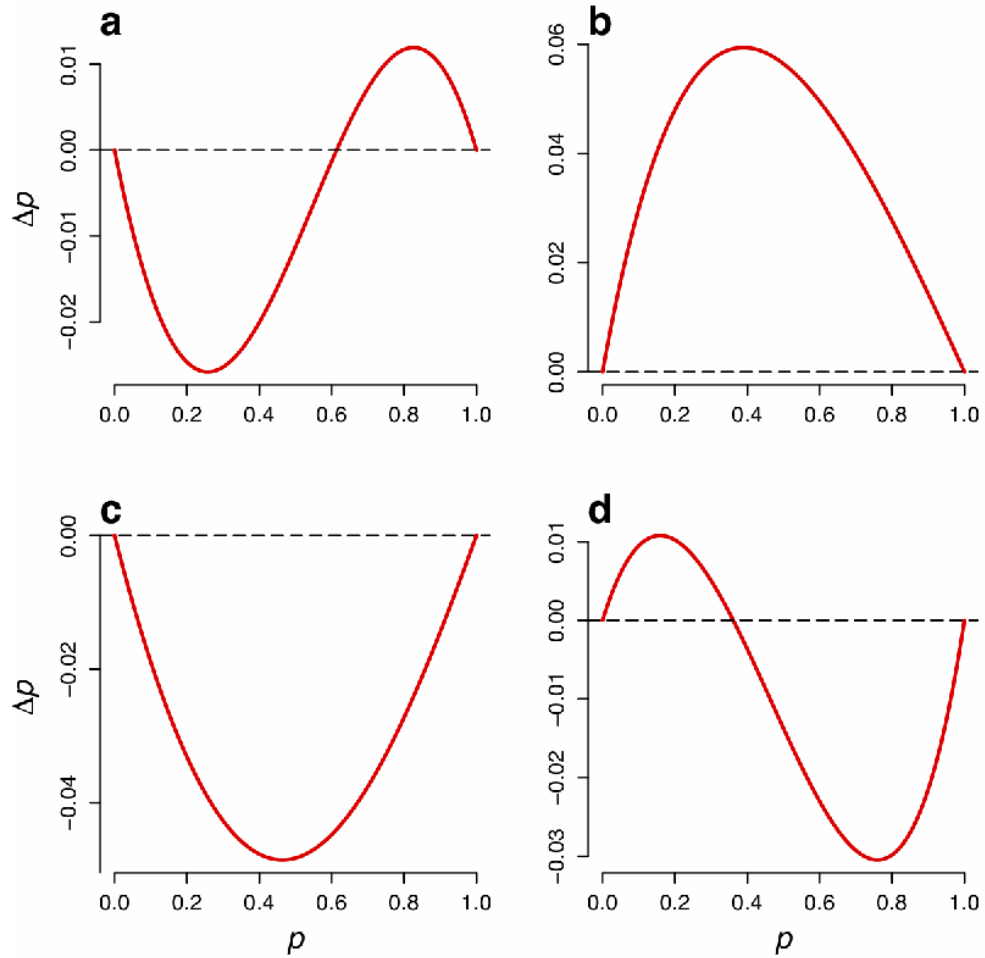Question 1
Mutations in the gene PKHD1 cause Polycystic Kidney Disease in humans. Approximately 30% of affected infants die within the first year of life primarily of respiratory insufficiency or superimposed pulmonary infections. More than 50% of affected children progress to end-stage renal disease, usually in the first decade of life.

The normal and disease alleles are denoted by D and d, respectively. Both DD and Dd individuals are normal; dd individuals show Polycystic Kidney Disease. If the fitness of DD individuals is $w_{DD} = 1$, and if s is a positive number, how would describe the fitness of Dd and dd individuals?

a) $w_{Dd} = 1$ and $w_{dd} = 1$
b) $w_{Dd} = 1$ and $w_{dd} = 1 - s$
c) $w_{Dd} = 1 - s$ and $w_{dd} = 1 - s$
d) $w_{Dd} = 1 - s$ and $w_{dd} = 1 + s$
e) $w_{Dd} = 1 + s$ and $w_{dd} = 1 - s$

Question 2
The following figure shows four hypothetical patterns of change in the frequency of an allele as a function of its frequency. In which of them do heterozygotes have a **higher** fitness than either homozygote?

a) A
b) B
c) C
d) D
e) None of the above

Question 3
An experimental population of *Drosophila melanogaster* is started with 4900 *AA*, 4200 *Aa* and 900 *aa* individuals. The fitnesses of the different genotypes are: $w_{AA} = 0.95$, $w_{Aa} = 1$ and $w_{aa} = 1.05$. What is the expected frequency of the *A* allele in the next generation?
a) 0.63
b) 0.65
c) 0.67
d) 0.69
e) 0.71

Question 4
Which of the following evolutionary scenarios can cause a **neutral** equilibrium involving allele frequencies between 0 and 1 (exclusive)?
a) Genetic drift
b) Hardy-Weinberg equilibrium
c) Heterozygote disadvantage
d) Mutation selection balance
e) Negative frequency-dependent selection

Question 5
Triosephosphate isomerase (TPI) is an enzyme that plays an important role in glycolysis. In humans, there are both dominant lethal and recessive lethal mutations in the gene that encodes TPI. If the mutation rate from normal to dominant lethal TPI alleles is the same as that from normal to recessive lethal TPI alleles, and if the alleles are maintained in the human population through mutation-selection balance, what would you predict about their frequencies at equilibrium?
a) Dominant lethal alleles will occur at a higher frequency than recessive lethal alleles
b) Dominant lethal alleles will occur at a lower frequency than recessive lethal alleles
c) Dominant lethal alleles will occur at the same frequency as recessive lethal alleles
d) All of the above are equally likely
e) None of the above are true

Question 6
Imagine a mutation accumulation (MA) experiment with *Drosophila melanogaster*. Every generation, each MA line is maintained by transferring one female and two males. What is the effective population size in each MA line?
a) 1.5 individuals
b) 2.1 individuals
c) 2.7 individuals
d) 3.0 individuals
e) 3.6 individuals

Question 7

The *act-1* gene in the nematode *Caenorhabditis elegans* encodes the ACT-1 protein, an actin isoform that is required for proper body wall muscle and pharyngeal muscle structure and function. ACT-1 also functions to control cytoplasmic microfilament function in the early embryo. The 29th amino acid in ACT-1 is Arginine (Arg) and is encoded by the DNA sequence CGC. Which of the following point mutations is most likely to be **neutral**? The following genetic code table shows RNA sequences after transcription.

Second letter

First letter	U	C	A	G	Third letter
U	UUU, UUC } Phe; UUA, UUG } Leu	UCU, UCC, UCA, UCG } Ser	UAU, UAC } Tyr; UAA Stop, UAG Stop	UGU, UGC } Cys; UGA Stop, UGG Trp	U C A G
C	CUU, CUC, CUA, CUG } Leu	CCU, CCC, CCA, CCG } Pro	CAU, CAC } His; CAA, CAG } Gln	CGU, CGC, CGA, CGG } Arg	U C A G
A	AUU, AUC, AUA } Ile; AUG Met	ACU, ACC, ACA, ACG } Thr	AAU, AAC } Asn; AAA, AAG } Lys	AGU, AGC } Ser; AGA, AGG } Arg	U C A G
G	GUU, GUC, GUA, GUG } Val	GCU, GCC, GCA, GCG } Ala	GAU, GAC } Asp; GAA, GAG } Glu	GGU, GGC, GGA, GGG } Gly	U C A G

a) CGC → AGA
b) CGC → AGC
c) CGC → CAC
d) CGC → CCC
e) CGC → GGC

Question 8

Which of the following statements about **natural selection** is true?
a) It always causes allele frequencies to decrease from generation to generation
b) It always causes allele frequencies to increase from generation to generation
c) It always causes allele frequencies to remain constant from generation to generation
d) It sometimes causes allele frequencies to remain constant from generation to generation
e) None of the above

Question 9
Deleterious alleles at several loci are maintained in a population by mutation-selection balance.
What is the expected effect of **inbreeding** in this population?
a) A decline in mean fitness
b) An increase in mean fitness
c) An increase in population size
d) An increase in the beneficial mutation rate
e) None of the above

Question 10
A population of bark beetles undergoes selection every winter. Beetles that are not large enough to acquire a deep hole in the tree by excluding other beetles in the tree are killed by winter freezes, so only the largest beetles survive each year. The values of the selection gradients that best describe selection in this population are:
a) $\beta > 0$ and $\gamma = 0$
b) $\beta < 0$ and $\gamma = 0$
c) $\beta > 0$ and $\gamma > 0$
d) $\beta = 0$ and $\gamma > 0$
e) $\beta = 0$ and $\gamma > 0$

Question 11
You are studying a population of cotton rats on Galveston Island. By carefully cross-fostering offspring, you have been able to eliminate virtually all genotype-environment covariation. You found that the covariance between mothers and offspring in incisor length was 0.5. Since cotton rats eat the leaves of various grass species, the length of their incisors influences the rate and therefore the amount of food they can eat. The variance in incisor length is 4.0. While you were studying the population, drought caused a massive die-off of grasses. Because of the lack of food, only those rats that had incisors that averaged 2 mm longer than the mean could survive and breed. Relative to the original population, what will be the average change in incisor length in the next generation?
a) 0.25 mm longer
b) 0.5 mm longer
c) 1.0 mm longer
d) 2.0 mm longer
e) 3.0 mm longer

Question 12

You are studying two traits z1 and z2 which have a genetic correlation of +0.03 and an environmental correlation of +0.04. Which of the graphs shown below is the best representation of how the traits will change under selection for larger phenotypic values of z1?

A

z2

z1

B

z2

z1

C

z2

z1

D

z2

z1

E

z2

z1
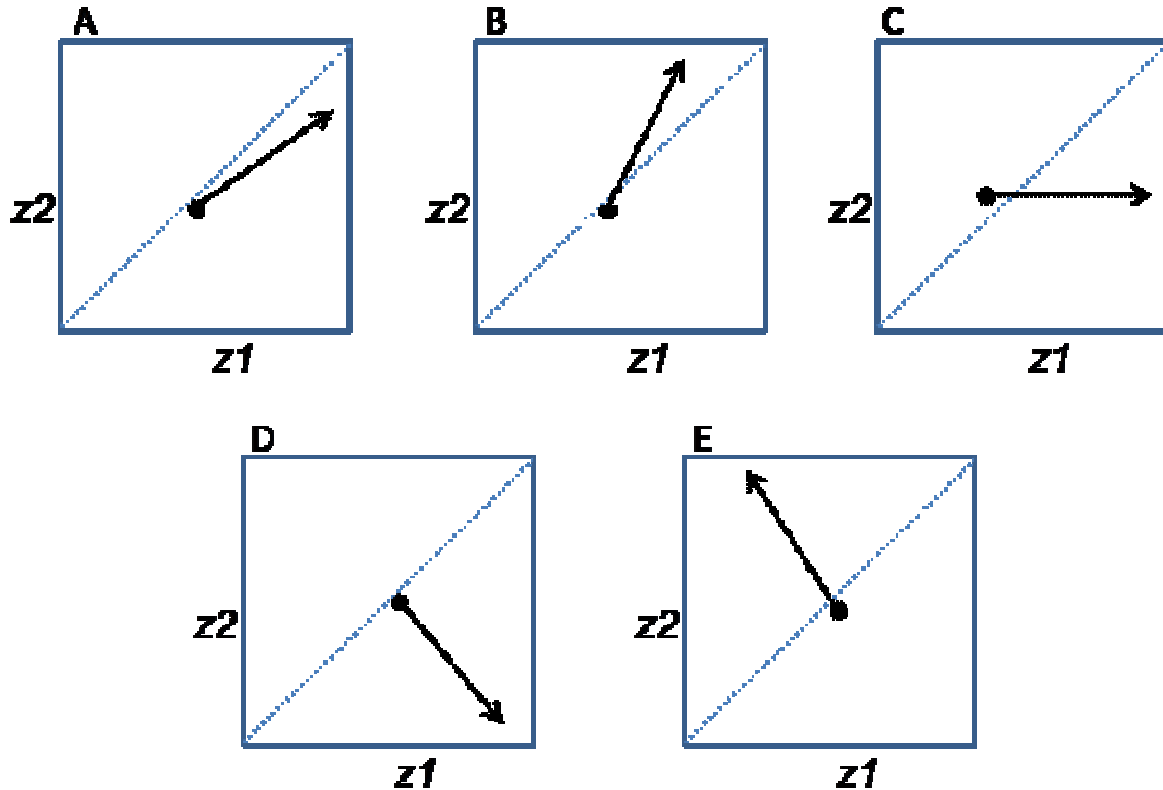
a) A
b) B
c) C
d) D
e) E

Question 13

Which of the following statements is true?
a) A trait for which there is no additive variance lacks genetic variation
b) Traits with only dominance variance cannot evolve under natural selection
c) Offspring inherit half of the dominance component of their parent
d) Estimates of additive variance from one population are usually similar for other populations of the same species
e) Populations with different allele frequencies at the loci affecting a quantitative trait have different patterns of natural selection

Question 14
You have reconstructed the phylogeny for a newly discovered group of ambrosia beetles, based on the character matrix shown below (the phylogeny is to the right). In the character matrix, x represents the ancestral state and x' the derived state.

A a'b c'd'e f g'h'i j
B a'b c'd'e f g'h i j
C a'b c d e f'g h i j'
D a b'c d e'f'g h i j'
E a b'c d e'f'g h i j
F a'b c d e f'g h i j
Out a b c d e f g h i j
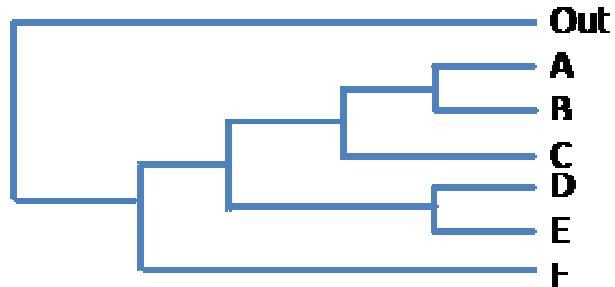
On the basis of the phylogeny you have made, which character is a reversal (homoplasy)?
a) a in species D and E
b) e' in species D and E
c) f in species A and B
d) j' in species C and D
e) c' in species A and B

Question 15

You are reconstructing the phylogeny of a group of nematode species (A - Z). You conduct a bootstrap analysis (1000 bootstrap samples) and produce the consensus phylogeny shown below. Which node lacks support and should be collapsed into a polytomy?
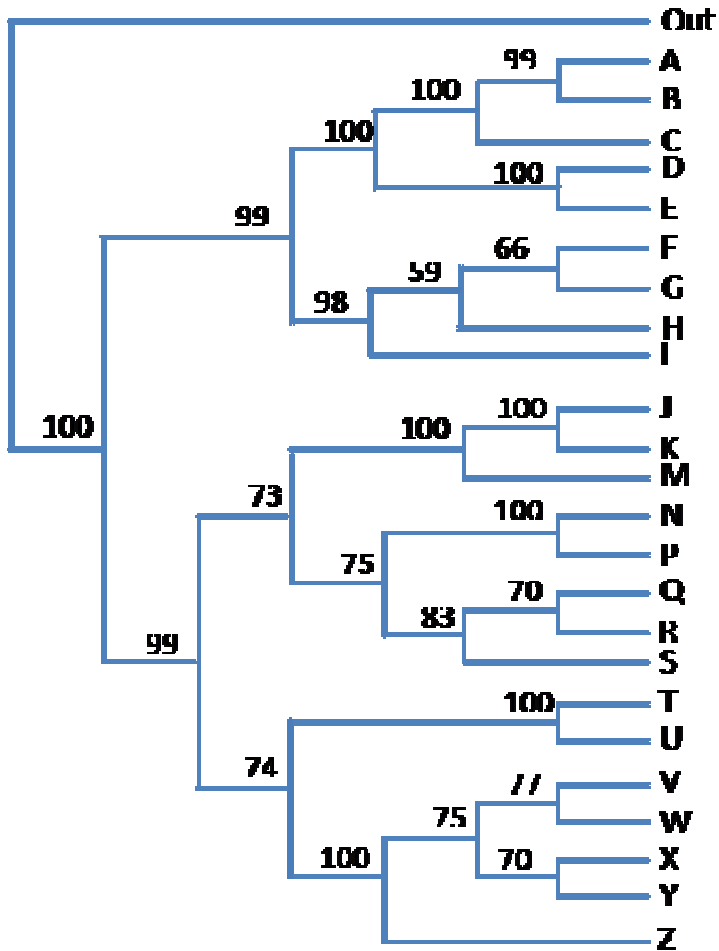
a) A, B and C
b) F, G and H
c) J, K and M
d) Q, R and S
e) V,W and X, Y

Question 16
Punctate flower beetles eat the leaves of only one species of plant, the filiform locoweed. In the lab these beetles are capable of eating other species of plants, but are never observed to do so in the field. Filiform locoweed contains a variety of alkaloids and is toxic to most species. No vertebrate herbivore is able to eat the locoweed, and most species of insects do not eat it; the few that do, also eat other plants. Punctate flower beetles are brilliant red with black markings, other insects that eat the plant are not brightly colored. You hypothesize that the beetles may contain toxins derived from the plant, as a defense against predators. Which of the following predictions is derived from your hypothesis?
a) beetles reared on other species of plants in the lab will be less brightly colored than those reared on filiform locoweed
b) beetles reared on other species of plants in the lab will be more brightly colored than those reared on filiform locoweed
c) beetles reared on other species of plants in the lab will grow more slowly than those reared on filiform locoweed
d) beetles reared on other species of plants in the lab will be less poisonous than those reared on filiform locoweed
e) beetles reared on other species of plants in the lab will have higher survival in the field than those reared on filiform locoweed