

$$pq + pq = 2pq$$ ← ***genotype frequency***

HARDY-WEINBERG

- the total of these genotype frequencies should, again, total 1.00
- the Hardy-Weinberg principle can be summarized by the following equation:

$$p^2 + 2pq + q^2 = 1.00$$

p^2	+	$2pq$	+	q^2	=	1.00
frequency of homozygous dominant		frequency of heterozygous		frequency of homozygous recessive		100%

USES OF THE HARDY-WEINBERG EQUATION

- calculate the proportion of a population that are carriers for a genetic disorder
- calculate the number of individuals with a specific genotype
- compare allele frequencies in a population over time
  - if there is no change in allele frequencies (p and q) over time, the population is said to be in **genetic equilibrium**, or Hardy-Weinberg equilibrium
  - if there is change in p and q, the population is considered to be evolving
    - if the first four conditions are the H-W principle are still being satisfied, but the allele frequencies are changing, we could conclude that natural selection is at play
    - the gradual change in allele frequencies in a population is called **microevolution**

SOLVING A H-W PROBLEM:

- e.g. In a randomly mating population of snakes, one out of 100 snakes counted is albino, a recessive trait. What is the theoretical percentage of each of the genotypes in the population?

- step 1: analyze the value of the information given to you in the question. Convert any fractions or percentages into decimals

  1/100 snakes is homozygous recessive →

  $q^2 = 1/100 = 0.01 = 1\%$

  $q = \sqrt{q^2} = \sqrt{0.01} = 0.100$

SOLVING A H-W PROBLEM:

- step 2: use the allele frequency calculated in step 1 to find the other allele frequency

  $q = 0.100$ $p + q = 1.00$ →

  $p = 1.00 - 0.100 = 0.900$

- step 3: apply the two allele frequencies to the Hardy-Weinberg equation

  $q^2 = 0.01 = 1\%$

  $p = 0.900$ → $p^2 = (0.900)^2 = 0.81 = 81\%$

  $2pq = 2(0.900)(0.10) = 0.180 = 18\%$

SOLVING A H-W PROBLEM:

- step 4: check your solution

  $p^2 + 2pq + q^2 = 1.00$

  (0.81) + (0.18) + (0.01) = 1.00

- step 5: summarize the results

  The genotype frequencies are as follows:

  AA = 81%

  Aa = 18%

  aa = 1%

SUMMARY

- when the question asks for allele frequencies, you only need to calculate *p* and *q*
- when the question asks for genotype frequencies, you need to calculate p^2, $2pq$, and q^2
- the two relationships you will need to solve this problem are

$$p + q = 1.00$$

$$p^2 + 2pq + q^2 = 1.00$$

EXAMPLE:

- A single pair of alleles codes for wing length in fruit flies. The long wing allele (L) is dominant to the short wing allele (l). If 40 fruit flies out of 1000 that are counted have short wings, how many fruit flies out of 1000 would be expected to be heterozygous?

$q^2 = 40/1000 = 0.04$

$q = \sqrt{q^2} = \sqrt{0.04} = 0.2$

$p = 1.00 - q = 1.00 - 0.2 = 0.8$

$2pq = 2(0.8)(0.2) = 0.32$ → 320 flies

DIPLOMA PRACTICE QUESTION

- Multiple choice #12

Use the following information to answer the next question.

Cystic fibrosis (CF) is one of the most common autosomal recessive disorders. Geneticists estimate that 1 in 2 500 Caucasian newborns are affected with CF.

The predicted frequency of the recessive allele for CF in the Caucasian population is

A. 0.02
B. 0.04
C. 0.25
D. 0.33

GENETIC DIVERSITY

- **Genetic diversity** refers to the degree of genetic variation within a species or population
  - if the Hardy-Weinberg principle holds true, one would expect the amount of genetic diversity in a population to remain constant
  - the Hardy-Weinberg principle represents an ideal situation that rarely occurs in natural populations
  - the principle is still useful for measuring the amount of change in allele frequencies due to changes in the gene pool
- the processes involved in a changing gene pool tend to be interacting

MUTATIONS

- changes occurring in the DNA strand of an individual
- if that mutation is in the DNA of a gamete, the entire gene pool could be affected
  - e.g. Queen Victoria's hemophilia was the result of a mutation, but subsequently affected many members of the royal family
- most mutations are neutral and harmless, but some can be beneficial, and others, harmful
  - it is also possible for "back mutations" to occur, which is a reversal of the effects of a previous mutation
  - the more genetic variation there is in a population, the greater the chance that a variation will provide a selective advantage

GENE FLOW

+ **gene flow** refers to the net movement of alleles from one population to another, due to migration of individuals
+ a member of one population migrates to a nearby population and mates with a member of the second population
  – the migrating member increases the genetic diversity of the second population
  – at the same time, it reduces the genetic differences between populations, so populations that are geographically close to each other tend to share many of the same alleles

NON-RANDOM MATING

+ random mating: no way to predict which males will mate with which females
  - like a lottery – breeding partners are randomly selected
  - probabilities of genotypes is bases solely on the frequency of those alleles
  - in nature, random mating rarely happens
+ preferred phenotypes
  - in animal populations, individuals often choose mates based on their physical and behavioural traits
  - e.g. In North America, a tall woman is, statistically, more likely to choose a tall man as her partner than a man who is shorter than her.
  - e.g. In caribou herds, males spar other males to win a female

NON-RANDOM MATING

- inbreeding
  - occurs when closely related individuals breed
  - close relatives share similar genotypes (or, in the case of self-fertilization of plants, “both parents” have the exact same genotype)
    - → inbreeding increases the frequency of homozygous genotypes,
    - → harmful recessive alleles are more likely to be expressed – explains why inbreeding tends to result in higher rates of birth defects
  - inbreeding can potentially be beneficial
    - because inbred individuals are more likely to be sterile or die at a young age, which can help harmful recessive alleles be “phased out” of a population
  - inbreeding also allows wild plant populations to reproduce even when isolated

GENETIC DRIFT

- a change in allele frequencies due to chance events in a small breeding population
- a small population is more likely to lose alleles from its gene pool than a large population, because in large population is less affected by chance events
  - e.g. a small town has a family of Irish descent who all have red hair. The family is killed in a car crash, and the population no longer has the allele for red hair in its gene pool. (If the same family lived in a large city, the effect of their deaths on the gene pool would be minimal).

THE FOUNDER EFFECT

+ a new population is formed by only a few individuals, who carry some, but not all, of the alleles from the original population’s gene pool
+ occurs frequently on islands and in other geographically isolated areas
+ in human populations, the founder effect can increase the incidences of inherited health conditions
  - e.g. the Amish population of Pennsylvania were founded by a few families in the 1700s, one of whom carried a recessive allele for a form of dwarfism. As a result, dwarfism is about 300 times more common in this Amish population than the general population of the USA

DIPLOMA PRACTICE QUESTION

+ Multiple choice #13

Use the following information to answer the next question.

The Amish are a group of people who rarely marry outside of their community. In one group of Amish in Ohio, the incidence of cystic fibrosis was 19 in 10 816 live births. A second group of Amish in Ohio had no affected individuals in 4 448 live births. No members of either group are related. These data illustrate what population geneticists refer to as the "founder effect."

—from *Klinger, 1983*

The "founder effect" seems to occur when

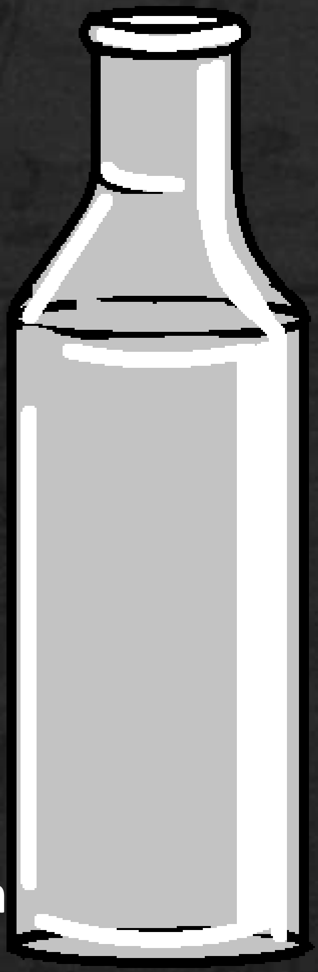
A. the environment favours one population over another population

B. a non-representative subpopulation forms the basis for an isolated population

C. individuals from one population move into and become part of a second population

D. two similar populations exist in the same community without being reduced in number

THE BOTTLENECK EFFECT



+ a gene pool change resulting from a rapid decrease in population size, due to a significant event, such as human activity, disease, severe weather, etc.
+ the survivors only have a small sampling of the genetic variation that was present in the initial population
+ often seen in species that have been nearly extinct, then their populations restored
  - e.g. elephant seals were hunted in the North until there were only about 20 remaining seals. The species became listed on the "protected" list and hunting them was declared illegal. The population has been restored to over 20,000 now, but little genetic variation exists between them

NATURAL SELECTION

+ the only process that leads directly to evolutionary adaptation
+ the environment in which the population lives decides what mutations are beneficial, neutral, or detrimental
+ sexual selection (non-random mating) is a form of natural selection
+ heterozygote advantages are also due to natural selection, where a carrier for a disease gets the beneficial side effects of the disease, without the detriment of the disease itself

HUMAN ACTIVITY

- habitat disruption and removal
  - habitats can become fragmented when previously "wild" areas become developed
    - splits a population in half, and could prevent gene flow between the two populations
  - removal of a habitat (e.g. clear-cutting a forest) can cause a population to decline rapidly and suddenly, causing the bottleneck effect

HUMAN ACTIVITY

- unregulated hunting
  - when an animal's particular trait becomes desirable (e.g. long-haired fur coats become fashionable), animals with that trait are selected against
  - unless hunting is controlled, it can drastically alter normal allele frequencies of a population
- introduction of new species for biological control
  - occasionally, a government will introduce a new species into the population to combat a problem with an invasive insect or weed population
  - seen as a more "natural" option than pesticide or herbicide spraying, although it can often have unpredicted consequences

DIPLOMA PRACTICE QUESTION

- Multiple choice #14

Because insects are probably our main ecological competitors, scientists search for ways to get rid of them. Scientists have discovered that the hormone ecdysone, produced by all insects, stimulates moulting and development into adult insects. Another hormone, juvenile hormone (JH), inhibits the effect of ecdysone and maintains the insect juvenile state (pupa). Typically, insects winter as pupae and emerge as adults in spring.

An effective insecticide would be one that

A. inhibits JH in the spring
B. stimulates ecdysone in the spring
C. maintains a high level of JH in the fall
D. inhibits the release of ecdysone in the spring

DIPLOMA PRACTICE QUESTION

- Multiple choice #15

The fathead minnow is a small fish common in Alberta waters and is used as a food source by many different predators. When injured, some minnows secrete a chemical (called schreckstoff) that both attracts predators and causes other minnows to huddle in large groups. Approaching predators tend to be distracted by the mass of minnows and by each other. Often, the injured minnow can escape.

—from *Gonick, 1996*

The frequency of the gene that controls the production of schreckstoff by minnows is likely

A. to increase in the gene pool of the population

B. to decrease in the gene pool of the population

C. to stay the same in the gene pool of the population because natural selection is occurring

D. to stay the same in the gene pool of the population because natural selection is not occurring

TECHNOLOGY IN ECOLOGICAL STUDIES

- mitochondrial DNA
  - when fertilization occurs, only the sperm's nuclei containing its nuclear DNA enters the female's egg cell
    - a cell's mitochondria, besides being the "power plant" of the cell, contain their own DNA (abbreviated mtDNA), which forms small loops rather than the double-helix structure of nuclear DNA
  - unlike your nuclear DNA which is a combination of the DNA from each parent, the mtDNA present in your cells is 100% from your mother
    - mtDNA also mutates very seldomly
    - as a result, by sequencing an individual's mtDNA, a geneticist would likely also be sequencing the DNA of that individual's female relatives for the last few thousand years
  - applications of mitochondrial DNA sequencing
    - better tracking of the lineage of animal species
    - possible recreation of extinct species
    - tracing human ancestry back to a particular region or individual (referred to in the scientific community as Mitochondrial Eve)
    - possible connection between faulty mitochondrial genes and inherited human diseases like Parkinson's

TECHNOLOGY IN ECOLOGICAL STUDIES

+ computer simulations
  – analysis of population changes, gene frequencies, weather patterns, etc. can all be done by computer simulation now
  – collection of data, interpretation, and production of charts and graphs are facilitated by the use of computers
+ technology for counting live animals
  – microchips can be implanted into members of a sample population and tracked by ecologists monitoring the population for migratory patterns, risk of extinction, etc.