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EVOLUTIONARY BIOLOGY EXAM #1 Fall 2017

There are **3** parts to this exam. Use your time efficiently and be sure to put your name on the top of each page.

Part I. True (T) or False (F) (2 points each). Circle the correct answer.

1. Reconstructing the Last Universal Common Ancestor (LUCA) is challenging because horizontal gene transfer appears to have been common among early life forms. **T** **F**

2. Rare alleles have a higher probability of being lost during a population bottleneck event **T** **F**

3. Natural Selection can cause either an increase or a decrease in population mean fitness. **T** **F**

4. Self-replicating proteins are the most likely candidate for the first information bearing molecule in living systems. **T** **F**

5. Selection acts on the genotype not the phenotype **T** **F**

6. Homology is similarity in traits due to shared inheritance from a common ancestor. **T** **F**

7. Aristotle was the first scientist to articulate a theory of evolutionary change. **T** **F**

8. Under directional selection, the rate of evolutionary change in gene frequencies occurs most rapidly when heterozygosity is highest. **T** **F**

9. Inbreeding causes an increase in the probability that individuals carry alleles that are identical by descent. **T** **F**

10. Mutation accumulation experiments indicate that mutation can rapidly change allele frequencies in natural populations **T** **F**

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Part II. Multiple Choice (3 points each). Circle the best answer.

11. Which of the following statements regarding the early history of life is **TRUE**:

a. According to the Oparin-Haldane model the development of a cellular membrane must have preceded the development of an information-bearing polymeric molecule.
b. The basic chemical building blocks for complex biological molecules must have originated in outerspace.
c. Ecological systems based on iron sulfide metabolism may have supported the earliest living systems on earth.
d. A reducing atmosphere during the early history of the earth prevented the evolution of cellular life forms.

12. Which of the following statements is **FALSE**?

a. Panspermia is the hypothesis that life has an extraterrestrial origin.
b. Gene duplication can lead to novel function.
c. Natural selection is the same as evolution.
d. The adaptive value of a mutation changes with the ecological circumstances.

13. Which of the following statements is **NOT** true?

a. Lamarck proposed that organisms arose through spontaneous generation and evolved toward increasing complexity.
b. The Law of Succession is based on the observation that extant organisms often resemble recent fossils from the same geographic region.
c. Thomas Malthus developed the mathematical framework to describe exponential population growth.
d. Fisher argued that mutations with small effects are more likely to be deleterious than mutations with large effects

14. Which of the following statements about migration and selection is **TRUE**?

a. Selection can promote population homogeneity, but migration causes population differentiation.
b. Migration between two populations experiencing different selection regimes will tend to keep each population from achieving its expected allele frequency under selection alone.
c. Migration cannot introduce enough new variation to maintain a polymorphism, even when selection is weak.
d. Selection is impossible in the face of high rates of migration.

15. Darwin's four theories of evolution include each of the following **EXCEPT:**

a. Evolution has occurred.
b. Natural selection is the primary cause of evolutionary change.
c. The splitting of lineages into two or more species has occurred.
d. Evolutionary change proceeds rapidly, and is fueled by mutations of major effect.

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16. Mutations are necessary for evolution to proceed. Which one of the following statements about mutation is **TRUE**?

a. In a stressful environment, mutations occur preferentially in biochemical pathways that are of adaptive significance.
b. Point mutations are the most common type of mutation and are the most likely type of mutation to have major effects on fitness.
c. The most likely fate of duplicated genes is that they accumulate point mutations and become functionless pseudogenes.
d. Exposing *Drosophila* to x-ray radiation causes an increase in population mean fitness.

17. Which of the following statements about genetic drift is **TRUE**?

a. Genetic drift can rapidly homogenize allele frequencies in different populations.
b. If unchecked by other processes, genetic drift will result in a genetically uniform population.
c. Genetic drift changes only genotype frequencies, not allele frequencies.
d. The effective population size is usually larger than the actual population size.

18. A large value of $\boldsymbol{F_{ST}}$ indicates…

a. random genetic drift is stronger than selection
b. a pattern of non-random mating within populations.
c. restricted gene flow between populations.
d. The populations are in migration-selection balance

19. A likely explanation for the maintenance of the sickle-cell gene in Africa is that it confers an advantage to heterozygotes by increasing their resistance to malaria. Such overdominant selection results in a stable equilibrium. What do you think the nature of selection on the sickle-cell gene should be in a place where malaria rarely occurs (like the United States)?

a. There should still be overdominant selection.
b. There should be underdominant selection.
c. There should be directional selection to eliminate the sickle cell gene.
d. There will be no selection at all.

20. Which of the following statements is **FALSE**?

a. Frequency-dependent selection can maintain genetic variation
b. Inbreeding depression is stronger when deleterious alleles are dominant
c. Evolution occurs in populations not individuals
d. Recombination is a source of genetic variation

21. Lamark's ideas about the process of evolution include each of the following **EXCEPT:**

    a. Acquired characteristics are inherited.
    b. Organisms arise by spontaneous generation.
    c. Evolutionary relationships among organisms can be depicted by groupings based on similarity.
    d. Organisms develop adaptations to the environment through the use and disuse of organs.

22. Which of the following is **NOT** used by scientists as evidence for evolution?

    a. The fossil record of organisms living in the past.
    b. Experimental tests of the effects of selection.
    c. Similarity in functional traits, like the wings of insects and birds.
    d. Rapid phenotypic change in natural populations in response to changing environments.

23. Why do some eyeless cave fish have genes that control eye development?

    a. Their ancestors had eyes and they inherited these genes even though they no longer have eyes.
    b. If they return to the surface environment they will need eyes so evolution keeps them around.
    c. Evolution can cause gene gain but not gene loss.
    d. None of the above.

24. Which of the following statements is **NOT** true?

    a. The outcome of selection depends on the frequency of an allele and its effects on fitness.
    b. Rare alleles are almost always in the heterozygous state.
    c. Selection cannot easily eliminate a dominant deleterious allele because when the beneficial recessive allele becomes rare it will almost always be in the heterozygous state.
    d. Selection occurs whenever genotypes differ in their relative fitness.

25. Which of the following statements about evolution is/are true?

    a. Evolution is change that is heritable across generations.
    b. Evolution is a property of populations not individuals.
    c. Evolution is a change in gene frequencies through time.
    d. All of the above
    e. a and c

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Part III. Short Answer/Problems. Be concise and to the point, short focused answers are better than long rambling ones. **Show your work for partial credit.**

21. (3 pts.) Darwin developed his theory of Evolution by Natural Selection over the course of many years of careful observation and study. List **three (3)** scientific areas / theories / observations that contributed to his revelation in the following passage:

"… it at once struck me that under these circumstances favourable variations would tend to be preserved and unfavourable ones to be destroyed."

September 28, 1838

There are a lot of possibilities for this one including the observations he made on te effect of selection in domesticated animals, the observation of variation among island populations in the Galapagos, the emerging understanding of the age of the earth from the field of geology, the law of succession, Malthus's work on population growth, etc.

22. (8 pts.) By the early 1940's the unification of evolutionary biology that we now refer to as the "Modern Synthesis" had been completed. The unification of the field was facilitated by a large number of researchers in the fields of genetics, systematics, and paleontology. One of the major outcomes of the "Modern Synthesis" was a clear description of the evolutionary forces acting on natural populations. Below, list **four (4)** forces affecting the evolution of natural populations. (1 pt each)

1) **SELECTION**

2) **MUTATION**

3) **RANDOM GENETIC DRIFT**

4) **MIGRATION**

These forces influence the patterns of genetic variation in natural populations. Briefly compare and contrast the way that each of these forces influences genetic diversity. (1 pt each)

These forces all influence the patterns and amounts of genetic variation in natural populations in different ways. Mutation increases genetic variation. Random genetic drift reduces genetic variation. Selection typically reduces variation. However, some forms of selection can maintain genetic variation. For example, frequency dependent or overdominant (heterozygote advantage) selection can maintain genetic variation. Migration can either increase or decrease genetic variation depending on how it influences gene frequencies. In the extreme case when novel alleles are being introduces from another population, migration can rapidly change gene frequencies and increase variation. However, if gene frequencies are changed so that the population is moved farther from equal frequencies of alleles (p=0.5, q=0.5) migration will tend to reduce heterozygosity and reduce genetic variation.

22. (10 points) List **AND** briefly explain **3** different mechanisms by which natural selection can maintain genetic variation in a population. (3 pts each with partial credit for just the name or just the definition)

1. Overdominance. When there is heterozygote advantage, as long as a population starts with two alleles (*i.e.,* is not fixed for one or the other allele) both alleles will be maintained at a stable equilibrium.

2. Fluctuating selection. Temporally or spatially varying selective regimes that favor different genotypes can preserve genetic variation. The maintenance of variation by this mechanism requires a fairly narrow set of conditions.

3. Frequency-dependent selection. If the rare genotype has a fitness advantage and the common genotype a selective disadvantage, then genetic variation will be maintained in the population.

Provide an example of a real system in nature that demonstrates one of these mechanisms: (1 pt.)

26. (8 points) One of the classic cases in conservation genetics is the elephant seal. This enormous pinniped was hunted for its fur to near extinction in the late1800's. At the lowest point the total population size of the elephant seal may have been as small as a few dozen.

a) One major concern for small populations is the loss of genetic variation due to random genetic drift. If a population goes through a bottleneck with a population size of 12 individuals and it initially has a heterozygosity of 0.35;

How much of the initial heterozygosity will be lost after one generation? (4 pts)

$H_1 = H_0(1-1/2N_e)$
$H_1 = (0.35)((1-1/(2(12)))$
$H_1 = 0.335$
$0.335/0.35 = 0.958$

This population retains 95.8% of the initial heterozygosity and has lost 4.2% of the initial variation in one generation.

If the population size remains the same, how much of the initial heterozygosity will remain after 10 generations? (4 pts)

$H_{10} = H_0(1-1/2N_e)^{10}$
$H_{10} = (0.35)((1-(1/(2)(12)))^{10}$
$H_{10} = 0.229$
$0.229/0.435 = 0.653$

65.3% of the initial heterozygosity will remain after 10 generations

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28. (6 points) Another concern for any small population is inbreeding that tends to lower mean fitness.

How does inbreeding lower fitness? (3 pts)

Inbreeding leads to INCREASED HOMOZYGOSITY because of non-random mating among related individuals. This non-random mating leads to an increase in the probability of alleles being identical by descent (IBD) and causes a change in the genotype frequencies in the population. When there are *DELETERIOUS RECESSIVE ALLELES* segregating in the population increased homozygosity will lead to greater expression of these deleterious alleles since their effects will no longer be masked in the heterozygous condition. The result is a reduction in population mean fitness. If deleterious alleles are not recessive no reduction in fitness will be observed. This phenomenon is referred to as *INBREEDING DEPRESSION.*

An interesting observation is that inbreeding depression is almost universal. Virtually any population (including humans) that inbreeds will suffer a loss of fitness. What can we learn from this observation? (3 pts)

A good explanation of the importance of genetic variation to population in changing environments, or the clear indication that the observation of inbreeding depression suggests that natural popuatlion (including humans) harbor a large load of slightly deleterious recessive alleles.

Section 1 _____/20
Section 2 _____/30
Section 3 _____/50

Total _____/100