Population ecology

Scope

Topic	Breakdown of topic	Investigations	DBE textbook activities
Population ecology	**Population size** influenced by: Immigration, emigration, mortality, natality, fluctuations and limiting factors carry capacity. Logistic and geometric growth curves with phases. **Interactions in the environment**: Predation: two South African examples of predator-prey relationships: graphs **Competition**: Interspecific: for light, space, water, shelter and food Intraspecific: for food, access to mates, water, space, and shelter; survival is determined by access to the above, ecological niches. **Specialisation**:competitive exclusion and resource partitioning; discuss one example of co-existence in animals and one example in plants **Parasitism**: two examples from South Africa; one species benefit **Mutualism**: two examples from South Africa; both species benefit **Commensalism**: two examples from South Africa **Human Population** Reasons for exponential growth: Age and gender distributions for different countries including South Africa Forecast of South Africa's population growth over the next twenty years and predict possible consequences for the environment.	Determine the size of a population by quadrant or simple sampling e.g. simulated mark/recapture.	Activity 1 page 239 Activity 2 page 243 Activity 3 page 247 Activity 4 page 256 Activity 5 page 267 End of topic exercise page 268-274

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Population Ecology Notes

Population ecology is the study of populations in relationship to their environment and the social interactions amongst each other.

The study includes:

- Population size
- Interactions in the environment (predation, competition & symbiosis)
- Social organisation & Succession (not tested CAPS)
- Human population

Population size

a population is a group of the same species that occupies the same habitat at the same time and are able to interbreed

Affected by: Natality, mortality & migration

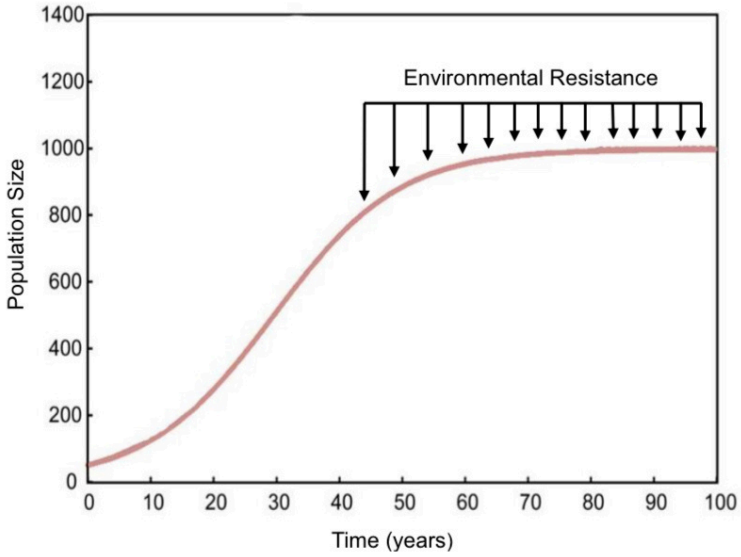
Increasing population	Decreasing population
Population increases because of **Natality** • Birth rate within a population. **Immigration** • Introduces new members into the original population. These members could have entered the population temporarily for the breeding season, or permanently. This is species dependent.	Population decreases because of **Mortality** • Death rate within a population. **Emigration** • Individuals leaving a population because of migrations at the end of a season or the original population splitting into sub-populations across a large geographical area.

Population Change = (Number of births + Immigration) – (Deaths + Emigration)

Population Ecology Notes

Fluctuations in population size

Density dependent and **independent factors** contribute to fluctuations in population size. These factors increase environmental resistance as indicated by arrows on the graph below



Density is the number of individuals in an area

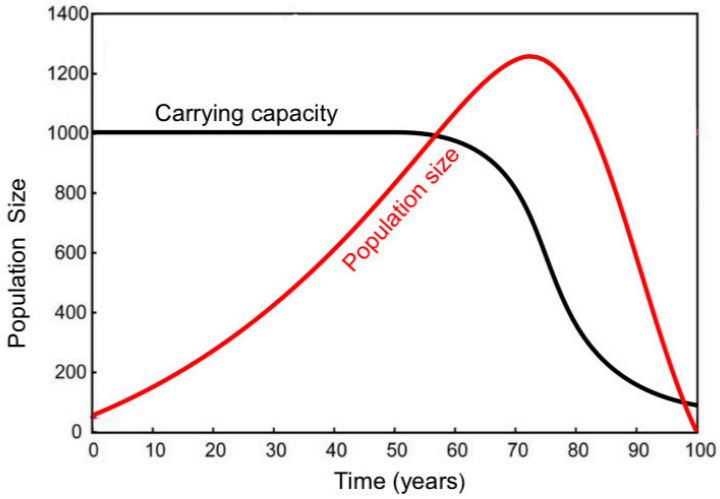
Examples of environmental resistance include:

- Carrying capacity, density dependent & density independent factors.

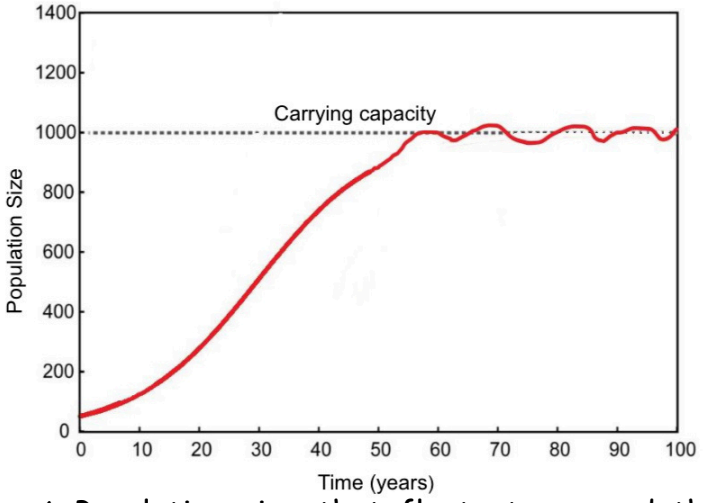
Carrying capacity

Carrying capacity refers to the number of individuals an environment can support in a specific season.

If populations exceed their environmental carrying capacity, resources to sustain the population may be depleted. The population may decrease.



A population size that exceeds the carrying capacity is called an unstable population.



A Population size that fluctuate around the carrying capacity is known as a stable population size.

Resources such as:

- food
- water
- shelter

Density dependent factors	Examples
• those factors that have a **direct correlation** (relationship) **to the size of the population in an area** • exert a greater influence when a population is large	• territorial behaviour • predation and competition • accumulation of waste • food, space and shelter • parasitism and disease
Density independent factors • factors that will **exert an influence on a population regardless of its size** • are abnormal events in nature and occur randomly	**Examples** (natural disasters) • tsunamis • landslides • volcanic eruptions • veld fires • floods

population size Terminology

Key terminology

species	a group of organisms capable of interbreeding, producing fertile offspring
population	a population is a group of the same species that occupies the same habitat at the same time and are able to interbreed
community	Groups of different species populations that interact with each other within a specific habitat
ecosystem	a biological community of interacting organisms and their physical environment
abiotic factors	non – living factors in an ecosystem
biotic factors	living factors of an ecosystem
environment	the sum of all biotic and abiotic factors in an ecosystem
habitat	the environment in which an organism completes its lifecycle (growth, reproduction and eventual death)
niche	the specific area where an organism inhabits
natality	the percentage increase of a population because of the number of births in a given season or year
mortality	mortality refers to the death rate within a population, usually as a percentage of the population
fertility	the number of births per year for all females who can produce offspring (between the ages 15 to 45)
immigration	new members may have migrated for the breeding season and are only temporary or may become permanent members, species dependent
emigration	individuals leaving a population because of migrations at the end of a season and the original population splitting into sub-populations across a large geographical area.
migration	movement from one place to another at certain times of the year or during a particular period of an organism's life cycle
environmental resistance	all factors that are limiting the biotic potential and numerical increase of a population e.g. lack of water, food, space
carrying capacity	the largest number of individuals in a biological species that an ecosystem can support over an indefinite time.
stable population	a population with a zero growth rate, neither growing nor shrinking in size
unstable population	a population whose size exceeds the carrying capacity of an area
density dependent factors	factors that have a direct correlation (relationship) to the size of the population in an area. The greater the size of the population the greater the influence of these factors
density independent factors	factors which exert an influence on a population regardless of its size.
endemic	organisms found only in specific area and nowhere else in the world
indigenous	Organisms found naturally in an area or country
endangered	organisms threatened with extinction (dying out forever)

Population Ecology Notes

Determining a population size

the size of the population can be determined either **directly** or **indirectly**.

Direct technique

Direct techniques determine the actual population sizes.
suitable for counting larger, slow moving organisms or organisms that are sessile.
Include:

- Aerial photography

By taking an aerial photo of a population, the actual number of individual members who make up the population can be determined by counting.

- Census

A census is a direct method used to determine the actual number of humans in an area or a country.

Indirect technique

Indirect counting techniques are used to estimate population size where it is difficult to determine the actual number of organisms.
used for smaller organisms or fast-moving organisms. They include:
Mark and recapture & Quadrat method

Mark and recapture involves taking two samples of the population.

- first sample - mark & release organisms. Allow enough time for them to mix. (Not too long)
- second sample recapture & count marked & unmarked organisms. The following formula (Petersen Index) is used to determine the size of the population.

$$N = \frac{M \times C}{R}$$

N represents the total number of individuals estimated in the given population
M represents the number of animals captured and marked in the first sample
C represents the number of individuals captured in the second sample
R represents the number of individuals marked in the second sample

Precautions

- Capture a large enough sample
- Markings must remain entire duration
- Markings must not harm or hinder movement
- Take secondary sample & calculate average (reliability)

Calculating population size

Terminology

Key terminology

closed population	a population where only natality and mortality influence population size; no emigration or immigration
direct counting	techniques that attempt to measure exact population sizes; no estimation are done
census	an official count or survey, especially of a population
indirect counting	techniques which estimate population size; ideal for smaller organisms

mark-recapture	a technique used to indirectly calculate the size of a population by capturing and marking a sample which is then released - a second sample is captured later, and the number of marked organisms counted
quadrats	square frames placed randomly on an area containing the organism; works well for both small sedentary animals and small plants

Population Ecology Notes

Population growth forms

Populations have characteristic patterns of growth. When population sizes are plotted over time, two different growth patterns can be found in nature. They are referred to as **geometric** (or a J-shaped growth curve) and **logistic** (or S-shaped growth curve) growth.

Geometric growth

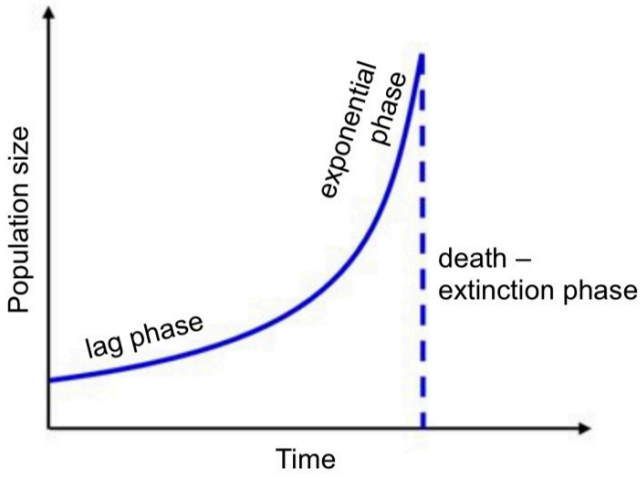
Geometric growth is characteristic of many micro-organisms e.g. bacteria and protists.

Has three phases:

1.**Lag phase** – population number inceases slowly because:
- individuals may still be acclimatising to their environment
- they need time to find mating partner
- most of the population is sexually immature

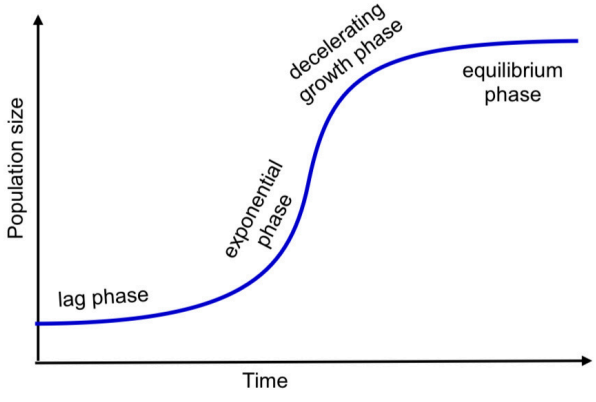
2. **Geometric** (or accelerated) growth phase – individuals have acclimatised.
- many reproducing individuals exist and in favourable conditions produce offspring.
- The birth rate is higher than the death rate.
- Little environmental resistance.

2. **Extinction** or **death** phase – resources become limited.
- not reproducing effectively.
- The mortality rate is greater than the natality rate.
- The population decreases rapidly.



Logistic growth

Logistic growth is found in higher-order organisms (e.g. mammals) which reproduce slower.



consists of five phases.

1. **Lag phase**: the population numbers increase slowly.
2. **Exponential** or **accelerating growth phase**: rapid increase because of enough food, space and shelter
3. **Decelerating** growth **phase**: higher levels of environmental resistance and old age.
4. **Equilibrium / stationary phase**: Carrying capacity of the environment has been reached. One or more limiting factors are exerting a toll on the population.
5. **Death / extinction phase** (not shown on graph): Some populations cannot regulate their resource usage and/or changes to abiotic and biotic factors in their environment and are then unable to sustain themselves.

Population Growth forms

Terminology

Key terminology

growth curves	graphs that plot population size against time
geometric growth	a doubling after every reproductive event, i.e. exhibit exponential growth; graph has a **J-shape**
logistic growth	the type of population growth that starts with a few individuals and many resources – growth rate and consumption then increases. As resources are used up, growth rate levels off, resulting in an **S-shaped** graph
lag phase	first phase in a population growth curve where growth is slow; individuals may be acclimatizing to environment; few individuals that are sexually mature and able to reproduce
exponential growth phase	second phase in a growth curve; individuals have acclimatized, many reproducing individuals exist; in favourable conditions can produce many offspring
decelerating growth phase	third phase in a growth curve; environmental resistance leads to a decrease in the number of individuals; initially, natality rate is higher than the mortality rate but later the mortality rate is equal to the natality rate and eventually exceeds it
equilibrium phase	forth phase in a growth curve; carrying capacity is reached and factors limit size of population; carrying capacity is stable and able to maintain the population at a set value
death / extinction phase	fifth phase in population curve; without management of resource usage, and changes to abiotic and biotic factors in their environment, the population may not be able to sustain itself and enter a population crash phase

Population Ecology Notes

Interactions in the environment

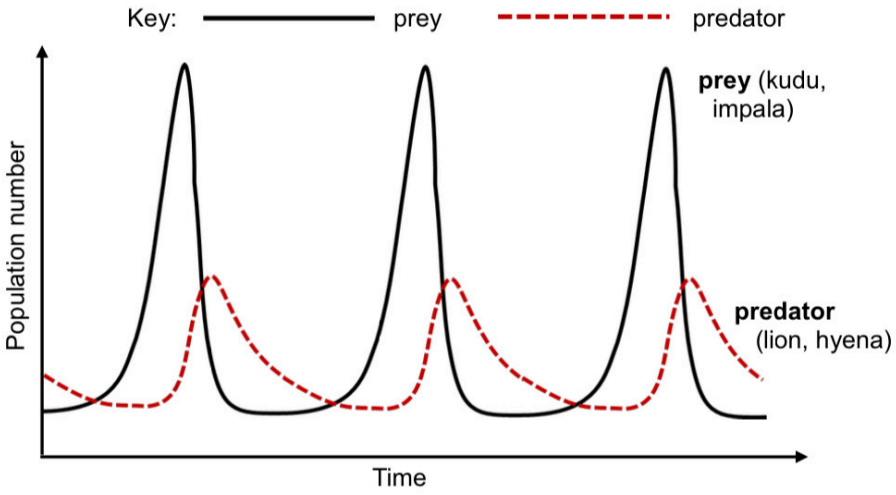
Species interact with each other in a variety of ways. These include:

- predation
- competition
- symbiotic relationships

Predation

A predator is an organism that actively hunts, kills and consumes its prey to meet its energy needs.

Prey increase first, then predators slowly start to increase as they acclimatise.
Prey numbers will then decrease as prey increases . The decrease in prey leads to decreased predators as they may emigrate to other habitats as food becomes a limiting factor.

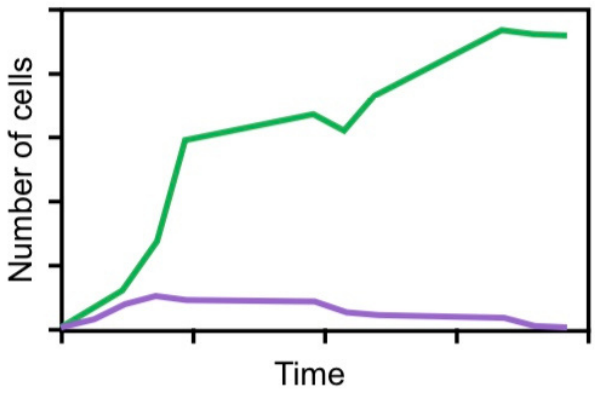


Competition

Competition is the interaction between individuals over scare resources.

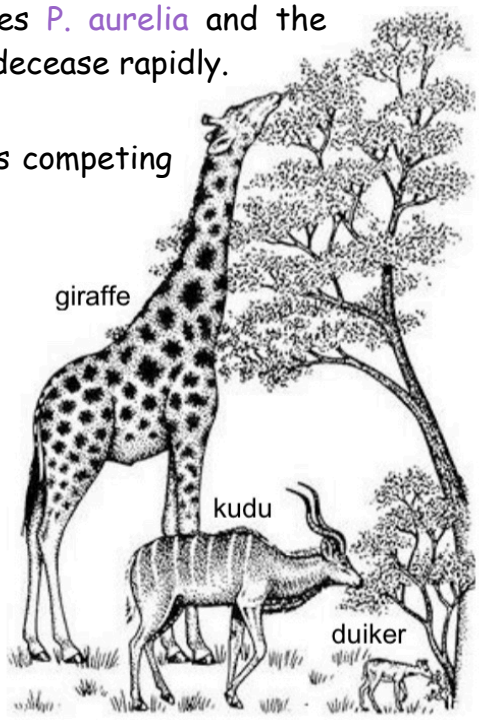
<u>Two types:</u>

- intraspecific competition: individuals of same species compete
- interspecific competition: involves individuals of different species



When Paramecium aurelia and Paramecium caudatum are kept in same container P. caudatum out-competes P. aurelia and the numbers of P. aurelia decease rapidly.

The competitive exclusion principle states that when two species competing for the same resources, one species will out-compete the other.



Resource partitioning

Resource partitioning refers to the sharing of resources so that different species can co-exist in the same area.

<u>Example</u>: herbivores grazing in the same area.

<u>This is only possible if:</u>

- individuals use different parts of the resource
- individuals use the resource at different times

Population Ecology Notes

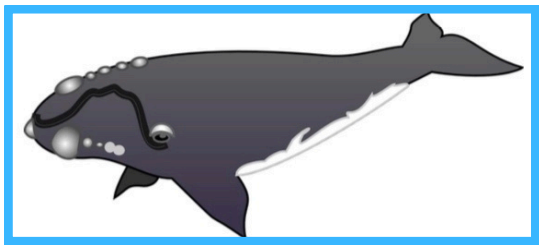
Symbiosis

Symbiosis is a close, long-term biological relationship between individuals of two or more species.

There are 3 types of symbiotic relationships:
- mutualism
- commensalism
- parasitism

Mutualism

Mutualism is an example of a symbiotic relationship between two different species in which both species benefit.



Buffalo and oxpeckers: The oxpecker feeds on ticks and the buffalo benefits by having the ticks removed.

Commensalism

In a commensalistic relationship, one species benefits while the other neither benefits nor is it negatively affected from the shared interaction.

Whales and barnacles share a commensalistic relationship.
Barnacles attached to whales filter water for food while the whale moves through the ocean. The whale is not harmed by the barnacles.

Parasitism

In parasitic relationships, one species (the parasite) benefits while the other species (the host) is harmed.
Parasites can be either
- **endoparasites**: those that parasitise the host internally e.g. tapeworms; or
- **ectoparasites**: those that parasitize the host externally e.g. leeches and ticks

Predation Terminology

Key terminology

predation	the act of preying on another animal
predator	heterotrophic organisms (usually animals) that hunt, kill and eat other organisms (or animals)
predator – prey curve	a curve that describes the dynamics of biological systems in which two species interact

Competition Terminology

Key terminology

competition	social interaction between organisms fighting for dominance over the same limited resources (food, living space)
interspecific competition	competition between two or more different species
intraspecific competition	competition within members of the same species
competitive exclusion	process whereby species can exist independently and survive; when placed in the same environment, one species will out compete the other and cause its extinction / death

Symbiosis Terminology

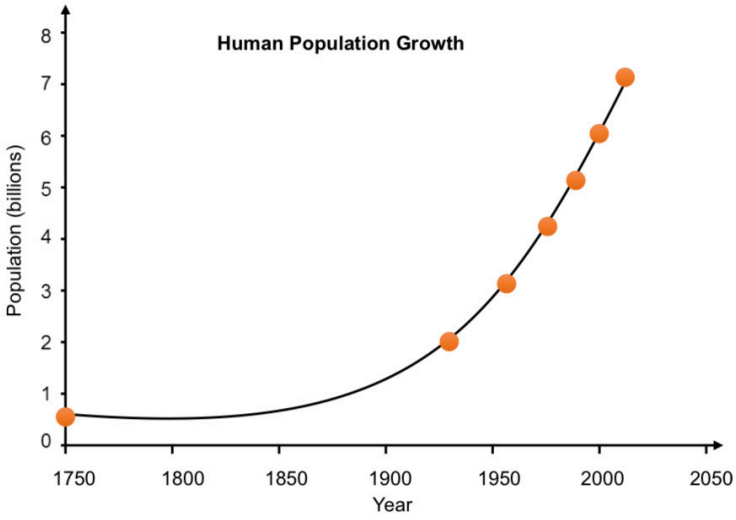
Key terminology

symbiotic relationship(s)	close physical association between two different organisms; includes mutualism, commensalism and parasitism
mutualism	species that partake in this relationship benefit equally
commensalism	symbiotic relationship where one organism benefits without harming or affecting the other organism
parasitism	symbiotic relationship in which one organism benefits from the relationship (parasite) while causing harm to their host
obligatory parasitism	parasite which cannot complete its life cycle without exploiting the bodies of suitable host(s)

Population Ecology

Human population

Human population has growth exponentially over the years



Reasons

Agricultural improvements

Through agricultural improvements, man has been able to increase and secure food availability.

Medicinal improvements

Our medical technology has improved drastically. We can counter the effects of pathogenic diseases and their subsequent spread

Technological improvements

Technology has made our daily lives easier and more convenient. Carrying capacity was further increased.

Age-gender pyramid

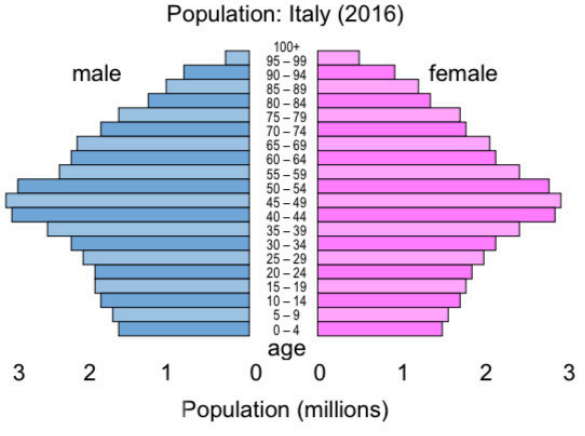
Age-gender pyramids represent human populations

<u>Three types of population pyramids can be observed namely:</u>

- expanding population pyramid
- stable population pyramid
- declining population pyramid

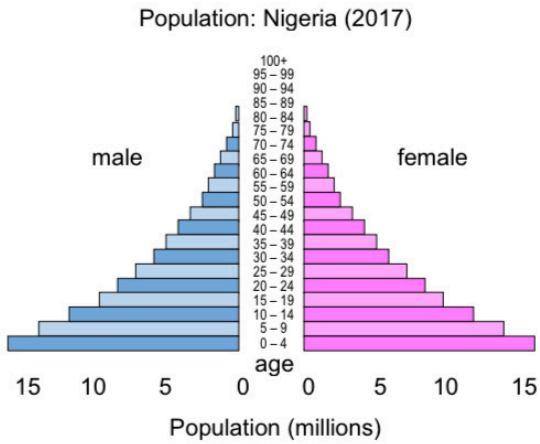
Negative or declining growth pyramid

- pre-reproductive groups are smaller than reproductive group
- natality and mortality rates are low
- many individuals reach older ages because of medical assistance and strong social welfare
- life expectancy, education levels and general standard of living are relatively high
- characteristic of developed countries, e.g. UK, Japan, Denmark and Italy



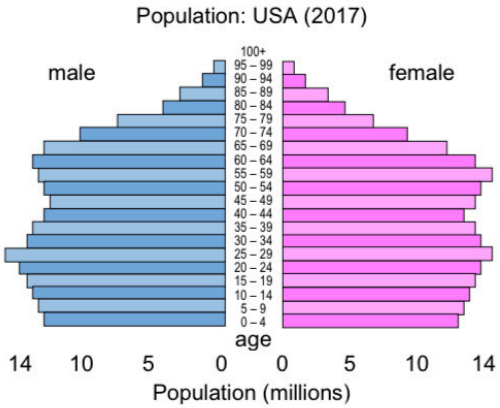
Expanding population growth pyramid

- more youth than elderly
- both natality and mortality rates are high
- few individuals reach old age - not much medical and social welfare assistance
- life expectancy, education levels, general standard of living are all quite low
- characteristic of developing countries / third world countries / many African countries



Stable population growth pyramid

- number of pre-reproductive individuals approximately the same as the number of reproductive individuals
- natality rates are low
- many individuals reach older ages because of medical and social welfare services
- life expectancy, education levels and general standard of living are all relatively high
- characteristic of certain developed countries, e.g. USA and China



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