Biology 30 IB
Populations

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Unfinished!

Contents

- Most species have thousands of genes
- More genes = more genetic diversity
- More alleles in said genes = more genetic variation
- Genetic diversity increases from sexual reproduction

Human Populations

Problems with Human Genes

- Few offspring
- Observations take time
- Many traits affected by environment as well as genes

Population Sampling

- Technique used to study human populations
- **Representative group** = group within population is selected, not entire population
- **Trends** or **Frequencies** = how often genes occur in the representative group
- **Gene pool**, aka. **genome** = all genes in a population
- **Fixed frequency** = only 1 allele for a gene, all organisms in population has gene

Frequency

- **Genotype frequency** = proportion of a population with a particular genotype (expressed as a decimal)
- **Phenotype frequency** = proportion of a population with a particular phenotype (expressed as a decimal or %)
- **Allele frequency** = rate of occurrence of a particular allele in a population with respect to a particular gene (expressed as a decimal)

Hardy Weinberg Principle

- Populations have either a...
  - tendency to remain stable
  - tendency toward variability
- **Genetic equilibrium** = if all other factors remain constant, the gene pool will have the same composition generation after generation
- Population evolve when equilibrium is upset

Hardy Weinberg Equilibrium

1.

$$p + q = 1$$

- Allele frequency
- $p =$ frequency of dominant allele (e.g. A)
- $q =$ frequency of recessive allele (e.g. a)

2.

$$p^2 + 2pq + q^2 = 1$$

- Genotypic frequency
- Above formula, but for all heterozygote father and heterozygote mother crosses

Tips

- A $= p$, a $= q$
- AA $= p^2$, Aa & Aa $= 2pq$, aa $= q^2$
- Work with homozygous recessive individuals first
  (only one possible genotype — homozygous recessive)

Conditions of No Evolution

Conditions under which no change will occur in a gene pool are...

- Large populations = changes in gene frequencies are not the result of random chance alone
- Random mating
- No mutations
- No migration = no immigration, no emmigration, no new genes enter or leave the population
- Equal viability (no disease), fertility, and mating ability of all genotypes (no selection advantage)

(21.2) Conditions of Evolution

The population gene pool is very unstable.

Conditions under which change will occur in a gene pool are...

- **Mutation**
  - Changes in the genetic makeup, either chromosome mutation or gene mutation
  - Occurs during meiosis
  - May be harmful in some parts and beneficial others
    e.g. sickle cell anemia carriers (heterozygous) have malaria resistance
- **Migration** (aka. Gene Flow)
  - Movement of members of a species, into (immigration) or out of (emigation) a population
  - **Immigration** = new genes are added to existing gene pool
  - **Emigation** = genes are removed
- **Non-random Mating** (aka. Sexual Selection)
  - Choice of which males will mate with which females
  - Choice often made by woman, based on physical or behavioral traits of mate
  - **Sexual dimorphism** = difference between male and female phenotypes (e.g. mane, antlers)
- **Small Populations**
  - **(Random) Genetic Drift**
    * Disruption of genetic equilibrium in small populations
    * If a unique allele does not mate, the allele is gone forever
  - **Founder Effect**
    * Few individuals of large population leave, forms new population
    * Allele frequencies will not be the same as former population
  - **Bottleneck Effect**
    * Severe environmental event, drastic reduction in population size
    * Allele frequencies very different than original population
  - **Natural Selection**
    * Only process that leads directly to evolution
    * Individuals with greater survival traits reproduce, passing on their favorable genes to the next generation

Mitochondrial DNA & Evolution

- **mtDNA** = Mitochondrion contain their own genetic material
- Mitochondria and chloroplast were once individual organisms, but symbiotic relationship formed with cells
- Mutations in mtDNA = Parkinson's

Speciation

- Process by which species originate
- **Species** = organisms that can...
  - interbreed
  - produce fertile offspring

Geographic Isolation

- Caused by physical obstacles/barriers
- Gene flow between main population and isolated group ceases
- Eventually, new species; become so genetically different that they can no longer interbreed, due to...
  - different adaptations
  - different gene frequencies
  - different mutations

Reproductive Isolation

- Organisms in a population can no longer mate and produce offspring
- Even if barriers are removed
- Even if fertilization occurs, genes so different that zygote doesn't develop
- Due to...
  - differences in mating habits
  - seasonal differences in mating
  - inability of sperm to fertilize eggs

(22.1) Populations & Communities

Characteristics

- **Population** = all individuals, same species, living in the same place, at a certain time
- **Community** = all species that occupy a given area
- **Ecosystem** = all biotic and all abiotic components
- **Geographic range** = map region where sightings of an animal have occurred
- **Habitat** = physical area where an organism lives

Competition

- **Interspecific** = competition between members of different species
- **Intraspecific** = competition between members of same species

Niche

A population's role and contributions in the community.

- Feeding habits
- # of offspring produced
- Prey
- Feces (enrich soil)

Population

Size

- # of the named organisms of the same species
- Location of the population, same habitat
- Time when the #'s were determined

Density

Describes the # of organisms in a defined area.

$$D_p = \frac{N}{S}$$

- D_p = population density
- N = # of organisms counted
- S = space occupied by the population
  (A = land area, V = aquatic volume)

Ecological Density

- Same formula as above
- Area/volume of what the organisms uses (given value)
  Not necessarily area/volume of entire ecosystem

Dispersion

General pattern in which organisms are distributed through a specified area.

- **Clumped dispersion** = grouped in patches or aggregations
- **Random dispersion** = uncommon; no attraction/repulsion among members; typically in tropical rainforest — habitat conditions are relatively uniform and plentiful resources, little competition
- **Uniform dispersion** = competition among organisms
  habitat conditions are not uniform and/or plentiful

Chaos Theory

Seemingly random phenomena may have an orderly system/explanation.

(22.2) Changes in Population Size

Terms

- **Natality** = # of offspring of a species born per unit of time
- **Mortality** = # of individuals of a species that die per unit of time
- **Immigration** = # of individuals of a species moving into an existing population
- **Immigration** = # of individuals of a species moving out of an existing population

Change In Population Size

Populations Given

$$\Delta N = P_f - P_i$$

- P_i = population size initially
- P_f = population size at end of study

Populations Not Given

$$\Delta N = (\text{factors that inc. pop.}) - (\text{factors that dec. pop.})$$

$$\Delta N = (n + i) - (m + e)$$

n = natality, i = immigration, m = mortality, e = emigration

Growth Rate

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

- ΔN = change in population size
- Δt = change in time

Per Capita Growth Rate

$$cgr = \frac{\Delta N}{N}$$

$$cgr = \frac{P_f - P_i}{P_i}$$

Equilibrium

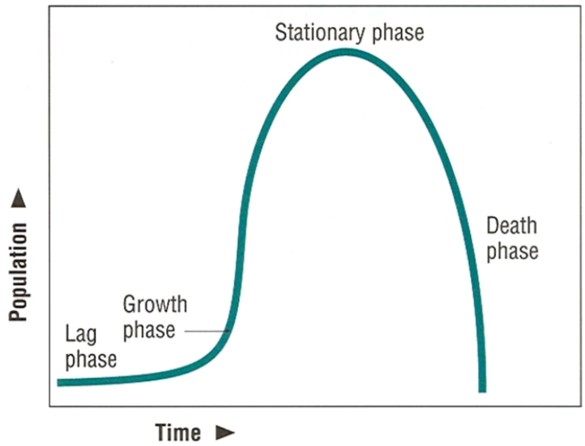
- **Dynamic equilibrium** = populations adjust to changes in environment to maintain equilibrium
- **Homeostasis** = organisms tend to maintain a constant internal environment, despite changing external environment

Population Types

- **Open populations** = natural; all 4 factors (natality, mortality, immigration, emigration) are occuring
- **Closed populations** = in lab settings, no immigration and emigration

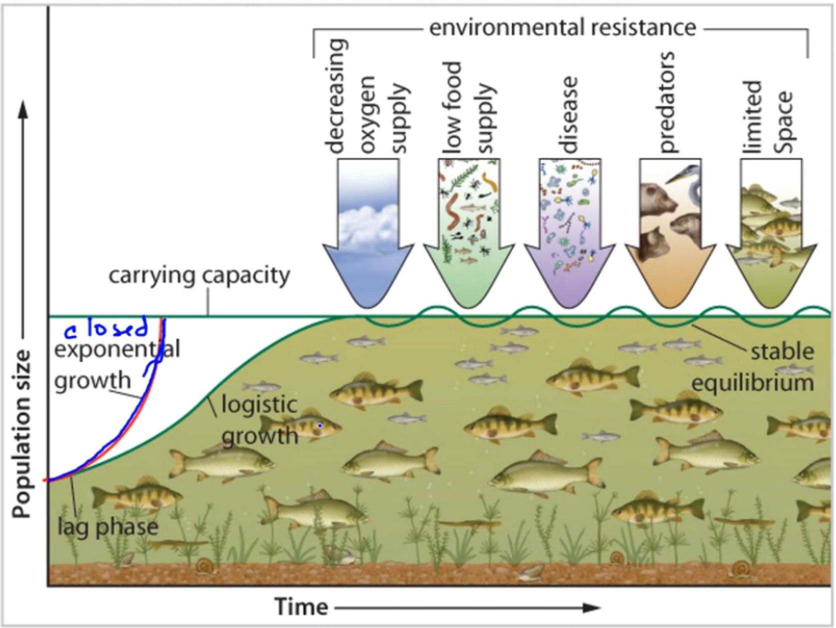
Growth Curves

- **Carry capacity (K)** = max # of individuals an environment can support; where a population curve flattens/plateaus



- **Lag phase** = delay before population reproduce, cells adjusting to new environment, cell growth enzyme synthesis
- **Log phase** = population increasing at its fastest rate; binary fission doubles each division, exponential
- **Stationary phase** = mortality = natality; lack of space, shortage of nutrients, accumulation of toxic wastes
- **Death phase** = mortality > natality; nutrients run out, wastes accumulate, # of organisms decrease at a constant rate

Growth Curve Types



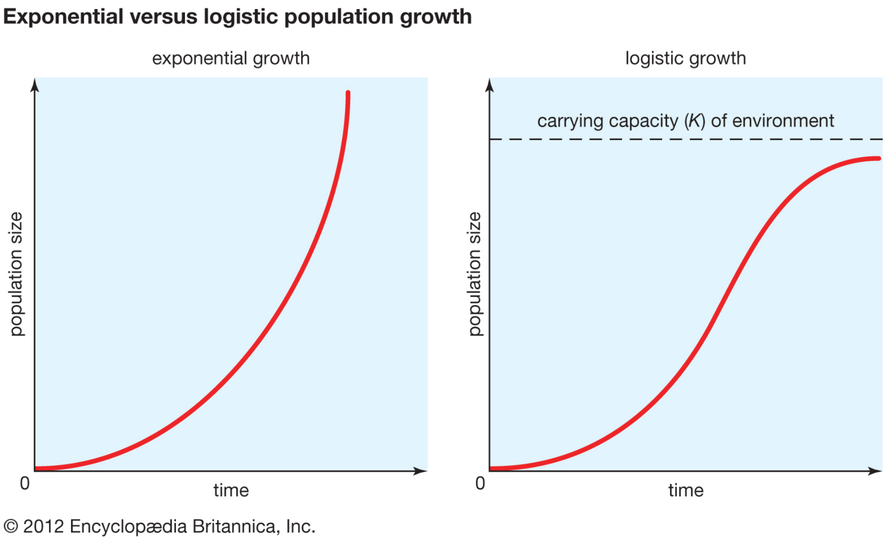


Figure 1: J-shaped, closed system left; S-shaped, open system right

J-shaped

- Occurs in closed populations
- Exponential growth
- No carrying capacity

S-shaped

- aka. Sigmoidal curve
- Occurs in open populations, typical of an organism placed in a new environment

Biotic Potential (R_{max})

- Ability to reproduce at a typical rate under ideal conditions
- Ideal conditions — not perfect, some predators/disease/etc.
- Regulated by... (don't need to memorize)
  - Offspring = max # of offspring per birth
  - Capacity for survival = chance of offspring reaching reproductive age
  - Procreation = # times per year an organism reproduces
  - Maturity = age at which reproduction begins

Environmental Resistance

- All factors that limit population growth
- Affect carrying capacity of an environment
- Biotic and abiotic
- Continually changing
- For instance: predation, competition for space, disease
- Food is usually the most important **limiting factor**

(22.3) Factors Affecting Population Change

- **Minimum viable population** = smallest # of individuals needed for a population to continue
- **Density dependent** = biotic affect biotic;
  factors brought on by population size may limit further growth and reduce population
  - Intraspecific competition: same species compete for resources
- **Density independent** = abiotic affect biotic;
  abiotic factors that affect populations, regardless of its size
- **Law of the minimum** = the resource in shortest supply is the limiting factor

Strategies

- K **selected populations**
  - Environmental conditions are fairly stable, fluctuations are few
  - Intense intraspecific competition
  - Members are usually large, slow-growing, and require parental care
  - Usually S-shaped curves — except humans, who are J-shaped
  - Examples include elk, bears, coconut trees, humans
- r **selected populations**
  - Environmental condition flucuations can result in massive number of deaths

– Small, short life span, reproduce at a high rate
– J-shaped curves

(23) Population Interactions

Population Histograms

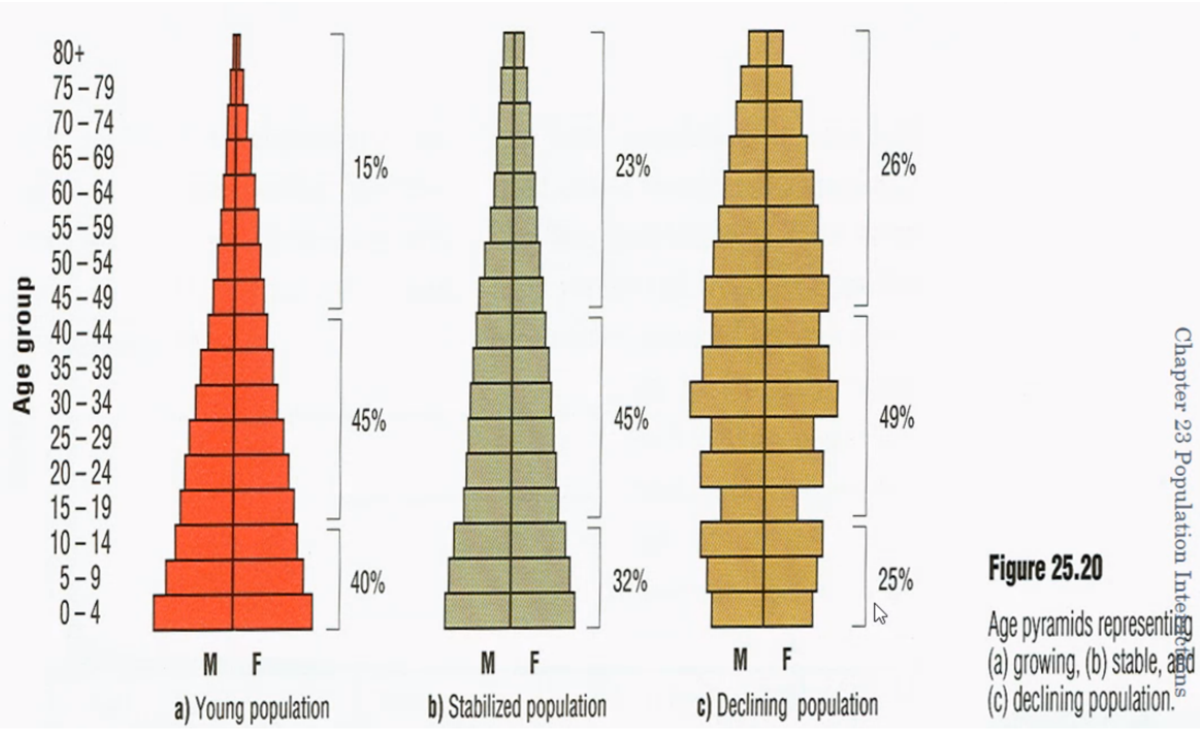


Figure 25.20
Age pyramids representing (a) growing, (b) stable, and (c) declining population.

- Don't need to know how to draw
- Wider = greater # of individuals in population

Types

- **Growing populations** = wide base, high # of reproductive-capable animals
- **Stable populations** = young > adult, growing very slowly, approaching zero growth
- **Population decline** = base narrower than middle

Human Population Growth

- Industrial revolution = production of more food
- Transport systems = food distribution
- Reduction of infant mortality = water, health care

(23.1) Interactions within Communities

Interspecific Competition

- Competition between different species, restricts population growth
- **Interference competition** = aggression for same resource, e.g. stealing
- **Exploitative competition** = consumption of shared resources

Gause's Principle

- If 2 populations of organisms occupy the same ecological niche, one of the populations will be eliminated
- Competition can be avoided by...
  - **Resource partitioning** = one species canges its behaviour;
    i.e. use different resources, at different times, different places