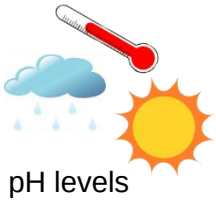
1A Population Dynamics
Population Ecology

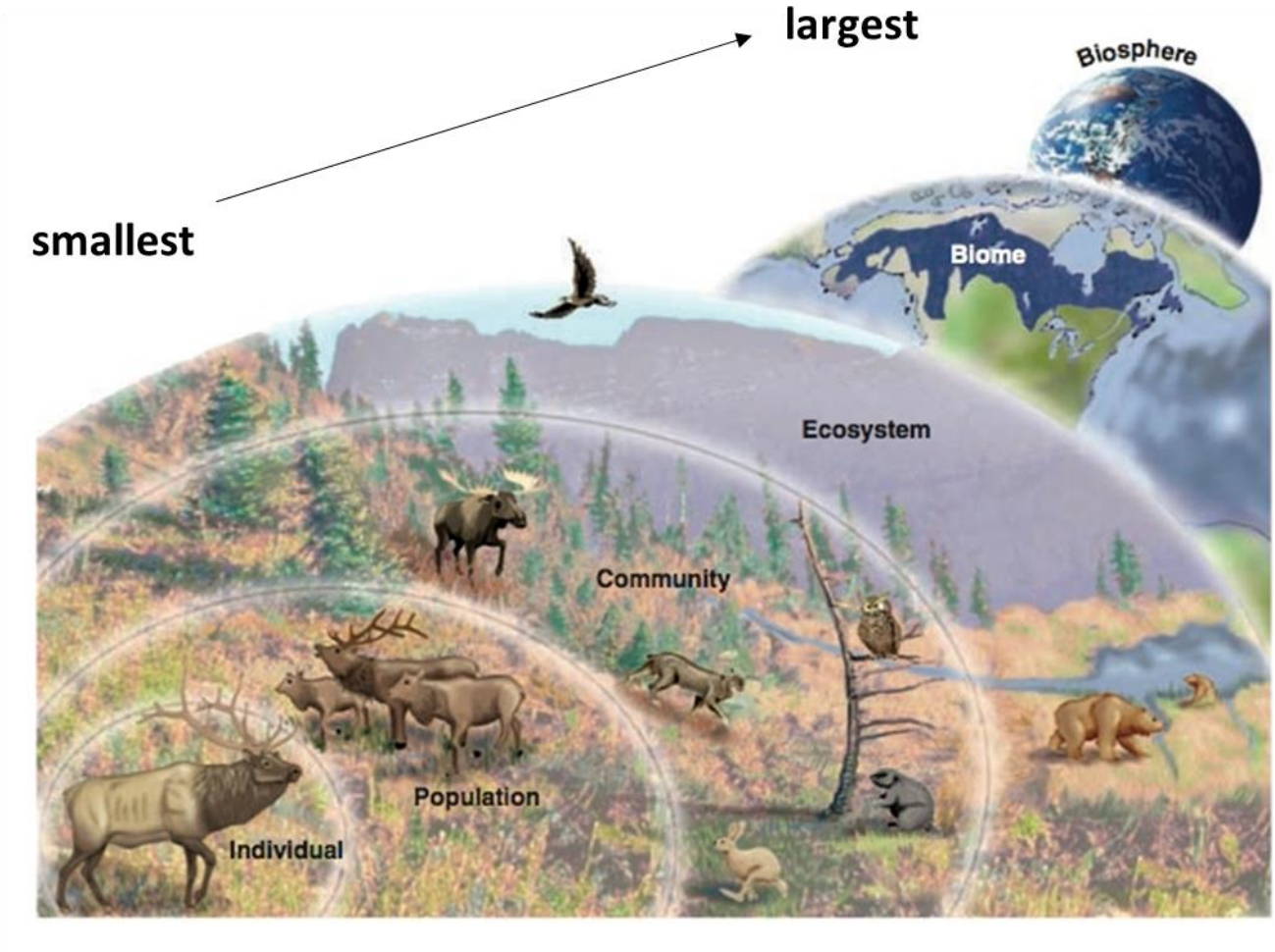


Terminology

- **Biotic factor –** any *living* factor in an organism's environment
  - Examples: producers, consumers, decomposers
- **Abiotic factor –** any *nonliving* factor in an organism's environment
  - Examples: temperature, water, sunlight, soil, oxygen and carbon dioxide levels, pH levels

Levels of Organization

We use terms to describe groups of organisms and their relationships to each other and to abiotic factors.



Individual	Population	Community	Ecosystem	Biome	Biosphere

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A single organism	A group of organisms of the *same* species Live at the same time, same place	All the populations of species (all biotic factors) Live at the same time, same place	Biological community and all abiotic factors that affect it All biotic & all abiotic	A group of ecosystems that share the same climate and have similar types of communities	The layer of Earth that supports life From high in the atmosphere to deep in the ocean

How does an organism fit in its ecosystem?

- **Habitat** – the area where an organism lives
- **Niche** – the role or position that an organism has in an ecosystem
    - Can be described as how it meets its needs for food - what does it eat, when and how does it obtain its food, what is its role in the energy flow of the ecosystem, shelter, when and how does it reproduce, how does it care for offspring

Zebra and wildebeest live in the same **habitat** and also fill a similar **niche**: large grazing animals that travel in herds and are hunted by lions.

Diversity in Ecosystems

- **Biodiversity –** the variety of life in an area
    - Determined by the number of different species in that area
    - biodiversity encompasses the genetic variety within each species and
    - the variety of ecosystems that species create.
- Changing biodiversity
    - Extinction *reduces* biodiversity (or species being eliminated from the area)
    - Small populations can result in lack of genetic diversity and are more susceptible to extinctions
    - New species *increases* biodiversity; larger populations are generally more genetically diverse
- High biodiversity = healthy ecosystem

QUESTIONS:

1. All of the silver maples in a given area make up a(n) _____.
    A. population
    B. community
    C. ecosystem
    D. biosphere

2. Silver maples, red oaks, red wolves, deer, robins, blue jays, a fresh water stream, river otters, black rat snakes, various soil bacteria and fungi, loamy soil, and lots of rain in the spring could describe a(n) ____.
    A. population
    B. community
    C. ecosystem
    D. biosphere

3. When ecologists study the abiotic components of the environment, they are studying ____.
    A. all organisms
    B. all predators
    C. soil, water, and weather
    D. all organisms, soil, water, and weather

4. Where an organism lives and how it interacts with other organisms is the organism's:
    A. habitat
    B. species richness
    C. trophic level
    D. ecological niche

5. A niche is best described as _____

_____

6. High biodiversity leads to a healthy ecosystem because _____

_____

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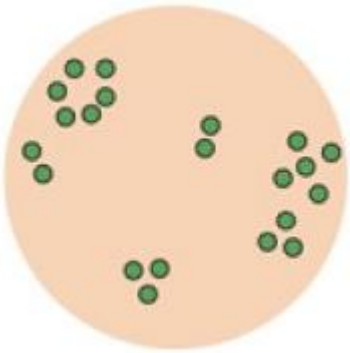
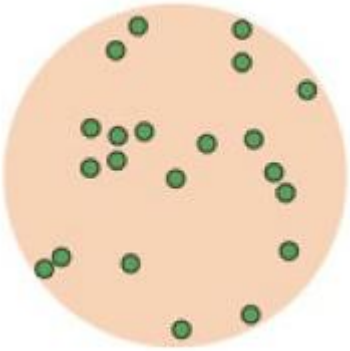
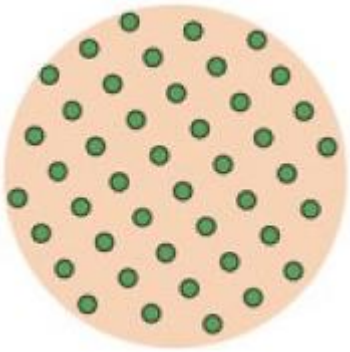
1B Density and Distribution

Population Density and Distribution

- **Population density** – the number of individuals per unit area
- **Population distribution** – the pattern of dispersal of individuals across an area
    - Distribution can be due to biotic factors, such as being limited by food source or abiotic factors (example: big human dwellings are build around large bodies of water - waste disposal)

Patterns of Distribution		
		
Clumped Due to attraction between individuals or attraction of individuals to a common resource	**Random** Due to neutral interactions between individuals, and between individuals and local environment	**Uniform** Due to antagonistic interactions between individuals or local depletion of resources

On a global scale, the distribution of species is clumped because organisms are located in areas suitable to their adaptations.

The distribution of the population in the United States would be best described as clumped.

- Clumped distributions is when species are clumped together across an area, such as wolves in packs.

Factors that can affect species distribution and abundance:

- Species-specific catastrophes

- Environmental catastrophes
- Geological events
- Sudden influx/depletion of abiotic resources
- Increased human activities

Model 2 – Factors Affecting Density

Factor	Density Dependent	Density Independent
Food supply	X	
Rainfall		X
Flood		X
Parasites	X	
Acidity		X
Disease	X	
Drought		X
Competition	X	
Predation	X	

QUESTIONS:

1. On a global scale, the distribution of species is:
   A. Uniform
   B. Random
   C. Clumped

2. The distribution of the population in the United States would be best described as _____.
   A. uniform
   B. random
   C. clumped

3. Why do most species have a clumped distribution?

4. An Earthquake would be an example of a density-dependent or density-independent factor? Justify your answer.

5. The Corona virus is an example of _____-dependent factor. Explain.

6. Explain why predation is a density-dependent factor.

1C Variation in Populations

1. Population Ecology

A population's ability to respond to changes in the environment is affected by genetic diversity. Species and populations with little genetic diversity are at risk for extinction.

Low genetic diversity means:

- Similar susceptibility to hereditary health problems, to potential pathogens or to environmental changes that could lead to population collapse

In many cases, species with low genetic diversity are as genetically similar as siblings or cousins.

Organism	Background
California condor 	● Largest North American land bird ● Recent data based on museum specimens shows that condors were fairly widespread and abundant prior to increases in human-caused mortality ● Humans likely drove their numbers down quickly in the 1800s and early 1900s ● The current population of California condors are descended from just 14 individuals ● Efforts are being made to prevent inbreeding to improve the likelihood of producing an eventual self-sustainable wild population

Black-footed ferret 	● In 1987, only 18 black-footed ferrets were known to exist, and only seven passed their genes to subsequent generations
	  ○ Decline due to decrease in prairie dog populations from cropland development, and from sylvatic plague
	  ○ Now there are >1000 wild-born individuals
	● There is a current effort to introduce DNA from dead specimens in zoos and museums back into the population
	  ○ Without this genetic restoration effort, inbreeding could push the animals back into decline or event extinction
	  ○ Also cryopreserved semen has been used for artificial insemination of live female ferrets

Prairie Chicken 	● Decrease from millions of birds in Illinois to fewer than 50 birds in 1993
	● Cause of genetic bottleneck
	  ○ Loss of habitat (US grassland converted to other uses)
	  ○ Fragmentation (isolation of populations with no natural corridors between groups)
	● Decrease in hatching success (less than 50% of eggs hatched)
	● Where birds have continuous habitat, there is more genetic diversity
	  ○ Efforts to maintain large continuous patches of suitable habitat
	  ○ Brought in birds from neighboring states, egg-hatching rate improved to over 90%

Corn and wheat rust effects on agricultural crops	● Rust describes a pathogenic fungus in plants ● Many crops are susceptible, implying that higher crop diversity is required to protect crops from infection

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Farmers may grow cultivars that are high yielding though susceptible to rust
Many farmers may grow cultivars with a similar genetic basis of resistance (aka, no resistance)

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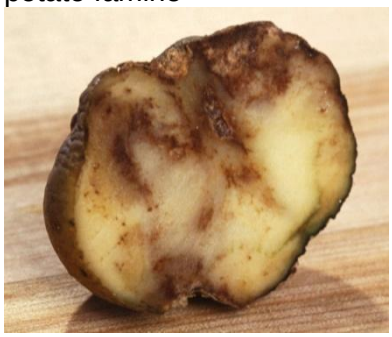
<td>Potato blight causing the potato famine
  </td>
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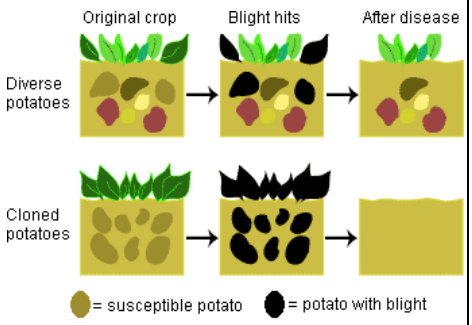
Lack of genetic variation in Irish potatoes contributed to the severity of the Irish potato famine

Evolutionary theory tells us that relying on crops with low genetic variation can lead to disaster

The Irish planted the “lumper” potato variety and because potatoes can be propagated vegetatively, all of these lumpers were clones (genetically identical to each other)
The genetically identical lumpers were all susceptible to a rot caused by Phytophthora infestans, which turns non-resistant potatoes to inedible slime

The disaster would likely not have been so terrible had more genetically variable potatoes been planted. Some potatoes would have carried the right genes to make it through the epidemic, and more of the resistant varieties could have been planted in the years following the first epidemic



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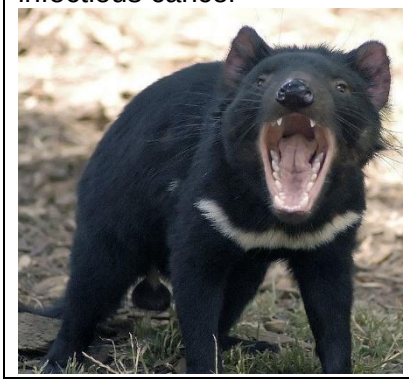
<td>Tasmanian devils and infectious cancer
  </td>
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Tasmanian devils are being infected with devil facial tumor disease (DFTD) since its emergence in the mid-1990s

High mortality rate
Contagious cancer
Has caused extensive population decline

Devils have responded behaviorally (females reducing their dispersal distance, devils breeding at a younger age)
Devils have low genetic diversity
Cause of genetic bottleneck

Likely not human impact
An ice age about 20,000 years ago and a prolonged El Nino drought about 5,000 years ago drastically reduced the species’ population and led to more inbreeding

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<u>Significance of Genetic Diversity</u>

Genetic diversity allows individuals in a population to respond differently to the same changes in environmental conditions.

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- Examples:
    - Not all animals in a population stampede
    - Not all animals have the exact same fur color
    - Not all individuals in a population in a disease outbreak are equally affected; some may not show symptoms, some may have mild symptoms, or some may be naturally immune and resistant to the disease

QUESTIONS:

1. Why is genetic diversity within a population important?
    A. So the population is less susceptible to disease
    B. So individuals of the population can survive when the environment changes
    C. So museums can have more realistic collections
    D. Both A and B are correct

2. When genetic diversity is lost due to a random event (such as a bottleneck), we call this:
    A. natural selection.
    B. gene flow.
    C. genetic drift.
    D. nonrandom mating.
    E. mutation.

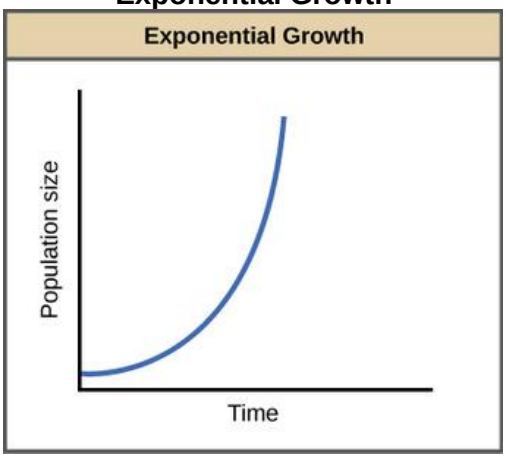
1D Growth Models

1. Population Ecology

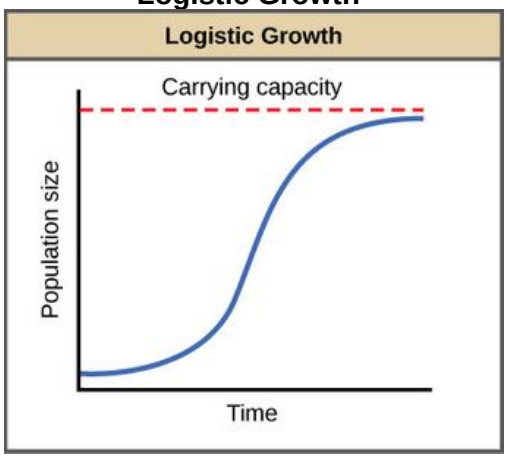
We can use (1) mathematical models and (2) graphical representations to represent patterns in population growth and how populations interact.

Two forms of growth

Exponential Growth



Logistic Growth



Which seems more likely to occur in real populations? _____

- Exponential growth, if it actually occurred would create *huge* populations
    - If there were *no* constraints on a population, this is what you would expect
- Logistic growth shows that there is something that limits population size, which is what we would expect

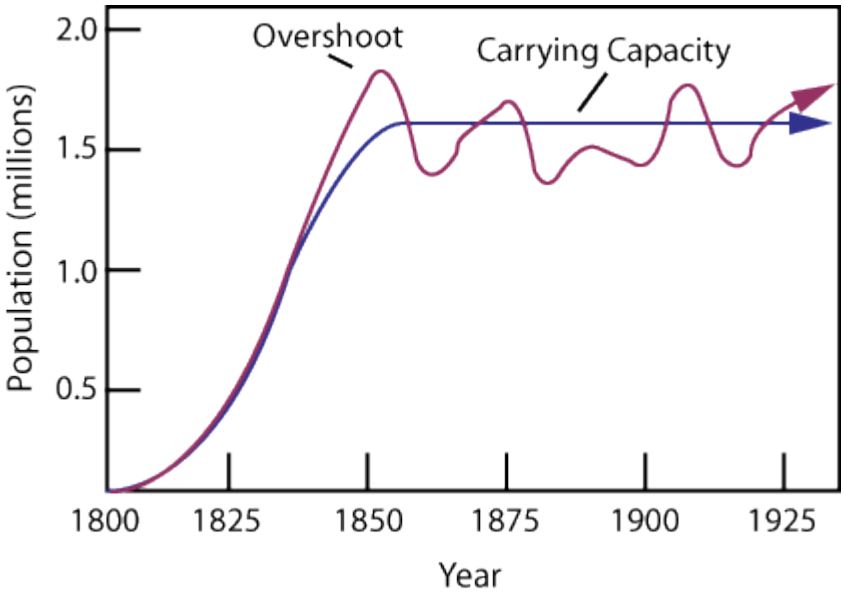
Factors limiting growth

- **Limiting factor** – biotic or abiotic factor that restricts the number, distribution, or reproduction of a population within a community
    - Examples: sunlight, temperature, water, nutrients, fire, other plants and animal species
- **Tolerance –** an organism's ability to survive biotic and abiotic factors

Density-dependent factors	Density-independent factors
Density-dependent = any factor that depends on the number of members in a population	Density-independent = usually an environmental factor that affects populations regardless of their density - Think: this is equally likely to affect one individual per square mile as it would 100 individuals per square mile
Examples	**Examples**
Predation: - If your population is dense, it is more likely that a predator will find you - This will limit your population size, if there are enough predators	Storms or natural disasters - Regardless of density, storms or natural disasters will affect all individuals in the area
Disease: - If a population lives in places tight together (aka in a dense population), disease will spread more quickly - Think of how likely it is you'll get the flu at home versus when you come to school	Extreme heat or cold - Temperature occurs regardless of population density Rainfall - Precipitation occurs regardless of population density
Competition: - If the population density increases, so will the demand for resources - With more individuals, there is more demand for resources	Seasonal cycles - Seasons change regardless of density

Carrying capacity

- **Biotic potential –** the highest rate of natural increase for a population, when resources are unlimited
- **Carrying capacity** – largest number of individuals in a species that an environment can support long-term
    - Prevents true exponential growth (due to limiting factors)
    - Generally population growth overshoots carrying capacity and then settles on carrying capacity numbers
- Determined by limiting factors



Under ideal conditions:

- Population increases exponentially until it overshoots the carrying capacity
- At this point, the environment can no longer sustain this population
    - Population, due to lack of resources, will begin to die out, allowing the environment to recover
    - As environment recovers, the population is able to flourish again
- Leads to a fluctuation between prosperity of the species and prosperity of the environment
- This is logistic growth

QUESTIONS:

1. The maximum number of individuals of a given species that can be supported by a given area on a sustained basis is known as ____.
    A. biotic potential
    B. carrying capacity
    C. exponential growth
    D. environmental resistance

2. How do limited resources affect a population?
    A. Increase the rate of natural increase
    B. The population grows exponentially
    C. Prevent a population from reaching its carrying capacity
    D. Prevent a population from reaching its biotic potential

3. Which of the following is a density-dependent factor that regulates population size?
    A. Competition
    B. Drought
    C. Accidental fire
    D. Earthquake

4. Which is a density-independent factor?
    A. Storms
    B. Disease
    C. Predation
    D. Competition

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5. What would allow a population to experience exponential growth?

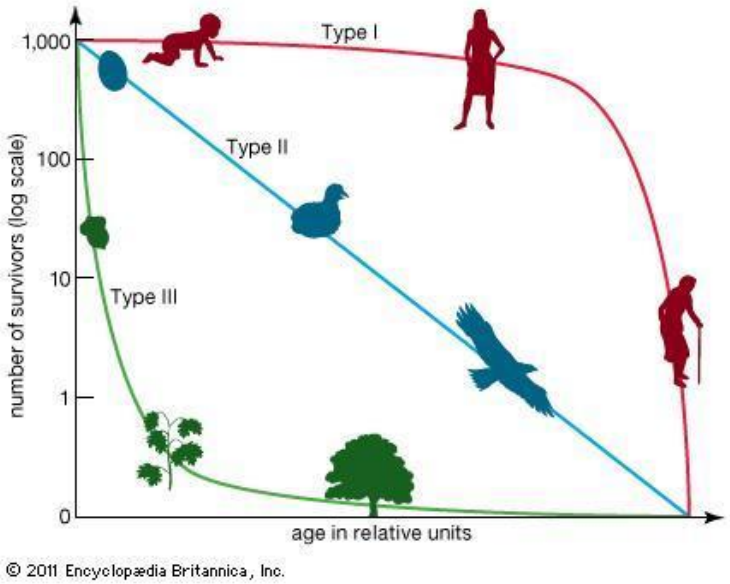
6. Is it possible for a population to produce a density of individuals that exceeds the system's resource availability? Why and why not?

7. If your population is limited due to density-dependent and density-independent factors, which model of growth would you see: exponential or logistic?

1E Mortality Patterns and Age Distributions

Terminology

- **Cohort** – all members of a population born at the same time
- **Survivorship** – the probability of newborn individuals of a cohort surviving to particular ages
    - Survivorship curve is characteristic of each species obtained by plotting the number of individuals surviving at each age



Type I Survivorship Curve	Type II Survivorship Curve	Type III Survivorship Curve
Most individuals live out their lifespan and die of old age (e.g. humans in well-developed countries)	Individuals die at a constant rate across their lifespan (e.g. birds, rodents, perennial plants)	Most individuals die early in life (e.g. fishes, invertebrates, plants)

1. Nemo, the clownfish has what type of survivorship curve? _____
2. Look at the questions on the next page. What type of survivorship curve do people in Mexico have? Justify your answer with data from the age pyramid.

Age Distribution Patterns

A population contains three age groups: prereproductive, reproductive, and post reproductive.
An age structure diagram is a representation of the number of individuals in each age group in a population.

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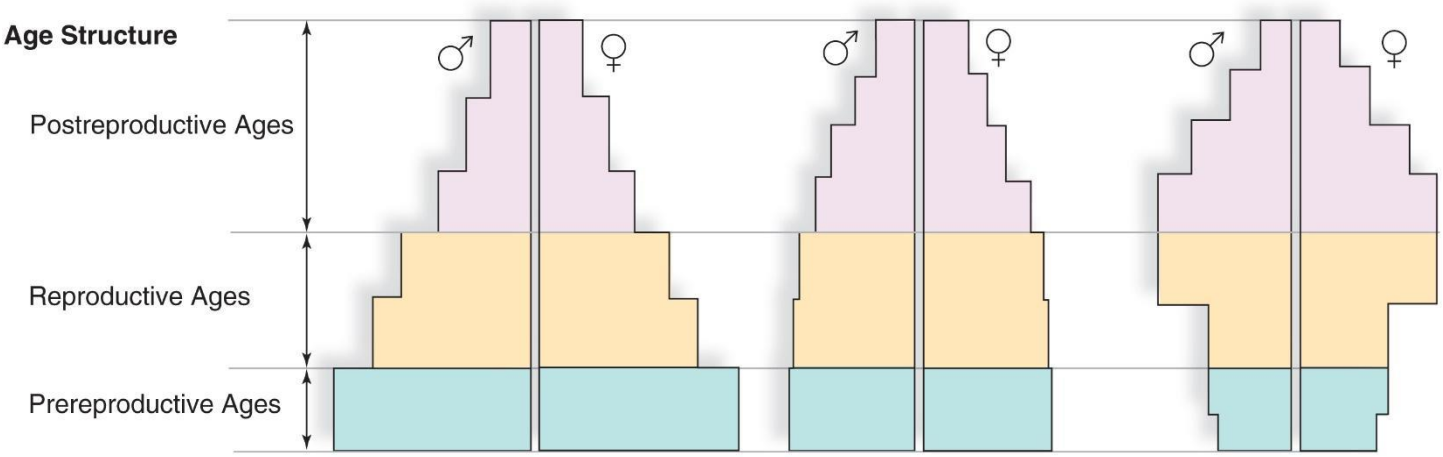
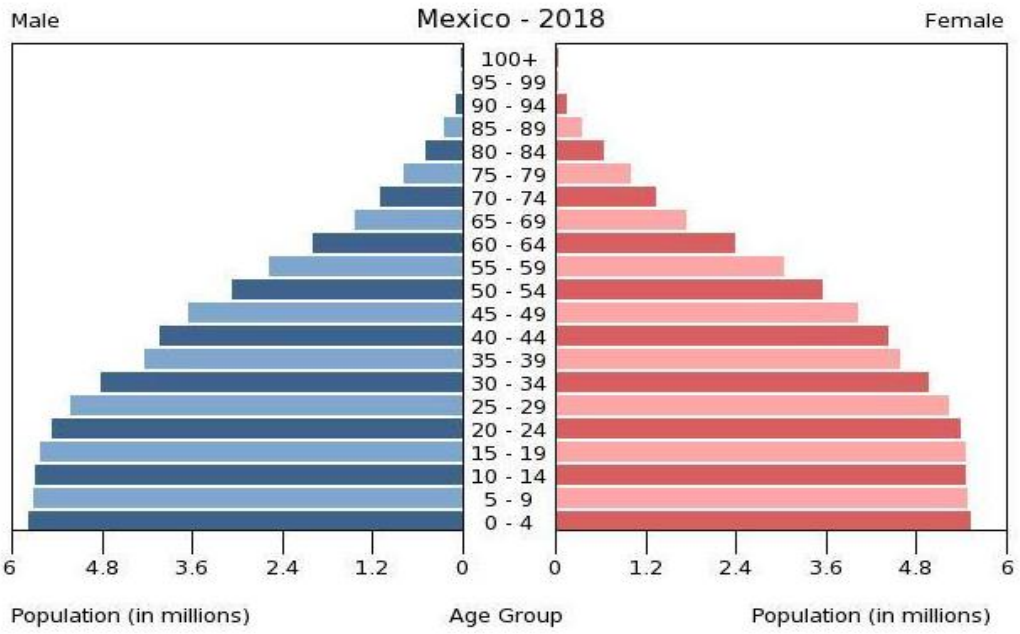


	Increasing Population	Stable Population	Decreasing Population
	Pyramid Shape	**Bell Shape**	**Urn Shape**
Information obtained from these graphs is used to determine past and future history of a population.	Indicates the population has high birthrates, is undergoing exponential growth	Characteristic of stable populations	Birthrate falling below the death rate Characteristic of declining populations

The Population pyramid of Mexico is shown below.



1. Based on the age structure shown, predict what will happen to the population (think size).

(A) The population will remain stable
(B) The population will probably decrease
(C) The population will probably grow rapidly
(D) The number of older people will probably increase rapidly.

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2. Based on the age structure of the country, which of the following situations would be most likely over the next 20 years? (think long term and use your answer to q. 1 when thinking).

(A) strong economic gains stimulated by population growth
(B) an increased demand for resources based on population growth
(C) a decreased demand for medical services resulting from small number of elderly citizen
(D) a decline in housing prices based on lack of demand