

1. *JD* Fossil evidence indicates that hominin brains probably got larger, then smaller, then larger again. This provides evidence *against*:
  - A. Inheritance of acquired characteristics
  - B. Goal-directed evolution
  - C. Adaptation
  - D. Acclimation
  - E. Vestigial traits
  
2. What can we infer if a gene has accumulated a large number of nonsynonymous substitutions, relative to the number of synonymous substitutions, over the course of evolution (i.e., the nonsynonymous to synonymous ratio is greater than expected)?
  - A. The gene is probably the cause of a genetic disease
  - B. The mutation rate is unusually high
  - C. Changes in the phenotype coded by the gene are adaptive, or beneficial (i.e., the gene is the target of positive selection)
  - D. Variability in the phenotype coded by the gene is maladaptive, or deleterious
  - E. The gene is the target of purifying selection
  
3. The fact that phenylketonuria does not cause harmful phenotypic effects if an affected person eats a diet that is very low in phenylalanine is an example of:
  - A. gene-by-environment interaction
  - B. genetic drift
  - C. mutation-selection balance
  - D. heterozygote advantage
  - E. balancing selection

*Choose the strongest accurate answer*

4. *JD* Polyploidy is an important mechanism for diversification because it
  - A. Increases gene flow
  - B. Both increases gene flow and provides material for new genetic innovation
  - C. Decreases gene flow
  - D. Both decreases gene flow and provides material for new genetic innovation

5. *JD* According to the class material, how do scientists know that our hominin ancestors had less sexual dimorphism in tooth size than chimpanzees do?
- A. The overall distribution of adult tooth sizes in our hominin ancestors is not bimodal
  - B. Tooth experts can tell the difference between fossil male and female teeth
  - C. Skeleton experts can associate fossil teeth with skeletal hip bones
  - D. Our hominin ancestors were closely related to us, and we don't have much sexual dimorphism in tooth size
6. *JD* The large amount of detailed splitting on the hominin tree (Hominidae, Homininae, Hominini, Hominina ...) is most likely due to:
- A. The fact that hominins evolved more than other species
  - B. The fact that hominins change their environment more than other species
  - C. The fact that hominins went through several cycles of radiation and contraction
  - D. Observer bias
  - E. Goal-directed evolution
7. Which of the following can genetic data *not* give us information about?
- A. Use of tools by hominins in the past
  - B. How long ago a deleterious mutation occurred in the population
  - C. Occurrence of positive selection in the past
  - D. Occurrence of purifying selection in the past
  - E. Population bottlenecks
8. Which one of the following statements is false?
- A. Use of tools broadens the availability of food resources
  - B. *Homo sapiens* is the only hominin to have used stone tools
  - C. A wide variety of mammals and birds have been observed to use tools
  - D. Tools may have been used by humans as part of a scavenging strategy
  - E. Use of tools is limited to terrestrial animals
9. Which of the following statements is true in general of modern hunter/gatherer societies?
- A. Most of the calories are obtained by women's foraging activities
  - B. Meat makes up more than 99% of the diet
  - C. Men's foraging activities (mostly hunting) bring in the majority of the calories
  - D. People become experts in complex foraging at an early age
  - E. Cooperative activities and food sharing rarely occur

10. *JD* Primates are an order characterized by highly developed stereoscopic vision; versatile limbs; and large brains. Which of the following is *least* likely to have contributed to these adaptations in early primates?

- A. Climbing and balancing on trees
- B. Leaping from branch to branch
- C. Hanging from branches
- D. Exploiting new plant resources
- E. Catching insects

11. *JD* Long-billed hummingbirds feeding on long, tubular flowers provides evidence for:

- A. Goal-directed evolution
- B. Co-evolution
- C. Convergent evolution
- D. Radiation and contraction

12. *JD* If a group of hominin ancestors showed very slow development (long childhoods), this provides evidence that they:

- A. Were highly social
- B. Obtained most of their calories from meat
- C. Obtained most of their calories from plants
- D. Walked upright

13. *JD* Bonobos swing through trees. Their close relatives humans and gorillas do not. Does this provide evidence that humans are closer to gorillas than to bonobos?

- A. No. Humans are closer to bonobos.
- B. Yes. It provides *some* evidence, even if that's not the final answer.
- C. It provides evidence only if the relevant common ancestor could swing through trees
- D. It provides evidence only if the relevant common ancestor could *not* swing through trees

14. *JD* Slash pine is a tree that lives in swampy areas, and is closely related to shortleaf pine, which lives on higher, drier ground. In a particular area, shortleaf pine fossil remnants are up to 20,000 years old, while slash pine fossil remnants are only up to 5000 years old. Which of the following is the *least* likely explanation for this?

- A. Shortleaf pine was the first to arrive in the area
- B. Shortleaf pine is more likely to fossilize than slash pine because of its habitat
- C. Shortleaf pine is more likely to fossilize than slash pine because it has harder cones
- D. Shortleaf pine is historically more abundant than slash pine

15. *JD* Which of these is *not* a reason why scientists' trees are imperfect models of how evolution occurred?

- A. Genetic information can be transferred between organisms
- B. Sex can combine genes from different organisms
- C. Mutation can produce new alleles
- D. Scientists may not have enough information to make the best trees

16. What (according to Prof. Bolker) is wrong with the statement, "because males collected the majority of the calories in the environment of evolutionary adaptation (EAA), they are better adapted to foraging and should be responsible for being wage-earners in modern society, while females should be primarily responsible for child care"?

- A. Males and females should have similar, not different, roles in a modern society
- B. Males did not collect the majority of calories in the EAA
- C. Child care was shared between males and females in the EAA
- D. Science should not be used to make normative statements
- E. Nothing; the statement is actually correct

17. How does cultural evolution work?

A. Behavioural traits are transmitted by social learning from individuals in one generation to other individuals within the same generation (e.g., among siblings or among similarly aged individuals in a social group)

B. Behavioural traits are transmitted by social learning from individuals in one generation to individuals in the next generation (e.g., from parents to offspring)

C. Individuals inherit tools from their parents

D. Behavioural traits are coded in the genome, so they can evolve across generations

E. Material objects that are created by organisms are coded in the genome as part of the *extended phenotype*

18. What does reduced genetic variation in human populations outside of Africa tell us about the history of human migration and evolution?

A. evolutionary rates decreased after humans left Africa

B. populations that stayed in Africa experienced stronger selection pressures from infectious diseases

C. populations that stayed in Africa experienced weaker selection pressures from infectious diseases

D. populations that left Africa experienced population bottlenecks

E. populations that left Africa experienced lower rates of deleterious mutation

19. Why are mitochondrial genomes useful for understanding human evolution?
- A. Relatively rapid evolution makes them good for detecting recent evolutionary events
  - B. They can be used to reconstruct the history of past population sizes
  - C. We can use them to reconstruct gene trees and find the date of the most recent common ancestor
  - D. Because they are maternally inherited, they can help distinguish female and male migratory patterns
  - E. All of the above
20. Which of the following regions was the *last* to be colonized by modern humans?
- A. Africa
  - B. North and South America
  - C. Australia
  - D. Europe
  - E. Asia
21. How do we know that modern humans interbred with other recent human species such as Neanderthals and Denisovans?
- A. fossils of all three species have been found at the same archaeological sites
  - B. all three species are known to have used stone tools
  - C. phylogenetic analysis of louse DNA shows that some louse species migrated among these three species
  - D. Neanderthals are more morphologically similar to humans in areas where the species overlapped
  - E. Haplotypes of Neanderthal and Denisovan origin can be found in the human nuclear genome
22. What phylogenetic pattern tells us that genetic introgression has occurred across species?
- A. Gene trees show evidence of lots of very recent branching
  - B. Gene trees show evidence of lots of very ancient branching
  - C. The shape of the phylogeny for particular genes is qualitatively different from the overall phylogenetic pattern of the different species
  - D. Mitochondrial genomes differ across species
  - E. The same genetic code is used by all extant species

23. Which of the following statements about human migration is true? (Note: “Homo sapiens” does *not* include Neanderthals and Denisovans)

- A. We are sure that the only time that Homo sapiens migrated out of Africa was around 60 kya
- B. The signature of migration bottlenecks can be seen in modern geographic patterns of genetic diversity
- C. Homo sapiens went extinct in Africa, only to recolonize Africa later
- D. All other hominin species went extinct before Homo sapiens evolved
- E. Homo sapiens migrated out of Africa about 1 mya

24. Which of the following statements about Mendelian and quantitative traits is *false*?

- A. Mendelian traits follow simpler rules of heredity than quantitative traits
- B. Quantitative traits are more affected by environmental variation than Mendelian traits are
- C. Only quantitative traits are subject to gene-by-environment interactions (GxE)
- D. Mendelian traits are typically either dominant, recessive, or overdominant
- E. Quantitative traits are affected by genetic variation at many loci

25. Why do we think that lactase persistence coevolved with the cultural practice of raising dairy cattle?

- A. Because it evolved by genetic drift
- B. Because it evolved due to heterozygote advantage
- C. Because the practice of raising dairy cattle could have spread through social facilitation
- D. Because lactase persistence doesn't have a selective advantage without access to non-human milk
- E. Because we can detect selective sweeps in the region of the genome surrounding the loci that control lactase persistence

26. What would you expect to happen to the frequency of sickle-cell allele in a population (in the long term) if an effective mosquito control program were implemented, preventing the transmission of malaria?

- A. Increase, because the advantage of being heterozygous for the sickle-cell allele disappears
- B. Decrease, because the advantage of being heterozygous for the sickle-cell allele disappears
- C. Decrease, because the disadvantage of being homozygous for the sickle-cell allele disappears
- D. Stay the same
- E. It depends on whether or not genetic counseling is offered to allow carriers to choose alternative reproductive options (adoption or gamete donation)

**27.** What are the potential impacts of a point mutation that affects the genome outside of any coding region?

- A. It must be neutral, because it doesn't affect the biochemical structure of a protein
- B. It could lead to changes in copy number
- C. It could lead to regulatory changes, changing the timing and amount of proteins produced
- D. It is a synonymous substitution, so it will have no effect on the phenotype
- E. It will change the type of RNA that is produced from the nearest coding sequence

**28.** Why are alleles that cause disease when they are homozygous (deleterious recessive alleles) generally found at higher frequencies in the population than alleles that cause disease when they are homozygous or heterozygous (deleterious dominant alleles)?

- A. Because recessive alleles cause milder forms of disease than dominant alleles
- B. Because of mutation-selection balance
- C. Because of genetic drift
- D. Because of purifying selection
- E. Because heterozygotes can carry a single deleterious allele without incurring selective disadvantage

**29.** When considering selective pressures in the evolution of human skin colour, why is skin cancer not considered a very good candidate?

- A. Because skin cancer rates don't vary with latitude
- B. Because having more melanin/darker skin doesn't have a protective effect against skin cancer
- C. Because having more melanin/darker skin will lower mutation rates, leading to a slower rate of evolution
- D. Because deaths due to skin cancer occur too late in life to prevent reproduction
- E. Because skin colour probably did not evolve due to sexual selection, as Charles Darwin speculated

**30.** Which of the following are advantages and/or disadvantages of genome-wide association studies (GWAS)?

- A. GWAS can only be used to provide information about Mendelian traits
- B. GWAS provide evidence of positive selection by locating regions of the genome with unusually low levels of within-population variation
- C. GWAS can detect genetic markers, and thus regions of the genome, that are associated with quantitative traits
- D. GWAS are more powerful than twin studies for quantifying the overall level of genetic variation in a trait
- E. GWAS can often be used to pinpoint the precise locations of the genes underlying a trait

**Short-answer questions**

Answer questions *in pen.* Briefly show necessary work and equations. Points may be deducted for wrong information, even when the correct information is also there.

**31.** (4 points) Cystic fibrosis (CF) is a deleterious recessive Mendelian trait. The median lifespan of people with the disease (homozygotes) is currently about 45 years (i.e. 50% die before age 45).

a) What would we expect to happen to the frequency of the CF allele (in newborns) if we discovered a drug that completely mitigates the symptoms of CF (i.e. homozygotes who take the drug are perfectly healthy)?

b) Why?

c) Would the change in the allele frequency be different if instead of making homozygotes healthy, the drug instead kept them healthy until age 65, at which point they all died?

d) Why?



**32.** (2 points) Where in the genome do synonymous mutations occur, and why are they selectively neutral?

**33.** (2 points) We have evidence of fire in human-inhabited caves (where it must have been deliberately set rather than naturally occurring) dating back to 1 million years ago. Why do we think that humans must have been using fire *earlier* than 1 million years ago?

**34.** (1 point) What are the differences in tool use between humans and other animals?

**35.** (1 point) Why is the lactase persistence allele only beneficial in human cultures that raise dairy cattle?

36. *JD* (2 points) What are two likely triggers for adaptive radiations?

37. *JD* (1 point) What is a likely reason that hominin species contracted after radiating?

38. *JD* (2 points) Give two different examples of things scientists learn about our ancestors from teeth.