

Males of Gunnison's Sage Grouse aggregate during the breeding season in leks where they display to females. Females chose a particular male as a mate, and after mating, go off and raise the offspring on their own. Unlike regular sage grouse, male Gunnison's sage grouse have elaborate head plumes (feathers). Females are more likely to mate with males that have longer head plumes. The most likely explanation for female preferences is:

- a) plume length indicates a high quality male
- b) plume length indicates a competitively superior male
- c) plume length indicates the amount of material benefit a female will receive
- d) plume length indicates the age of a male
- e) plume length is a signal of male territory quality

What is NOT true of traits that evolve via sensory bias?

- a) the trait has been shaped by natural selection in a different context (e.g., foraging)
- b) females prefer the trait because it leads to higher quality offspring
- c) females prefer the trait because it more strongly stimulates the female nervous system
- d) female preference for the trait evolves before males begin to use it in mating
- e) females receive no benefit from having a preference

Nepotism is defined as:

- a) directing help to relatives
- b) being altruistic
- c) acting in the best interests of the species
- d) increasing inclusive fitness
- e) acting as a helper

In Pied Kingfishers the secondary males gain most fitness by:

- a) increasing their opportunity to mate in their second year
- b) increasing their payoff from altruism during helping by being extra helpful
- c) increasing the rate of feeding of young when they are a parent
- c) maximizing the indirect component of inclusive fitness
- e) helping to raise young to whom they are highly related

Which of the following is NOT a vicariant event?

- a) restriction of lowland Amazon rain forests into refugia during Pleistocene glaciation
- b) spread of grasslands across central North America
- c) closing of the isthmus of Panama
- d) formation of the new volcanic island of Surtsey off the coast of Iceland
- e) formation of the island of Trinidad as it became cut off from the South American mainland due to the rise of sea levels at the end of the Pleistocene glaciations

Which of the following is not a hypothesis for the evolution of bipedalism?

- a) climate change
- b) thermoregulation
- c) better visibility
- d) carrying tools
- e) enhanced aggression

Which of the following was a member of the hominin clade?

- a) Gorilla
- b) Australopithecus
- c) Pan
- d) Drosophila
- e) Pongo

The first known organisms on earth were:

- a) prokaryotes
- b) phytoplankton
- c) dinoflagellates
- d) fungi
- e) dinosaurs

Which of the following was NOT likely to be true of the first cellular life?

- a) cell membrane composed of fatty acids
- b) information storage molecule enclosed in a nucleus
- c) information storage molecule is not DNA
- d) did not use photosynthesis for energy transduction
- e) more common in aquatic or marine environments

In allopatry, the males of two species of birds both have a red head stripe which the females use in mate choice. Where the two species occur together, one species lack the red head stripe instead having a red patch on the breast. Females select males on the basis of this red breast stripe. This phenomenon is referred to as:

- a) reproductive character displacement
- b) reinforcement
- c) character divergence
- d) reproductive isolation
- e) ecological divergence

The adaptive radiation of Lake Malawi cichlids is most likely due to:

- a) ecological speciation through feeding specialization
- b) ecological speciation through habitat specialization
- c) behavioral speciation through habitat choice
- d) behavioral speciation through sexual selection
- e) none of the above

Disruptive selection can lead to speciation

- a) when gene flow is reduced
- b) when the habitat is heterogeneous
- c) when strong sexual selection occurs
- d) when there is strong linkage disequilibrium
- e) when genetic drift is not important

All of the following represent premating isolating mechanisms except:

- a) a substance in the oviduct of females results in the death of sperm when the wrong species mates
- b) due to a shift in the use of a host-plant one species completes its life cycle in May-June while the other completes its life cycle in June-July
- c) with an increase in body size, the frequency of the call of a second species of frog becomes lower and is not recognized by females of the first species
- d) sexual selection (i.e. female choice) has resulted in males that have conspicuous red plumage in one species the possession of which is crucial to mate selection
- e) due to a change in a membrane receptor, sperm of one species of sea urchin can no longer bind to eggs of another species (sea urchins have external fertilization)

Which of the following represents an opportunity for founder event speciation?

- a) restriction of lowland Amazon rain forests into refugia during Pleistocene glaciation
- b) the Indian subcontinent collides with southern Asia
- c) the formation of the island of Ha'waii about 500,000 years ago
- d) formation of the island of Trinidad as it became cut off from the South American mainland due to the rise of sea levels at the end of the Pleistocene glaciation
- e) re-invasion of Spruce-fir forest into Canada after the retreat of the glaciers

Mallard Ducks are sexually dimorphic: males have a bright green head and a grey and white body pattern while females are a drab, mottled brown. The most closely related species to Mallards, the Black Duck, is sexually monomorphic: both males and females are drab, mottled brown. This pattern occurs repeatedly among the Anseridae (the duck family): among pairs of sister taxa, one species is sexually dimorphic, and the other is monomorphic with “female” coloration. In mallards, females choose mates on the basis of the intensity of the green color of the head (whether mate choice occurs in other species is unknown). Male ducks provide no parental care (in any species). Duck offspring are precocial (they can move and feed on their own), the period of female parental care is relatively brief compared to other species of birds, and the energetic cost to females is lower. Which type of speciation process is likely to have been most important in the Anseridae?

- a) vicariance
- b) founder event
- c) ecologically-driven divergence
- d) sexual selection-driven divergence
- e) all of the above

What is required for the evolution of altruistic behavior?

- a) direct fitness >> indirect fitness
- b) direct fitness >> inclusive fitness
- c) indirect fitness >> direct fitness
- d) inclusive fitness >> direct fitness
- e) inclusive fitness >> indirect fitness

Which of the following is NOT a direct benefit of female choice?

- a) nuptial gift
- b) paternal care
- c) foraging territory
- d) sexy sons
- e) lower disease risk

Males of the Superb Bird of Paradise aggregate during the breeding season in leks where they display to females. Females chose a particular male as a mate, and after mating, go off and raise the offspring on their own. Males perform an elaborate display. Females are more likely to mate with males that have longer and more variable display. The most likely explanation for female preferences is:

- a) display complexity indicates a high quality male
- b) display length indicates a competitively superior male
- c) display complexity indicates the amount of material benefit a female will receive
- d) display length indicates the age of a male
- e) display complexity is a signal of male territory quality

Which is the correct order of human traits, ranked from oldest to most recent?

- a) bipedalism < straight big toe < big brain < precision grip < language
- b) bipedalism < straight big toe < precision grip < big brain < language
- c) language < big brain < straight big toe < bipedalism < precision grip
- d) straight big toe < bipedalism < precision grip < big brain < language
- e) straight big toe < bipedalism < precision grip < big brain < language

The last common ancestor of humans and chimpanzees lived approximately

- a) sixty-five million years ago
- b) six million years ago
- c) five hundred thousand years ago
- d) one hundred thousand years ago
- e) ten thousand years ago

Which is the correct order of hominid species, ranked from oldest to most recent?

- a) Sahelanthropus tchadensis < Homo ergaster < Ardipithecus ramidus
- b) Sahelanthropus tchadensis < Ardipithecus ramidus < Australopithecus afarensis
- c) Paranthropus boisei < Homo erectus < Australopithecus afarensis
- d) Homo neandertalensis < Australopithecus afarensis < Paranthropus boisei
- e) Australopithecus afarensis < Homo neandertalensis < Ardipithecus ramidus

Which of the following does NOT support the hypothesis that all existing life on earth had a common ancestor?

- a) RNA as the information storage molecule
- a) arbitrary, but nearly universal, genetic code
- b) universal translation machinery (ribozyme)
- c) utilization of D-isomer sugars
- d) utilization of D-isomer nucleosides
- e) utilization of L-isomer amino acids

Which of the following was NOT likely to be true of the first cellular life?

- a) cell membrane composed of fatty acids
- b) information storage molecule enclosed in a nucleus
- c) information storage molecule is RNA
- d) did not use photosynthesis for energy transduction
- e) more common in aquatic or marine environments

Which of the following is unlikely to be an environment on the early earth where life could have evolved?

- a) shallow sea margins
- b) slopes of volcanoes
- c) deep sea alkaline springs
- d) deep sea thermal vents
- e) slopes of geysers

The Biological Species Concept applies to which of the following species?

- a) Homo sapiens
- b) Homo neandertalensis
- c) Homo ergaster
- d) Homo erectus
- e) the BSC applies to all of them

In allopatry, the males of two species of birds both have a red head stripe which the females use in mate choice. Where the two species occur together, one species lack the red head stripe instead having a red patch on the breast. Females select males on the basis of this red breast stripe. _____ is likely to have produced this phenomenon.

- a) reinforcement
- b) reproductive character displacement
- c) character divergence
- d) reproductive isolation
- e) ecological divergence

The adaptive radiation of Lake Malawi cichlids is a consequence of:

- a) initial speciation through macrohabitat specialization
- b) ecological speciation through foraging specialization
- c) behavioral speciation through habitat choice
- d) behavioral speciation through sexual selection
- e) all of the above

Hybridization between two species can lead to the formation of a third species, if

- a) the hybrid offspring can occupy a habitat different from either parental species
- b) the hybrid offspring have higher fitness than either parental species in each habitat occupied by the parental species
- c) the hybrid offspring are reproductively isolated from both parental species
- d) the hybrid offspring are geographically isolated from both parental species
- e) the hybrid offspring have greater genetic variance than either parental species

Which of the following does not commonly show a negative phenotypic correlation (trade-off)?

- a) number of offspring, size of offspring
- b) adult size, offspring size
- c) growth rate, age at maturity
- d) lifespan, age at maturity
- e) age at maturity, clutch size

Shiners are small fish that live in streams. Different streams contain different suites of predators. Gobies feed on adult shiners and eat relatively few juveniles. Lancefish eat juvenile shiners; adults are too large for them to consume. Which of the following statements best describes life history variation in shiners.

- a) shiners in streams with only lancefish will have larger offspring than those in streams with only gobies
- b) shiners in streams with only gobies will have larger offspring than those in streams with only lancefish
- c) shiners in streams with only lancefish will have more offspring over their lifetime than those in streams with only gobies
- d) shiners in streams with only gobies will reproduce more often than those in streams with only lancefish
- e) shiners in streams with only lancefish will have greater reproductive effort than those in streams with only gobies

In experimental tests of the antagonistic pleiotropy hypothesis for the evolution of senescence,

- a) there is selection for increased fecundity early in life, and correlated increase in early survival
- b) there is selection for increased fecundity late in life, and correlated increase in early survival
- c) there is selection for increased fecundity early in life, and correlated decrease in early survival
- d) there is selection for increased fecundity late in life, and correlated decrease in early survival
- e) there is selection for increased fecundity in late in life, and correlated increase in late survival

Traits that are important for an individual's survival or reproductive success are expected to be under strong selection. But when we assay genetic variation for such traits, they typically have some non-zero additive variance. Why?

- a) most traits are subject to density-dependent selection
- b) most traits are subject to stabilizing selection
- *c) quantitative characters have a higher mutation rate because there are many loci
- d) because of environmental variance, directional selection is very weak
- e) because effective population size is usually small

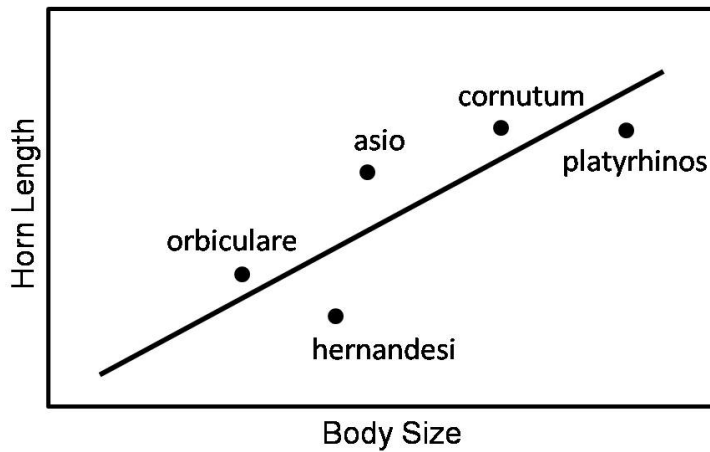
Hamilton's rule says:

- a) $rc > b$
- b) $rb > c$
- c) $c > rb$
- d) $b > rc$
- e) $rc = b$

The variance in male reproductive success is usually

- a) greater than the variance in female reproductive success
- b) identical to the variance in female reproductive success
- c) less than the variance in female reproductive success
- d) unrelated to the variance in female reproductive success
- e) dependent on the variance in female reproductive success

You are studying the relationship between the intensity of sexual selection and horn length in horned lizards. If your hypothesis that sexual selection has favored longer horns is correct, which of the five species in the figure below should have experienced the greatest sexual selection?



- a) asio
- b) cornutum
- c) hernandesi
- d) orbiculare
- e) platyrhinos

Female thirteen-banded ground squirrels breed once per year. During the breeding season, females mate with several males, sometimes repeatedly. This behavior is best explained as:

- a) females change their preferences when given many choices
- b) female survival is increased by multiple mating
- c) female fitness is increased by allowing sperm competition
- d) multiple mating allows the female to forage on multiple territories
- e) females are unrelated to males in their social group

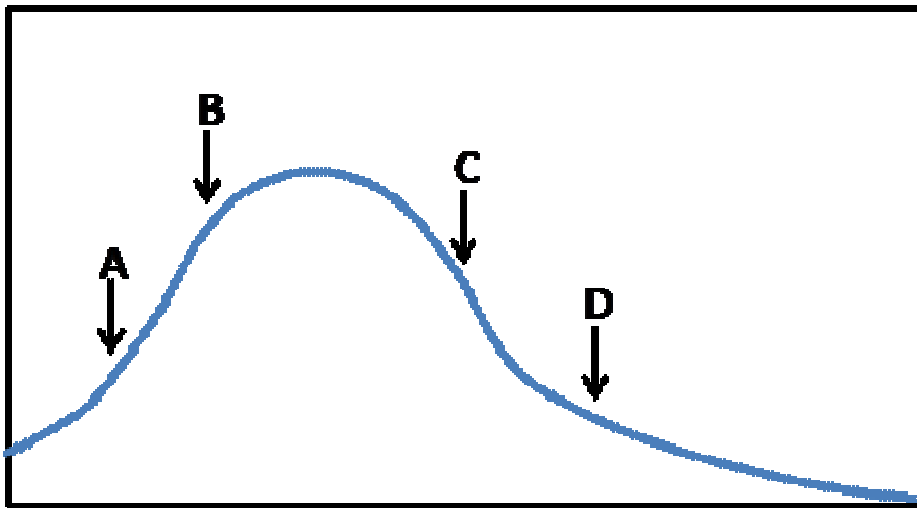
You are studying the rose-spotted numbat, which lives for one year. In this species there are two types of helpers. Type I helpers repel predators, bring food to the young and defend the territory. Having one of these helpers increases the reproductive output of the breeders by 0.5 offspring. Type I helpers are related to the young of the breeding pair by $r = 0.4$, on average. Additionally, the Type I helpers can occasionally breed and produce, on average, 0.5 offspring per year. Type II helpers do not breed, however, they are much more effective in providing help to the breeders. Their help, which is also given exclusively to the breeders (to whose young they are also related by $r = 0.4$) results in an increase of 1.5 offspring. Which of the following statements is true?

- a) Type II helpers have greater direct fitness than Type I helpers
- b) Type II helpers have greater inclusive fitness than Type I helpers
- c) Breeders with Type I helpers have higher fitness than breeders with Type II helpers
- d) Type I helpers have greater indirect fitness than Type II helpers
- e) Type I helpers do not increase the fitness of the breeders they help

Which of the following statements does NOT apply to semelparous species?

- a) they reproduce exhaustively
- b) they reproduce only once
- c) juvenile survival is greater than adult survival
- d) they usually produce large numbers of offspring
- e) they have short lifespans

Four new deleterious mutations have just arisen in the population that has the reproductive value curve shown below. They have an age-specific effect on survival at the times indicated by the arrows. Which deleterious mutation is likely to persist the longest in the population?



- a) the one at time A
- b) the one at time B
- c) the one at time C
- d) the one at time D
- e) there is no basis for making a prediction

Which of the following is most likely to represent incipient ecological speciation?

- a) a guppy population separated onto the island of Trinidad and mainland Venezuela due to the rise of sea levels at the end of the Pleistocene glaciation
- b) a population of honeycreepers that has colonized the recently formed island of Hawaii from the older island of Maui
- c) a population of bluegill sunfish using both nearshore and deepwater habitats in a pond
- d) a populations of tulip poplar separated by advancing glaciers along the Appalachian Mountains during the Pleistocene
- e) a population of mosses that has colonied the recently formed island of Surtsey from Iceland

Which of the following is NOT a possible outcome of secondary contact?

- a) reproductive character displacement
- b) population fusion
- c) stable hybrid zone
- d) new species that arises through hybridization
- e) all are possible

Which of the following is an example of Haldane's Rule?

- a) In the hybrids between blue-backed and golden poison dart frogs, egg-sperm incompatibilities lead to complete reproductive failure.
- b) The hybrid offspring of the glossy firefinch and the sedate firefinch are unable to feed on the seeds used by either parent species.
- c) The hybrid offspring of boll and spotted weevils die as embryos.
- d) The hybrid offspring of White-Footed and Plains deer mice are able to occupy a habitat that can't be used by either parent.
- e) In hybrids between *Drosophila mauritiana* and *D. yakuba*, males do not sing the species specific courtship song and are unsuccessful at mating.

The first fossil evidence of life on earth dates to approximately

- a) 6 million years ago
- b) 65 million years ago
- c) 550 million years ago
- d) 2 billion years ago
- e) 3.5 billion years ago

Which of the following does NOT support the hypothesis that all existing life on earth had a common ancestor?

- a) RNA as the universal information storage molecule
- b) arbitrary, but nearly universal, genetic code
- c) universal translation machinery (ribozyme)
- d) utilization of D-isomer sugars
- e) utilization of L-isomer amino acids

Which of the following statements is false?

- a) Humans originated in Africa.
- b) Members of the genus Homo emigrated from Africa more than once.
- c) Anatomically modern humans dispersed out of Africa approximately 100,000 years ago.
- d) There were several branches of the hominin clade, but all of these became extinct.
- e) Anatomically modern humans are thought to have preceded behaviorally modern humans.