

**BIOS 101 Dr. Molumby
Sample Exam**

NAME: _____
SECTION #: _____
INSTRUCTOR: _____

This exam, an old final, is annotated with the correct answers, and also WHY I asked the question. Professors never just "write questions" on an exam, there is always a certain logic to them. The average on this exam was about 25/40.

Multiple Choice Questions (worth 2 points each)

Questions 1-2 refer to the following scenario:

Imagine a population of 10,000 humans living on an isolated island. Every generation, an average of 100 individuals are born with cystic fibrosis, a genetic disease caused by a recessive allele (ie., individuals with the condition are cc, Cc individuals are unaffected, but carry the allele) Assume that the population is in Hardy-Weinberg equilibrium.

(You can always count upon a question like this to see if you have mastered the math. That is why it always turns up on a problem set.)

1. What is the expected frequency of the dominant allele?

- A) .50
- B) .10
- C) .01
- D) .90**
- E) .99

Find q from q^2 , which is 100(the carriers)/1000 or .01 So $q = \text{the square root of .01}$ or .10 $p + q = 1$ so $p = .90$ This is an estimate, of course.

2. What is the expected frequency of the heterozygous genotype?

- A) .50
- B) .18**
- C) .82
- D) .90
- E) .99

This is $2pq$. Thus $.90 \times .10 \times 2 = .18$

3. Which evolutionary mechanism is smallest in large populations?

(Basic memorization question, but this particular fact is central to understanding how genetic drift operates-if you do not know it, you do not understand genetic drift.)

- A) Mutation
- B) Migration
- C) Selection
- D) Nonrandom Mating
- E) Genetic Drift**

4. Which of the following is an assumption of the Hardy-Weinberg equilibrium.

- A) no mutation
- B) no migration
- C) infinite population size
- D) random mating
- E) all of the above**

(another straight memorization question, also another central point. If you do not remember this, you forgot a key point).

For questions 5-6, match the description of the event with one of the following types of mutation.

- A) substitution
- B) insertion
- C) deletion
- D) duplication
- E) transposition

5. An A-T base pair is spontaneously replaced with a G-C base pair **A**

6. A retrovirus incorporates itself into the host's genome, adding a 1,400 base pair sequence to the G6PDH gene of the target tissue. **B**

These are both questions where you are asked to classify a scenario. I do a lot of that-it is one step up from memorization. In this case, you have to remember the types of mutation and classify the events.

For Question 7-8, match the name of the scientist or philosopher with their contribution to the theory of Evolution.

- A) Plato
- B) Carolus Linneus
- C) Thomas Malthus
- D) Charles Lyell
- E) Georges Cuvier

7. Which scientist developed the idea that the geological processes in operation now are the same processes that occurred long ago?

D Lyell developed Hutton's earlier ideas about gradualism into a more specific view called uniformitarianism.

8. Which scientist was the first to point out that all populations organisms tend to multiply until they exceed the ability of the environment to sustain them?

C Both of these are memorization questions..these are two very important influences on Darwin, and they are a good index of whether or not you understood the lecture on Darwinism.

9. Which is FALSE about conditions on the Earth 3.8 billion years ago.
- A) The atmosphere contained more CO² than is present today
 - B) The atmosphere contained more O² than is present today**
 - C) Impacts with asteroids and comets were more common than today
 - D) There were frequent impacts from comets and asteroids.
 - E) All of the above are false.

This was a very central point in that lecture. The question is designed to test whether the student remembered even the most basic facts about the lecture on the origin of life.

10. The mutation rate from a normal allele to one causing a lethal, recessive genetic disease is 1×10^{-8} . Under mutation-selection balance what is the equilibrium frequency of this allele?
- A) .09
 - B) 1×10^{-16}
 - C) 1×10^{-4}**
 - D) 1.0
 - E) 0.0

This is a math question, you needed to remember how to use the equation $q^* = \sqrt{u/s}$ where u is the mutation rate and s is the selection coefficient. Remember, $s=1$ for a lethal illness.

Questions 11-12 refer to the following scenario:

In a colony of tropical wasps, several sisters found a colony together. They fight until one of them is the sole egg layer (the queen). The other sisters stay on, helping the queen to build an extensive paper nest and feeding her offspring. Eventually, the queen's sisters die and are replaced by her daughters (workers). These workers have special behaviors suited to aid in the defense of a large colony, including ferocious stings, an alarm pheromone, and special nest-building skills. Ultimately, with the help of the workers, the queen may produce hundreds of male and female reproductives, some of whom may found colonies of their own.

11. Why do the sisters that do not become queens themselves stay on to help the queen?
- A) survival of the species
 - B) frequency-dependent selection
 - C) stabilizing selection
 - D) kin selection**
 - E) none of the above

A lot of people blow off my discussion of kin selection. This is unfortunate, because it is a very important mechanism of evolution. In this case, you had to recognize an obvious case of the phenomenon and distinguish it from a few red herrings.

12. By what mechanism do adaptations for more successful worker wasps become common in the population?
- A) queens with better workers have more offspring themselves, since she shares many of their genes, the good genes are passed through her offspring**
 - B) better workers have more offspring themselves and pass their genes directly
 - B) efficient workers are good for the species
 - C) workers are a dead-end, since they do not pass on genes, they do not evolve

D) all of the above are true.

This is, after all, how kin selection works.

13. The radiation of terrestrial plants had which of the following effects?

A) An increase in the diversity of arthropods and vertebrates

B) A decrease in the diversity of arthropods and vertebrates

C) An increase in the CO₂ concentration of the atmosphere

D) B and C

E) none of the above

This is a question where the student needs to remember two things correctly, and more importantly, keep their gasses straight. The radiation of terrestrial plants enormously increased the diversity of arthropods and vertebrates, most of both groups are terrestrial nowadays, and probably decreased the CO₂ concentration of the atmosphere.

14. Which of the following processes were important in the development of drug resistant strains of Tuberculosis?

A) a rare point mutation in the genome of tuberculosis, conferring resistance to the antibiotic rifampin

B) natural selection within individuals being treated for tuberculosis, which confers a competitive advantage to mutant bacteria

C) inbreeding depression within human populations, which has eroded our resistance to the disease

D) A and B

E) none of the above

This is intended to be a difficult question. To get it right, a student needed to actually read the book and also remember two important details.

15. Which hypothesis has been shown to explain why biodiversity is highest in tropical regions?

A. Biodiversity is highest in the tropics because productivity is highest there.

B. Biodiversity is highest in the tropics because of the physical complexity of tropical forests.

C. Tropical regions have had more time for speciation to occur.

D. Tropical forests are less prone to disturbance than temperate forests.

E. No single hypothesis has been shown to be sufficient by itself.

This is actually an easy question if the student read the book. Here I am testing the student's ability to learn a concept entirely from the reading, which is not covered in lecture. This is the sort of question that distinguishes the A students from the B students.

Questions 16-17: refer to the following alternatives:

INTERACTION 1: Several species of barnacles live on the head, flukes, and tail of large baleen whales. They obtain an ideal environment for feeding, and relative safety from predation. The reproductive output of whales is not affected by the barnacles.

INTERACTION 2: Wax moths live in the nests of honeybees. Their larvae eat the stored honey of the bees, as well as the larvae of workers and reproductive honeybees. The adults mate and disperse to lay eggs in new nests.

INTERACTION 3: The foraging and activities of Hippos stir silt into the water column. As a result, these bodies of water are unsuitable for many species of fish and small invertebrates.

INTERACTION 4: Hyenas and Lions prey on antelopes, zebras, and gazelles in African Grasslands. Lions frequently chase Hyenas away from a kill, and take it for themselves.

INTERACTION 5: Several species of Trychogramminid wasps oviposit into scale insect eggs. Their larvae emerge and eat the contents of the scale insect egg. They then mate and disperse to find new patches scale insects.

INTERACTION 6: The red flour beetle, *Triboleum confusum*, and the beetle *Orzomyra sp.* both live in, and eat, stored flour. Red flour beetle larvae eat the eggs and larvae of their conspecifics, as well as *Orzomyra* larvae. In mixed species cultures, *Triboleum* always drives *Orzomyra* extinct.

16. Which is an example of amensalism?

- A. Interaction 1 B. Interaction 2 C. **Interaction 3** D. Interaction 5 E. Interaction 6

17. Which is an example of commensalism?

- A. **Interaction 1** B. Interaction 2 C. Interaction 5
D. Interactions 1 and 2 E. None of the above

The reason why I wrote the questions this way is to see if the student could distinguish phenomena that seemed superficially similar. Thus, this is a case where you need to classify the phenomenon, and distinguish it from similar phenomenon. This is two steps up from straight memorization-and a good index if your mind is putting the class material to use.

18. Why do scientists think RNA, rather than DNA, may have been the original genetic material?

- A) Most organisms on Earth use RNA as their genetic material
B) The simplest life forms, viruses, use RNA
C) RNA is more stable than DNA
D) **RNA has the ability to catalyze a few simple, chemical reactions**
E) A and D are correct

Simple memorization, with some red herrings designed around common misconceptions

19. What is a scientific paradigm? And how did it motivate Candace Galen to study alpine sky pilots?

- A) **A scientific paradigm is an intellectual framework that defines how scientists think the world works. The current paradigm in evolutionary**

biology (Darwinism) caused Galen to ask questions about how differences in flower size might result from adaptation.

- B) A scientific paradigm is a list of things you need to do to prove a hypothesis true. It caused Galen to test for heritability, reproductive success, and the number of pollinators visiting flowers.
- C) A scientific paradigm is an intellectual framework that defines how scientists think the world works. Motivated by the current paradigm in evolutionary biology (Creationism) Galen asked questions about why a creator would make flowers different sizes.
- D) A scientific paradigm is a list of things you need to do to prove a hypothesis WRONG. It motivated Galen to challenge the accepted notion that bumblebees prefer large flowers.
- E) All of the above are true.

Here I am testing the student's ability to learn a concept entirely from the reading, which is not covered in lecture, and combine it with material that I covered extensively in lecture. This is another question designed to distinguish A students from B students.

Questions 20 refers to the following alternatives.

- A. Coniferous Forest (Taiga)**
- B. Deciduous Forest**
- C. Desert**
- D. Grassland**
- E. Chaparral**

20. This biome is characterized by seasonal drought, occasional fires, and grazing by large mammals, all of which prevent woody shrubs and trees from invading and becoming established. The soils tend to be thick and nutrient-rich, and the roots of perennial plants are often very deep. Biome present in Oklahoma, central Asia, etc.. **D** Another classification questioned, borrowed from a Darrell Murray exam.

21. Which of the following is NOT a major abiotic component of the environment?

- A. Fire
- B. Rainfall
- C. Pathogens**
- D. Nutrient Levels
- E. None of the above

Vocab question, mostly testing whether you remembered what ABIOTIC was, intended as an easy question to distinguish the D students from the E students.

22. Which of the following designs would be the best nature reserve or set of reserves from the point of view of minimizing local extinctions and maximizing species diversity. Assume that each reserve or set of reserves has the same types and amounts of habitats present and draw from the same species pools.

- A. 1000 small reserves that are each 1 km² in area and round in shape
- B. 1000 small reserves that are each 1 km² in area and rectangular in shape
- C. One single large reserve that is 1000 km² in area and round in shape**

- D. One single large reserve that is 1000 km long and 1 km wide.
- E. None of the above

This preserve minimizes edge effect, in any case, and maximizes "island size". I waved away the other major consideration in nature preserve design in saying that the types and amounts of habitats were the same in all 4 alternatives. Question is designed to see if you understood the lecture and lab material on conservation biology.

Questions 23 refers to the following. An island is approximately circular, with a radius of 10km. There is no emmigration or immigration. In a mark-recapture study of a rattlesnake population, 210 snakes captured, banded, and released. In a second capture, 375 snakes were captured-of these 12 had marks.

23. What is the approximate number of rattlesnakes in this population?
A. 585 **B. 6563** C. 375 D. 78750 E. 4100

Math question, note that the incorrect alternatives are intentionally the most common errors made when doing this problem.

24. According to the logistic model, a population grows fastest when:
A) Birth rates are lowest and Death rates are highest.
B) In a coarse-grained environment.
C) It is close to its environmental carrying capacity.
D) It is well above its environmental carrying capacity.
E) It is well below the environmental carrying capacity.

This question is intended to see if you remembered the purpose of the logistic equation, which is to account for the effects of intraspecific competition on population growth.

25. Which of the following is true about scientific hypotheses?
A. Sciences tend to advance by falsifying incorrect hypotheses.
B. They are educated guesses or models of how a process works.
C. Scientists succeed when they prove their own hypotheses to be true.
D. A and B are true.
E. all of the above.

Concept/thought question. A student needs to know the basic advance of science by the falsification of incorrect hypothesis, and also avoid a common misconception about science.

26. Which of the following is a density-dependent factor limiting the growth of populations?
A. Space on rocky outcrops for mussels to settle
B. Damage caused by floating logs to mussel beds
C. Competition for light among redwood seedlings
D. A and C
E. All of the above

This is either a case of remembering three examples from lecture, or deduction.

27. Which is true about the Miller-Urey experiment?
A. Miller and Urey were almost certainly correct about the mixture of gasses present on the early Earth.

B. it resulted in the formation of simple amino acids and proteins

C. it was the first time living things were produced in a test tube

D. A and B are true.

E. All of the above are true.

Concept/memory question. The student has to understand my discussion of the experiment well enough to avoid two common fallacies and distinguish the true statement. The reason why questions like this are difficult for some people is because they intentionally force the student to critically examine the question and recognize INCORRECT ideas.

Question 28 refers to a community that contains the following species in the following numbers:

Species	Number	Species B	24
Species A	16	Species D	2
Species C	55	Species E	3

28. What is the species richness of this Community?

A. 100 species B. .623 C. .387 **D. 5 species** E. .0325

Mostly to see if the student recognized the term, and could distinguish it from biodiversity.

29. Which is true regarding succession?

A. Climax species permit early-successional species to colonize the disturbed environment

B. Pioneer species may modify the environment and permit the establishment of late-successional species.

C. Via inhibition, predator species permit several prey species to coexist

D. During early stages, competition is more intense than in later stages

E. B and D are both true.

Another question where the student must recognize several incorrect statements, but in this case, they are not particularly common misconceptions. I stole this question from one of Joel Brown's exams.

Questions 30 refers to the following list of mass-extinction events.

A) The Current mass extinction

B) The Oxygen Crisis

C) The Permian-Triassic mass extinction

D) The Cretaceous-Tertiary mass extinction

E) More than one of the above

30. Which mass extinction(s) happened early in the proterzoic eon?

Memory question-a lot of students blow off learning that material because it seems too easy and fun.

31. Which of the following could cause a fly with the bithorax mutation to exhibit the bithorax phenotype

A) Heat shock

B) Cold shock

C) Ether

D) Expression is automatic as long as the mutation is present

E) A, B and C

The most common response, D, is the fallacy that I intend to dispel by mentioning the mutation in the first place. It still sticks in students' minds, however, the idea that if a fly has the gene, it will have the trait. The bithorax mutation is a classical example of a gene by environment interaction.

Questions 32 refers to the following genetics cross:

Line A is a true-breeding line of **brown** rabbits. Line B is a true-breeding line of **white** rabbits. A male from line A is crossed to a female from line B. The resulting F1 are all **black**. The F1 mate with each other. The F2 have black, white, and brown rabbits.

32. What proportion of the F2 would you expect to be **brown**?

- A) 9/16
- B) 1/4
- C) 100%
- D) 0%

E) 3/16

Students frequently mistake this for incomplete dominance, it is NOT, because brown is not intermediate between black and white. To know the right answer, students need to understand my discussion of epistasis. For some, a Hard question, mostly because the concept is more advanced than the intro-level genetics taught in high school.

Questions 33-34: refer to the following genetics cross:

Albinism is a condition that results from the lack of normal pigmentation. In humans, individuals with two recessive alleles at the ALBINO (aa) locus are albino.

Attached earlobes result from two recessive alleles at the (ee) EARLOBE locus.

An albino man with attached earlobes marries a pigmented woman with non-attached earlobes. They have 20 children, (the F1) none of them twins. All of their children are pigmented with non-attached earlobes.

33. What set of alleles for earlobes and pigmentation do the **woman's** gametes carry?

- A) a e
- B) a E
- C) AA EE

D) A E

E) Aa Ee

Students frequently get this question wrong because they do not understand the most basic concept in genetics, the haploid gamete. Very important concept, frequently missed....there is a very strong correlation between getting this question correct and doing well on the rest of the exam.

34. What proportion of the gametes **from their children** (the F1) would be expected to contain the recessive allele for pigmentation and the dominant allele for earlobes? (assuming no linkage)

- A) 9/16

- B) 3/4
- C) 100%
- D) 1/4**
- E) 1/16

Again, another gamete question. Students that do not understand the question frequently answer E, because they are rushing to an answer to a question I did not ask.

Question 35 refers to the following genetics cross:

Line A is a true-breeding line of **white-flowered** snapdragons. Line B is a true-breeding line of **red-flowered** snapdragons. A plant from line A is crossed to a plant from line B. The resulting F1 offspring are all **pink-flowered**. The F1 fertilize each other. The F2 have red, white, and pink flowers.

35. What type of interaction between alleles is this?

- A) incomplete dominance**
- B) sex-linkage
- C) linkage
- D) epistasis
- F) pleiotropy

Classic, incomplete dominance. I threw this in to see if students would recognize it if they saw it because so many of them argued that my epistasis example was incomplete dominance.

36. How many different gametes can be formed by the following parental genotype?

Aa Bb cc Dd

- A) 2 B) 4 C) 6 **D) 8** E) 16

Math/logic question. There are three loci segregating (not four), thus two to the third power is eight.

37. If a normal man marries a woman who is a carrier for a sex-linked recessive trait, where might one expect to see the trait expressed in their children?

- A) In all the children
- B) In none of the children
- C) In all the sons
- D) In half the sons**
- E) In half the daughters

Classical sex-linkage question, comes up in genetic counseling all the time. Tests whether the student can diagram the cross, or at least has memorized the answer to the question.

Questions 38-40 refer to the following scenario. In *Drosophila melanogaster*, the recessive allele for the sepia locus causes flies to have very dark colored eyes. The recessive allele at the ebony locus causes the fly to have very dark body color.

A male from a true breeding line of sepia eyed-ebony bodied flies (line A) is crossed to a female from a true breeding line of red eyed, tan-bodied flies (the “wild type” line B) to create an F1:

Next, a female from the F1 is crossed to a male from the sepia-eyed, ebony bodied, line.

The phenotypes of 1000 progeny from this test cross were scored as follows:

Eyes	Body	Number Observed
Red	Normal	300
Sepia	Normal	200
Red	Ebony	200
Sepia	Ebony	300

38. Do a Chi-Square test of Observed vs. Expected values, using independent assortment to generate your expected values. What is the value of χ^2 ?

- A) 40
- B) 10
- B) 7.4
- D) 16
- E) 1000

The chi-square is a big concept in bios 101, question is intended to see if students can calculate it.

39. Based on the data above, how many map units apart are the two loci?

- A) 200
- B) 40**
- C) 12
- D) 1000
- E) Can't tell

Tests to see if students can calculate map units. This is covered primarily in discussion, so it also tests to see if students are learning anything from discussion.

Question 40 refers to the following scenario:

A man with type A blood marries a woman with type A blood. Their first child has type O blood.

40. What is the probability that their **next** child will have type A blood?

- A) .50
- B) .25
- C) 0
- D) .75**
- E) 1.0

Another sex-linkage question. Here the student must remember that two genotypes both code for type A blood.