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EEB 318 Midterm Exam #1

Do NOT begin before you are told to do so.

You are NOT permitted a calculator or any study aids.

Do NOT cheat. Looking in the direction of another student's paper is considered cheating. Cover your answer sheet as you work.

This midterm consists of 30 multiple choice questions, and accounts for 25% of your grade for the term. Pages are double-sided and numbered 1-14. A formula sheet is given on the last page.

Not all questions that have numbers and/or equations require you to do calculations!

Read each question carefully.

You will have approximately 50 minutes to write this exam. You will not be allowed extra time to fill in the scantron sheet, so be sure to complete your answers before the time is up.

You must stop writing immediately when you are told to do so.

AFTER you are told to begin:

1. Check to make sure you have a complete exam.

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1) Which of the following are correct characterizations of the notion of "blending inheritance"?

S1. It applies only to visible traits, such as flower color.
S2. It does not allow recovery of extreme phenotypes.
S3. It depends on the inheritance of characteristics acquired during an organism's lifetime.
S4. Darwin believed it to be true, although it was later refuted in the early 1900's.
S5. Experiments have demonstrated that variation for any continuous trait adheres to this principle.

a. S1 and S2 and S3 and S4 and S5
b. S1 and S4 and S5
c. S2 and S3 and S4
d. S2 and S4
e. S3 and S5

2) Which of the following does NOT accurately describe the dominant way that western thinkers explained the natural world in the centuries preceding the introduction of Darwinian evolutionary theory?

a. Life on earth had been present for a few thousand years.
b. Organisms could change through time in response to their environment.
c. The world was thought to have a natural hierarchy, ranging from inanimate minerals to god(s).
d. The role of scientists was to describe and catalog the natural world to better understand the divine plan for humanity.
e. Species were thought to have fixed properties.

3) What is the key feature of Uniformitarianism that aided Darwin's development of evolutionary theory?

a. Uniformitarianism is the notion that things remain immutable, which Darwin refuted.
b. Uniformitarianism is the idea that resources are uniform, leading to competition among individuals for survival and reproduction.
c. Uniformitarianism is the idea that the same structure could vary and be used for different purposes, as seen for the beak shapes of the Galapagos finches.
d. Uniformitarianism is the model of inheritance believed by Darwin to be true, albeit problematic.
e. Uniformitarianism is the idea that processes that act in the present are the same as the processes that have acted in the past.

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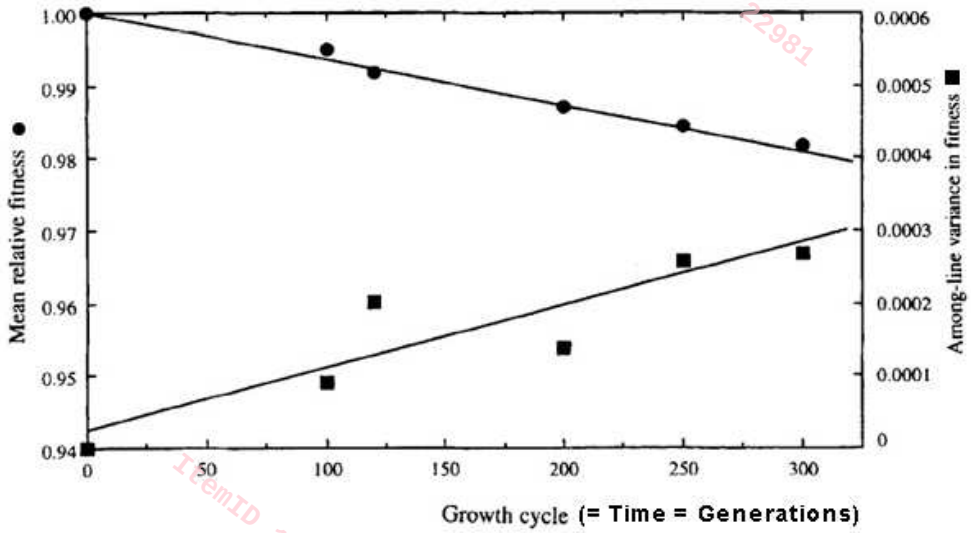
4) Which of the following statements about transcription, translation, and the genetic code is CORRECT?

a. The genetic code has more codons than encoded amino acids, leading to degeneracy of some sites.
b. There are more synonymous sites than replacement sites in a gene, according to the universal genetic code.
c. Degeneracy of the genetic code means that changing any site in a codon will have no effect on what amino acid will be translated.
d. Changes to synonymous sites are unlikely to have any effect on gene function or fitness because they are only present in introns.
e. The amino acid sequence of a protein is produced through the transcription of RNA.

5) Which of the following statements is an ACCURATE interpretation of the following graph of data from a mutation accumulation experiment?



a. The increase in among-line variance is consistent with the action of genetic drift.
b. The decrease in mean fitness implies that all new mutations are deleterious.
c. These results confirm the principle predictions of the Neutral Theory.
d. No beneficial mutations arose during the course of the experiment.
e. The change over time indicates that adaptation in the experiment was strong.

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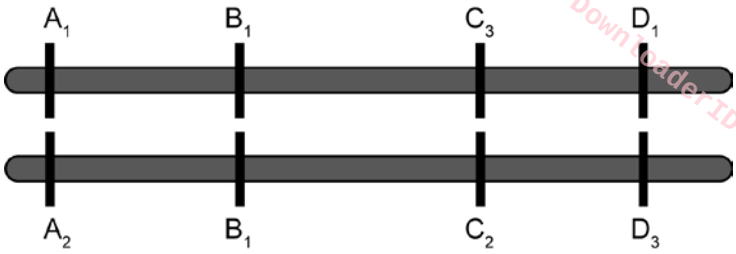
6) Which of the following is an INACCURATE statement about mutation?
   a. Different kinds of mutations exhibit different rates of mutation.
   b. Even though mutation is a stochastic process, we can predict that there is an equal probability that mutations will have deleterious, neutral, or beneficial effects.
   c. Environmental factors can increase or decrease the mutation rate.
   d. Mutation is an inevitable phenomenon.
   e. Mutation is the ultimate source of genetic novelty, even though genetic variation can also arise from recombination, migration, and hybridization.

7) Consider the following representation of allelic states on a pair of homologous chromosomes in a diploid individual. Which of the following corresponds to a HAPLOTYPE?



R1. A_1-A_2
R2. B_1-B_1
R3. A_2-B_1-C_2-D_3
R4. A_1-B_1-C_3-D_1/A_2-B_1-C_2-D_3
R5. A_1-B_1-C_2-D_1

   a. R1
   b. R1 and R2
   c. R3
   d. R3 and R4 and R5
   e. R1 and R2 and R3 and R4 and R5

8) A population is at Hardy-Weinberg Equilibrium (recall, $p^2 : 2pq : q^2$) with heterozygotes at frequency 0.6. Under the assumptions of the Hardy-Weinberg model, what fraction of individuals will be heterozygotes in the following generation?

   a. $2 * 0.6 * (1 - 0.6) = 0.48$
   b. 0
   c. 0.5
   d. 0.6
   e. Frequency can't be determined from the above information.

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9) Consider a locus Z that has two selectively neutral alleles (Z1 and Z2) in a single panmictic population in which there is no genetic drift, mutation, or migration. The Z1 allele occurs at frequency 0.4, and the Z1 homozygote is at frequency 0.16. What value of the inbreeding coefficient would you expect for this population?

a. 0
b. 1
c. -1
d. A value between 0 and 1
e. A value can't be determined without more information

10) Which of the following is NOT an assumption of the standard Hardy-Weinberg model?

a. Genetic drift does not occur in the population.
b. Natural selection does not affect the locus under consideration.
c. Gene flow occurs only between parapatric populations.
d. New alleles do not arise by mutation at the locus.
e. None of the above are assumptions of the standard Hardy-Weinberg model.

11) If a new mutation arises at frequency 1/(2N) in a finite population, what will happen to its frequency, given enough time?

a. It will always stay at frequency 1/(2N).
b. It will both increase and decrease in frequency forever.
c. Most likely, it will eventually be fixed by genetic drift.
d. Most likely, it will be lost from the population.
e. It will be maintained as a stable polymorphism in the population.

12) Why do allozymes underestimate the total amount of genetic variation at the locus?

a. Synonymous-site polymorphisms will not be detected.
b. Not all changes at replacement sites will be detected.
c. Only amino acid changes resulting in a net alteration of charge or size of the protein are likely to be distinguishable on a gel.
d. All of the above.
e. None of the above.

13) An undergraduate working on their honors project measured the radius of the patellas (bone in the knee-cap) for 100 randomly selected students as well as each of the students' parents. A mid-parent value was calculated as the average of the patella radii for the two parents. After performing a regression of student values on midparent values, she observed a positive correlation from which she calculated a heritability of 0.7. What fraction of the phenotypic variation in patella radius can NOT be explained by genetic factors?

a. All of the variation in patella radius is due to genetic factors.
b. 30% is due to non-genetic factors.
c. 50% is due to non-genetic factors.
d. 70% is due to non-genetic factors.
e. All of the variation in patella radius is due to non-genetic factors.

14) Which of the following observations is most consistent with the conclusion that natural selection has favored the HbS allele(s) responsible for sickled red blood cells?

a. The observation that there are multiple HbS haplotypes from different geographic regions.
b. The observation that HbA/HbS heterozygous individuals are most commonly found in regions that experience a high incidence of *Plasmodium* infection.
c. The observation that children with sickled red blood cells had a lower incidence of parasitaemia.
d. The observation that HbS/HbS homozygous individuals experienced severely detrimental effects.
e. The observation that a single amino acid replacement polymorphism is responsible for the hemoglobin allele that is associated with sickle-cells.

15) In a small population of annual wildflowers in Manitoba, a single gene controls leaf length and has 4 alleles in the population. The 4 alleles are selectively neutral, with their frequencies controlled entirely by genetic drift. Last spring, a biologist calculated that the frequencies of each allele were $C_1 = 0.7$, $C_2 = 0.2$, $C_3 = 0.08$, $C_4 = 0.02$. What is the probability that the frequency of the C_4 allele will be LOWER this spring?

a. 100%
b. 98%
c. 70%
d. 50%
e. 2%

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16) Which of the following is a way that phenotypic variation can be distributed?

a. In a gradual cline of trait values across a geographic range.
b. In two or more allopatric populations.
c. Into effects due purely to environmental differences across space.
d. Into two or more partially sympatric populations
e. All of the above.

17) Consider a population of mites that manage to colonize 100 small islands off the coast, but experience no further migration between them or with the mainland. The source population contained 2 selectively neutral alleles at the Y locus, with allele Y_1 at frequency 0.9. Each of the islands initially contained the Y_1 and Y_2 alleles at the frequency at which they were present on the mainland, and reach a demographic equilibrium effective population size of 1000. What is the probability that a new neutral mutation at the Y locus will go extinct when arising on one of the islands?

a. 0.90
b. 1 – 0.9 = 0.10
c. 0.5
d. 1 / (2 * 1000) = 0.0005
e. 1 – [1 / (2 * 1000)] = 0.9995

18) A researcher in a biology lab on campus set up a fly experiment in which 100 replicate populations were formed for each of 4 treatments, each initially containing allele *bw* at a frequency of 20% and allele bw^{75} at 80%. These two alleles have no effects on fitness relative to each other. The difference between the treatments was that different numbers of flies were transferred each generation: treatment A transferred 10 flies, treatment B transferred 20 flies, treatment C transferred 30 flies, treatment D transferred 40 flies. Which of the following statements CORRECTLY predicts a likely outcome of this experiment?

a. The fraction of replicates that will eventually fix the *bw* allele is 50%.
b. Treatment A will have the highest variance in allele frequencies over the course of the experiment.
c. Treatment D will more clearly show the effects of selection on the Bw locus.
d. The fraction of replicates that will eventually fix the bw^{75} allele will be greater in treatment C than in treatment B.
e. The average frequency of the *bw* allele will decrease over time in all four treatments.

19) Consider two populations each with 5,000 adults of each sex in which individuals are heterozygous at 10% of the loci in their genome, on average, as measured with allozymes. In population A, the organisms have a polyandrous mating system, in which females mate with multiple males, but not all females have mates. As a result the operational mating sex ratio in population A is 1 female to 4 males. In population B, the organisms are polygynous, in which males mate with multiple females, but not all males have mates, resulting in operational mating sex ratio in B of 1 male to 4 females. Based on this information, which of the following statements is TRUE?

a. Population A will have a larger effective population size than B.
b. The effective population size of population A will be about 10,000.
c. The populations diverged at least 40,000 generations ago.
d. The census size is greater in population A than in population B.
e. Genetic drift will be stronger in population B than would be predicted from the total census size.

20) A graduate student surveyed genetic variation for 6 darkling-beetle populations that inhabit islands off the cost of British Columbia. Based on her analysis of 22 allozyme loci, she calculated $F_{st} = 0.4$. She then quantified genetic variation on the same 6 islands for a leaf-beetle species and calculated $F_{st} = 0.2$. What is an appropriate conclusion from these findings?

a. There is lower genetic variation in darkling-beetles and leaf-beetles in these populations than would be expected from their census sizes.
b. There is more inbreeding in the darkling-beetle populations.
c. There is more migration among the leaf-beetle populations.
d. The leaf-beetle populations are more differentiated than the darkling-beetle populations for these 6 islands.
e. The populations of darkling-beetles on the different islands are reproductively isolated from one another.

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21) Which of the following statements about the Neutral Theory of molecular evolution is FALSE?

S1. The Neutral Theory predicts that most molecular differences between species arise as a consequence of genetic drift.
S2. Natural selection does not influence the probability of fixation of neutral mutations.
S3. The rate of substitution of neutral mutations depends on the effective population size, which can be different from the census size.
S4. Genetic drift is the major force controlling the change in allele frequency of deleterious mutations.
S5. The Neutral Theory applies to the evolution of DNA sequences, but not necessarily to the evolution of phenotypes.

a. S1 and S2 and S3 and S4 and S5
b. S3 and S4 and S5
c. S2 and S3
d. S3 and S4
e. All are true statements about the Neutral Theory.

22) What is the logical basis to why the Neutral Theory predicts that most of the molecular variation that is observed among individuals will be due to selectively neutral differences among them?

a. Because most new mutations that are input into the population are selectively neutral.
b. Because new mutations with effects on fitness will become fixed or lost fairly rapidly.
c. Because new mutations at synonymous sites represent changes in nucleotide positions within a gene that are mostly likely to be selectively neutral.
d. Because genetic drift is a stochastic force whereas selection is a deterministic evolutionary force.
e. Because a molecular clock does not depend on population size.

23) Which of the following represent complications in the application of the notion of a molecular clock to date the time to the most recent common ancestor, using DNA sequences?

S1. If the sequences are from species that diverged a very long time ago, then nucleotide sites might have experienced more than one substitution.
S2. If the sequences are from species that experience different mutation rates, then it will make molecular dating more difficult.
S3. If the sequences come from species that experience drastically different population sizes, then it will complicate use of the molecular clock for neutrally evolving sites.
S4. If DNA polymorphism is not correlated with DNA divergence in the present day, then the molecular clock method will not work properly.
S5. The molecular clock method will only work for proteins whose function is highly constrained, like histones.

a. S1 and S2 and S3 and S4 and S5.
b. S1 and S2 and S4.
c. S1 and S2 and S3.
d. S1 and S2.
e. S1.

24) When will interdemic selection be most effective?

a. When interdemic selection favors an increase in the trait value.
b. When interdemic selection favors a decrease in the trait value.
c. When gene flow is present.
d. When interdemic selection opposes individual selection.
e. When interdemic selection reinforces individual selection.

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25) In class we discussed a field experiment using guppies, in which the average number of spots on the fish increased in the absence of a predator, and decreased upon the introduction of a predatory fish into the guppy populations. What did this experiment demonstrate?

S1. Natural selection.
S2. Sexual selection.
S3. Interdemic selection.
S4. Genetic drift.
S5. Reproductive trade-off effects of traits.

a. S1 and S2
b. S1 and S2 and S3
c. S1 and S2 and S5
d. S1 and S2 and S4
e. S2 and S5

26) Which of the following statements about adaptation are CORRECT?

a. Adaptations arise only by way of natural selection.
b. Adaptation in and of itself does not require heritable variation.
c. The goal of an organism is to adapt to its environment more quickly than other species.
d. Adaptations can only evolve through individual selection.
e. Adaptations can evolve for any conceivable characteristic that improves life for an organism.

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27) In class, we discussed a study of sperm competition in primates, in which it was found that polygamous species had larger testes than monogamous species matched for overall body size. Another study compared monogamous and polygamous birds, but found no difference in average testes size between species from these two categories. Which of the following are plausible reasons for this result in birds?

S1. Sperm competition selects for more faster, rather than more, sperm in birds.
S2. Testes size does not predict sperm numbers in birds.
S3. The monogamous bird species might actually be polygamous.
S4. The collection of bird species might not contain appropriately independent datapoints of repeated convergent evolution in terms of mating system.
S5. Female bird reproductive tracts might allow them to choose which sperm to use in fertilization, regardless of how many sperm males deposit.

a. S1 and S2
b. S3 and S4
c. S1 and S3 and S5
d. S1 and S2 and S5
e. S1 and S2 and S3 and S4 and S5

28) Which of the following results was NOT found in Rich et al.'s study of beetles titled "Genetic drift in small populations of *Tribolium*"?

a. Larger populations had lower variance in b+ allele frequency.
b. At the end of the experiment, for all population size treatments, the average allele frequency was the statistically equivalent to the allele frequency at the beginning of the experiment.
c. More fixation events occurred in the smaller populations.
d. The variance in allele frequencies was smaller than expected by genetic drift alone.
e. None of the replicate populations in the largest population size treatment had any alleles become fixed.

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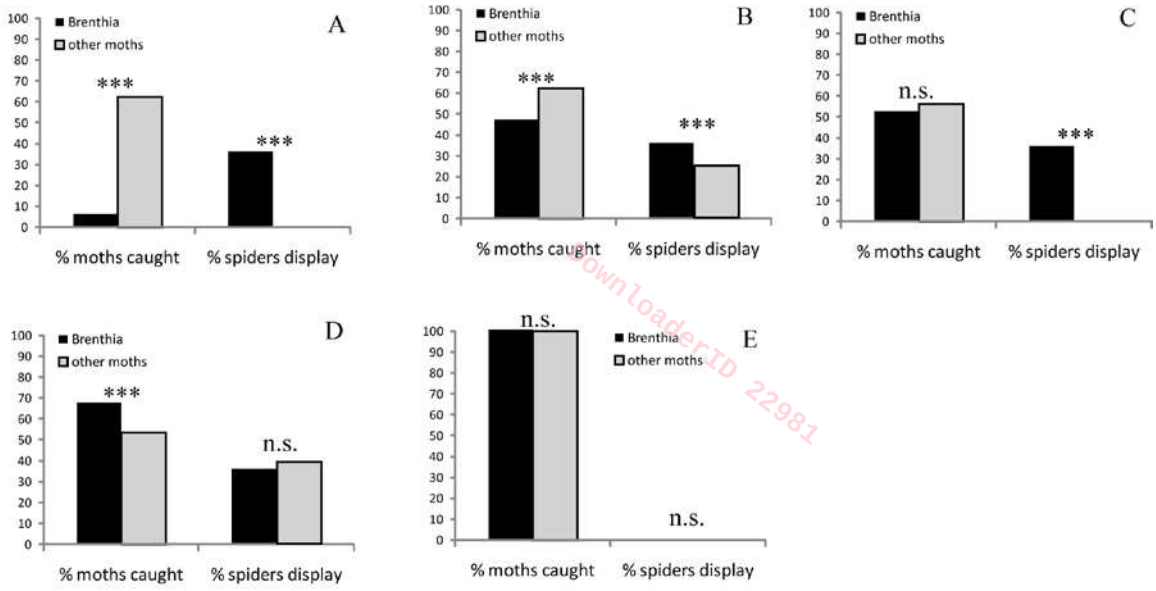
29) For the study by Rota and Wagner on metalmark moths and jumping spiders, imagine the following hypothetical data. The "***" indicates a statistically significant difference between the treatments, "n.s." indicates that there is no statistically significant difference between the treatments. Which of these sets of results would have unequivocally REFUTED the hypothesis that *Brenthia* moths mimic small jumping spiders?



a. A
b. B
c. C
d. D
e. E

30) Which of the following is an ACCURATE statement about the Rota and Wagner study on *Brenthia* metalmark moths and jumping spiders?

a. *Brenthia* moths successfully mimicked big and small jumping spiders alike.
b. Whenever *Brenthia* moths induced a spider to make a display, it never caught the moth during their experiment.
c. *Brenthia* morphology alone was sufficient to induce spider display, but it was *Brenthia* morphology that allowed them to evade capture.
d. *Brenthia's* morphology and behavior is a classic example of how genetic drift can result in evolution, given sufficient time.
e. A limitation of the study is that they used spiders that the moths would not encounter in nature.