Evolution

Evolution practice questions: evolution.pdf

Definitions:

1. Population - Community of individuals linked by bonds of mating and parenthood that are found in a common geographical area. Community of individuals of the same species.
2. Species- A group of organisms that can have fertile offspring.

A population has continuity from generation to generation. The genetic constitution of a population may change over time. Genetic variation is necessary for this change (evolution). Note: Populations evolve. Individuals cannot evolve.

A. EVIDENCE OF EVOLUTION

How do we know that changes in population have occurred?

1. Fossils- Fossils are the remains or imprints of organisms that have been preserved, including footprints.

Organisms are entrapped quickly and completely in an oxygen free environment. This prevents decay. Examples include insects in amber, tar pits, peat bogs, glacial ice, and volcanic ash.

1. Comparative Anatomy

a. Homologous Structures

Structures or parts of organisms that have the same origin, but may or may not have same function- example: the arm bones of humans is similar to bones of cat front leg, whale fin, bat wings b. Analogous Structures

Parts of different organisms that have similar function, but not similar originsfin of whale and fin of shark

c. Vestigial Structure

Structures or organs that have no apparent function. These structures are thought to have had a function in ancestors or organisms, for example, appendix, wisdom teeth, fingernails, hair, etc.

1. Comparative Embryology

Developmental patterns are similar in organisms with similar evolutionary relationships. There are fewer differences in organisms that are closely related. We can see a closer relationship between organisms if we compare them earlier in their fetal development. example: HOX genes - similar in all animals

1. Biogeography

The distribution of species first suggested common descent to Darwin. Islands have many species of plants and animals that are both endemic (found nowhere else) and that are closely related to species on the nearest mainland or neighboring island.

1. Comparative biochemistry

The sequence of DNA and the proteins that the organism produces. Evidence suggests that organisms with similar DNA and proteins are closely related evolutionarily.

1. Fossil Dating
   1. Relative dating

Due to different rates of sedimentation in seas and lakes, the rocks form layers or strata.

The fossils in a stratum are a local sampling of the organisms that existed at that time period. Younger sediments are on top of older sediments. Thus, the layers of sediments give us relative ages of the fossils.

* 1. Absolute dating

The determination of the actual age of the fossil.

1) Radioactive Dating: Fossils contain radioactive isotopes accumulated when the organisms were alive. Once dead, the organisms do not accumulate any more of the isotopes. Each radioactive isotopes has a fixed rate of decay which can be used to date the fossil. A half-life is the time it takes for 50% of the isotope to decay. The decay is unaffected by temperature, pressure, or other environmental factors. For example, C14 has a half life of 5,600 years.

1. using sedimentary rocks to tell age:

Sedimentary rocks have a unique method of deposition – one layer on top of another. This seemingly simple arrangement can be extrapolated to assume that the rocks nearest the surface will always be younger than rocks deeper down. Digging through the layers, geologists can analyze their composition, and determine much about the climate and landscape during the time of their formation.

1. EVOLUTIONARY THEORY

How did changes in population come about? Here are a couple of evolution theories.

* 1. Jean Baptiste de LeMarck

Two theories of how organisms changed over time.

* + 1. Acquired Characteristics

Organisms can change their body when needed and pass these changes onto their offspring. b. Law of Use and Disuse

If you don’t use a body part, it will be lost in the next generation.

* 1. Charles Darwin
     1. Darwin was appointed Naturalist o board the H.M.S. Beagle which went on a five year voyage (1831-1836). He observed plants and animals on the Galapagos Islands off the coast of Ecuador. Some of these organisms were: Finches, Giant Tortoises, Iguanas, Orchids.
     2. In 1859 Darwin published a book entitled The Origin of Species by means of Natural Selection. In this book he outlines his principles of natural selection.
        1. Individuals in a species vary.
        2. Some variations are heritable.
        3. More individuals are produced than the environment can support.
        4. Competition for resources occurs.
        5. Individuals with favorable traits (and genotypes) will survive and reproduce. These traits will then be passed to the offspring.

1. NATURAL SELECTION

Darwin used natural selection to explain how these changes came about. Natural selection states that nature is acting upon a phenotype. These phenotypes, or traits, are coded for by genes. If an organism is adapted it will live and reproduce. If the organism is not adapted, it will move to a new environment or die. Organisms must adapt, migrate or die. Darwin’s theory does not emphasize survival, but reproductive success. Organisms can, after all, live their full life span and never reproduce.

1. VARIATION

Where does the variation come from?

* 1. Mutations

Permanent, random chemical changes in the DNA molecule that are passed on to offspring. Examples: point mutations, transformations, transduction, conjugation, translocation

* 1. Variation from Recombination- meiosis

The creation of genetic variation by recombination can occur more swiftly than it does when due solely to mutations.

* 1. Variation from Migration

Migration of individuals into a population from other populations can introduce new genes into the population, or remove genes from a population when individuals leave.

Every species of organisms examined has revealed considerable genetic variation

(polymorphism), this is reflected in the phenotype. Here are some examples of variations in a population

* + 1. Morphological Variation

Different body shapes and colors. For example, the shell of the land snail (Lepea nemoralis) may be mink or yellow depending on the two alleles at the single locus.

* + 1. Chromosomal Variation

In some species the organisms vary in chromosome number and shape. Extra chromosomes, reciprocal translocations and inversions occur naturally in populations of plants, insects and a few mammals. Polyploidy in plants

* + 1. Protein Variations

There are instances of amino acids substitutions in proteins of animals within a species.

1. MAINTAINENCE OF GENETIC VARIATION

Genetic variation is promoted and preserved through preservation and promotion of variability.

* 1. Sexual Reproduction Produces New Genetic Combinations
     1. Independent assortment at time of meiosis.
     2. Crossing over with genetic recombinations.
     3. Combination of two parental genomes at fertilization.
  2. Mechanisms that Promote Outbreeding
     1. Plants
        1. Some plants only have male or female parts.
        2. Anatomical arrangements of some flowers do not promote self fertilization.
        3. There are genes for self sterility.
     2. Animals
        1. Hermaphrodites rarely self fertilize.
        2. Mammals
           1. Males leave communes to mate
           2. Human cultural taboos against incest

1. CHANGES IN GENE FREQUENCY: NATURAL SELECTION

How are gene frequency changed?

* 1. Gene Pool

All the genes of any population at a given time is called a gene pool. The variation in this pool can change over time.

Evolution is any change in allelic frequencies in the gene pool. Evolution can proceed randomly or it can proceed under the influence of natural selection. Sometimes traits are favored by an environment, the organism will reproduce, and those genes will be passed on to the offspring. Other times, the traits may be less favored and the organism will have fewer or no offspring.

* 1. How Gene Pools Change

Random changes in the gene pool are forms of evolution without natural selection

* + 1. Gene Flow

The movement of alleles into or out of a population. This can be a result of immigration or emigration of breeding individuals or the movement of gametes between populations (as in pollination).

Gene flow can introduce new alleles into a population or change allelic frequencies. The overall effect is the decrease in the difference between populations. Natural selection increases the differences.

* + 1. Genetic Drift

This is a change in the gene pool that takes place as a result of chance. There are two situations where chance plays a role in evolution.

* + - 1. Founder Effect: A small population branches off from a larger one. This population may or may not be genetically representative of the large population from whence it came. As the population increases in size, a different gene pool will develop from that of the parent population. For example, Afrikaaners in South Africa are descended from about 30 Dutch families and show a high frequency or recessive diseases. The Amish also have their own groups of recessive disorders.
      2. Population Bottleneck: A population is drastically reduced by an event such as a flood or volcanic eruption having little or nothing to do with the usual forces of natural selection. The individuals that survive may have rare alleles. The gene frequencies of these rare alleles would increase dramatically after the disaster
    1. Nonrandom Mating

All individuals prefer to mate with those of a particular phenotype. Nonrandom mating may cause changes in gene frequencies.

Individuals typically mate more often with close neighbors than with distant members of population. Thus, individuals of a neighborhood tend to be related, and inbreeding occurs. Inbreeding over the long term will increase the frequency of homozygous recessive traits.

Another type of nonrandom mating is assertive mating. Individuals select partners that are like themselves in certain phenotypic characteristics. d. Mutations

A new mutation transmitted by gametes immediately change the gene pool by substituting one allele for another. However, the mutation by itself doesn’t have much affect on a large population in a single generation. Mutations are a very rare event and are the ultimate source of all genetic variation.

3. Changes in gene frequencies due to Natural Selection a. Description

The Hardy-Weinberg Equilibrium considers the gene frequencies in a population. Let’s look at the frequencies of three genotypes produced by a pair of alleles (AA, Aa, aa). “A” is dominant, “a” is recessive.

Alleles: A and a

The frequency (f) of A in a population = (f) AA and 1/2 (f) Aa

The frequency (f) of a in a population = (f) aa and 1/2 (f) Aa Let the frequency of A = p and the frequency of a = q.

p = (f) AA + 1/2 (f) Aa q = (f) aa + 1/2 (f) Aa

The frequency of both genes in a population is equal to

P + q = (f) AA + (f) Aa + (f) aa = 1 (the whole population).

In other words p + q=1, then q=1-p. With this information, if we know q, then we can determine p and visa versa. If the frequency of A is 0.7, then the frequency of a is equal to 1-0.7=0.3.

The probability of A meeting A is p\*p=p2.

The probability of A meeting a and a meeting A is p\*q+p\*q=2pq.

The probability of meeting a is q\*q=q2.

The three genotypes (AA, Aa, aa) together add up to the whole poulation or 1 or p2+2pq+q2=1. This is called the Hardy-Weinberg equilibrium

We can determine the genotypes of a population if given these values.

A=.3

Q=1-p, q=1-0.3=0.7 AA=p2=0.3\*0.3=0.9 aa=q2=0.7\*0.7=0.49

Aa=2pq=2\*0.3\*0.7=0.42

Therefore, in the population, 9% are AA, 49% are aa, and 42% are Aa.

In a population 16% of the people are recessive. Determine the frequency of the three genotypes. 16% of the population =aa=q2. If q2=.16 then q= the square root of .16=.4. If that is the case then p=1-q or 1-.4=.6. If p=.6, then p2 (frequency of AA) is =.6\*.6=.36. 2pq (frequency of Aa) =2\*.4\*.6=.48. In this population, 36% of the people are AA, 48% of the people are Aa and 16% of the people are aa.

If we use this equation and if we can trace a change in gene frequency over a period of time, we can substantiate that evolution has occurred. b. Rules

Hardy-Weinberg has a number of rules that must be followed in order to be valid.

1. One must use one trait that is controlled by a pair of alleles.
2. There must be a random sampling of a population.
3. The trait appears equally in both sexes.
4. Mating is random.
5. No net change in alleles through mutations.
6. Population size must be large enough for the rules of mathematical probability to be valid.

c. Usefullness

Why is the Hardy-Weinberg Equilibrium useful?

1. Most of population genetics theory and quantitative evolution theories are built upon models. The Hardy-Weinberg Equilibrium is the ground work for most of the models.
2. Hardy-Weinberg Equilibrium predictions are useful when studying populations since they provide a benchmark genetic equilibrium against which change can be noted.
3. It permits an estimation of gene frequencies, especially useful in estimating the number of carriers of lethal alleles in human populations.

I. WHAT IS SELECTED IN NATURAL SELECTION?

A phenotype is an expression of many different genes. The phenotype includes all observable attributes of an organism. The entire phenotype of an individual is the unit of selection.

At the same time, the phenotype isn’t determined by genes alone, but by the interactions of the phenotype with the environment.

1. Stabilizing selection

Extreme individuals are eliminated and intermediate forms are favored. The mutant forms are probably eliminated quickly.

1. Disruptive selection

Increase the two extreme types in a population at the expense of the intermediate forms. The result is usually a marked difference between the two groups.

1. Directional selection

Directional selection results in an increase in the proportion of individuals with an extreme characteristic. There is a gradual replacement of one allele or group of alleles by another allele in the gene pool.

1. Sexual Selection takes two form
2. Result of Natural Selection: Adaptation

Adaptations occur over many generations. Individuals are being selected. Certain individuals with certain traits ( and genes) reproduce and pass their genes to the next generation.

Adaptations are a result of natural selection and can be clearly correlated with environmental factors or with the selective forces exerted by other organisms

a. Adaptations to Physical Environment

Some phenotypic variations within a species follow geographic distribution and correlate with gradual environmental changes. This graded variation of a trait or complex of traits is called a cline. b. Adaptations to the Biological Environment

Coevolution occurs when populations of two or more species interact closely so that each exerts a strong selective force on the other. c. Mimicry

One example of coevolution. d. Muellerian Mimicry

In insects, unrelated and unpalatable species often resemble each other in their warning coloration as means to avoid a predator.

e. Batesian Mimicry

Other palatable insects resemble unpalatable ones to avoid predation.

3. Patterns of Evolution

1. Convergent evolution

Organisms that occupy similar environments often resemble one another although they may be only distantly related. When they are subjected to similar selection pressures, they have similar adaptations.

1. Divergent Evolution

When populations become isolated from each other, different selective pressures lead to different phenotypes.

L. EVOLUTIONARY TREND

1. Gradualism

Gradualism is a gradual change of organisms over time.

1. Punctuated Equilibrium

Long periods of no change, punctuated by short periods of drastic changes. This could be brought about by natural disasters and intense natural selection. 3 Adaptive Radiation

An ancestral species gives rise to many different species.

SPECIATION:

1. ALLOPATRIC SPECIATION (GEOGRAPHIC ISOLATION)
   1. Isolation

Populations in one geographic area are split into two or more geographically separated populations. Initially this blocks gene flow between two parts of a population. For example, a glacier cuts across a plain. A small number of indivudals colonize the new habitats on either side of the glacier. The populations are geographically isolated. Other examples include islands and island like situations such as, lakes for fish, the break up of pangea into continents, mountain tops for animals and plants, and forest extent for small mammals.

The populations may begin to diverge genetically under the pressure of different selection forces. If enough time passes and the selective pressures are significant, the isolated gene pools of the populations diverge. Differences accumulate such that microevolution occurs, causing changes in the respective phenotypes. Even if the small isolated populations were reunited with the parent population, interbreeding under natural conditions would no longer occur

1. SYMPATRIC SPECIATION

Sympatric speciation refers to the production of a new species within the parent population, without geographical isolation. Sympatric speciation usually involves the incomplete separation of homologous chromosomes (nondisjunction) or the homologous chromosomes do separate properly but cytokinesis does not occur.

* 1. Polyploidy

A new species forms by polypoidy (multiplication of chromosomal numbers, i.e. 2n—3n or 4n) when the chromosomes fail to segregate during meiosis.

Sympatric speciation through polypoidy is a common occurrence in plants. Some polypoidy plants are able to survive harsher environments better than nonpolyploids. Some polyploid plants that have an odd number of chromosome sets cannot produce sexually, but survive through vegetative propagation, (i.e. Bananas have flowers but the fruit yields no seeds).

1. ADAPTIVE RADIATION

Adaptive radiation is the emergence of a number of species from a common ancestor, as the population spreads to new environments.

Darwin’s finches represent an important example of speciation. The different finch species live on different islands and, therefore, cannot interbreed. Different environmental pressures and thus different selective pressures occur and the populations differ from each other. Darwin was able to identify 13 different species of finches on the Galapagos Islands; all have apparently risen from one ancestral species. The finches were not able to mate, so the genes were isolated. Natural selection occurred on each island, selecting for different genes. Eventually, the gene pools diverged.

A hybrid organism is the offspring of two parents from different species. Hybrids can occur in animals (mule), but they are more common in plants.

The gene frequencies in a population start to change over a period of time depending on the environment and selection pressures. Once the gene frequency change, the gene pool changes, and new species develop.

1. AFTER ISOLATION

Once two animals populations have become separated and have evolved into separate species, why can’t the different species reproduce? Why can’t the different species have fertile offspring? There are two categories of isolating mechanisms which prevent the formation of fertile offspring. These are prezygotic isolating mechanisms and postzygotic isolating mechanisms. These categories can be altered slightly and termed pre-mating and post-mating isolating mechanisms.

1. PREZYGOTIC ISOLATING MECHANISMS

These occur before the zygote is formed. They prevent the fertilization of the mother’s egg.

* 1. Habitat differences

Two species may inhabit different habitats. They never encounter each other to mate

* 1. Differences in breeding times.

Two species may reproduce at different times.

* 1. Mechanical difference

Organisms genitals work on the lock and key method. If the male and female genitals do not fit, mating will not occur.

* 1. Behavioral differences

Courtship behavior may differ. If so, no mating will occur.

* 1. Gametic differences

Even if the gametes meet, they rarely fuse to form a zygote. The sperm may not be able to survive the environment of the female reproductive tract, the gametes may not recognize each other, or the sperm may not fuse with the ovum.

1. POSTZYGOTIC ISOLATING MECHANISMS

These prevent successful reproduction after fertilization of the mother’s egg has occurred.

* 1. The zygote does not survive the gestation period.
  2. The offspring are sterile. The incompatible chromosomes undergo meiosis. However, whenever the offspring mate, the sperm/egg will not be able to combine wit the egg/sperm of the other male.
  3. Hybrid Breakdown; Hybrids are fertile but produce infertile or inviable offspring in the F2 generation.

I. GENETIC MECHANISMS OF SPECIATION

When two populations adapt to different environments, they accumulate differences in frequencies of genotypes and phenotypes. In the course of the gradual adaptive divergence of the two gene pool, reproductive barriers between the two populations evolve. Hence, two species arise.

These reproductive barriers can come about without being favored by natural selection.

Reproductive isolation is usually a consequence of the divergence of the two populations in response to other selective pressures.

Postzygotic barriers may be attributed to differences in regulatory genes that control development. Prezygotic barriers can come about as products of the gradual genetic divergence of two populations.

B. PHYLOGENETIC TREES

Phylogenetic trees portray common ancestry, relative divergence from the ancestor, and evolutionary relationships in reference to living representatives of the groups.

Phylogenetic trees start off with a common ancestor. Speciation occurs in the common ancestor population with changes in the gene pool. New populations (new species) branch off from the common ancestor population. These new populations will be exposed to environmental conditions, and, over time these populations will undergo evolution and speciation, thus creating new branches and populations.

Populations with a recent common ancestor are closely related evolutionarily and the branches should be close to each other.

The organisms in these closely related groups will tend to exhibit homologous structures (similar structures, may have different functions), similar DNA sequences (and similar biochemistry), and similar embryonic development.

The development of new species from a common ancestor is not necessarily a linear development. It is more of a radial event that shows more than one species developing from a common ancestor.

C. TWO EVOLUTION THEORIES

1. Gradualism

Change occurs at a regular rate, gradually over time.

1. Punctuated Equilibrium

Refers to the tempo of evolution, assuming that new species formed principally in small populations on geographic periphery of the range of the species, speciation occurred rapidly, and the new species then outcompeted the old ones. The population changed faster at sometimes than at other times. These changes can come about by sudden changes in environmental conditions. This story was developed by Nils Eldredge and Stephen J. Gould.