Question 1

West Coast Leaping Frogs are endemic of Magic Island's West Coast and can have light green, yellow, or blue abdomens. Abdomen colour is controlled by a protein coded by a gene called "C". This gene has two alleles, C^B (for "colour blue") and C^Y (for "colour yellow"). Frogs that are heterozygous C^B/C^Y are light green, due to the mixture of blue and yellow pigments.

a) A field biologist conducts a study on Magic Island and finds that a population of West Coast Leaping Frogs living in a forested area is composed of 820 yellow individuals, 313 blue, and 78 light green individuals.

i) What are the respective frequencies of the C^B and C^Y alleles in this population? Show your calculations for full marks. **(2 marks)**

0.5 mark for the calculation and 0.5 mark for the correct frequency, for each allele

frequency C^B= (313 + ½ * 78)/(313+78+820) = 0.29

frequency C^Y= (820 + ½ * 78)/(313+78+820) = 0.71

ii) Is the population described above in Hardy-Weinberg equilibrium? Show all your reasoning and your calculations for full marks. **(4 marks)**

Need correct logic and go through the calculations and the comparisons for at least one of the three genotypes, for full marks.

Expected freq C^B/C^B = 0.29 * 0.29 = 0.084	**(0.5 marks)**
Observed freq C^B/C^B = 313/1211 = 0.26	**(0.5 marks)**
Expected freq C^B/C^Y = 0.29 * 0.71*2 = 0.41	**(0.5 marks)**
Observed freq C^B/C^Y = 78/1211 = 0.06	**(0.5 marks)**
Expected freq C^Y/C^Y = 0.71 * 0.71 = 0.50	**(0.5 marks)**
Observed freq C^Y/C^Y = 820/1211 = 0.68	**(0.5 marks)**

➔ observed frequencies different from expected, so not in HWE (1 mark)

NO MARKS for incorrect logic, wonky calculations, or saying that the frequency of an allele is or isn't in equilibrium (as opposed to saying that the population is or isn't in equilibrium).

iii) Propose a hypothesis that explains the low proportion of light green frogs in this population. Be precise and very specific. **(4 marks)**

1 mark for a reason that makes sense

Examples: selection against the heterozygotes selection/ reduced fitness for the heterozygotes; OR non-random mating where yellow frogs preferentially mate with frogs of the same colour as themselves.

Only 0.5 mark for something like "mass migration of the light green frogs" or for just saying selection without including something to say that it is against the light green frogs.

2 marks for including specifics about the reason; examples:
If hypothesis of selective disadvantage: what acts as a selective force against light green frogs? (E.g. may say that a particular predator preferentially hunts light green frogs for some reason, or the light green colouration interferes with some of their physiological processes, or it makes the frogs more visible to predators…).
Note: 2 marks for a good explanation; 1 mark for incomplete/not so good explanation. No marks for just saying that they have a reduced fitness.

If hypothesis of random mating:
1 mark for saying that the frogs may be preferentially mating with frogs of the same colour (this is also valid for light green frogs → if they mate with other light green frogs, they generate many homozygotes).
1 mark for giving a potential reason why there is preferential same-colour mating (it's OK if they just say things like "female frogs find males of their same colour more attractive).

1 mark for how the reason will lead to a low proportion of light green frogs; examples:
If hypothesis of selective disadvantage:
(If the disadvantage acts early in development) Although many light green frogs may originally be born (0.5), very few would survive to adulthood and be part of the population (0.5)

(If selective disadvantage acts in early adulthood, after metamorphosis) Although many light green frogs may originally complete metamorphosis (0.5), most of them would die/be killed shortly thereafter, so there would never be many light green frogs present in the population (0.5).

If hypothesis of non-random mating:
By mating with same-colour individuals, blue and yellow frogs would only ever produce blue and yellow offsprings (0.5), and light green frogs would decrease their proportion in the next generation by producing only 50% light green frogs (0.5).

b) The biologist collects a number of West Coast Leaping Frog tadpoles (baby frogs) and raises them in an aquarium under controlled conditions. A few tadpoles die before reaching adulthood, but most of them develop into healthy adult frogs. Altogether, this lab population is composed of 27 yellow, 23 blue and 9 light green individuals.

i) Compare the allele frequencies in this lab population to the frequencies in the natural population (showing your calculations) and propose an explanation for their similarity or for their difference. **(4 marks)**

1 mark for each allele frequency:

frequency of $C^B = (23+4.5)/59 = 0.47$ (1)

frequency of $C^Y = (27+4.5)/59 = 0.53$ (1)

1 mark for saying that they are different form the natural population's

1 mark for an explanation (best one is genetic drift given the small sample size; other answers possible but they have to make sense and be consistent).

ii) What could the biologist do to increase the proportion of light green frogs in his lab population in the next generation? In your answer give a specific description of what the biologist would be doing in terms of artificially manipulating the allele and genotype frequencies and causing Hardy-Weinberg criteria not to be met. **(6 marks)**
He could force the yellow frogs to mate with blue frogs/set up controlled crosses between yellow and blue frogs (2 marks)
by placing a male of one colour and a female of the other colour in an isolated environment during reproductive season (other procedures OK too….) (2).
This way the biologist would be enforce non-random mating. (2)
OR:
He could monitor the population in the next generation (2) and manually remove all/a large proportion of the blue and yellow frogs as soon as they reach adulthood. (2)
This way he would be enacting selection (1) in favour of the heterozygotes (1).

c) One night, members of the West Coast Leaping Frogs Fan Club break into the biologist's lab and steal one third of the yellow frogs for their club's pond. If the remaining frogs mate randomly with respect to colour, what will be

i) the allele frequencies in the next generation? **(2 marks)**
1 mark for each correct frequency
frequency C^y = (2*(27-9)+9)/(18+9+23)*2= 0.45
frequency C^B = 1-0.45 = 0.55

ii) the phenotypic frequencies in the next generation? **(3 marks)**
1 mark for each frequency; no marks if they calculated the allele frequencies incorrectly in the previous part.
Frequency blue = 0.55 * 0.55 = ~0.3 (may approx up or down)
Frequency yellow = 0.45*0.45 = ~0.2 (may approx up or down)
Frequency light green = 2 * 0.45 * 0.55 = ~0.5 (may approx up or down)

Question 2

The phylogenetic tree shown below represents the current view on the genealogical relationships among the primates alive today.

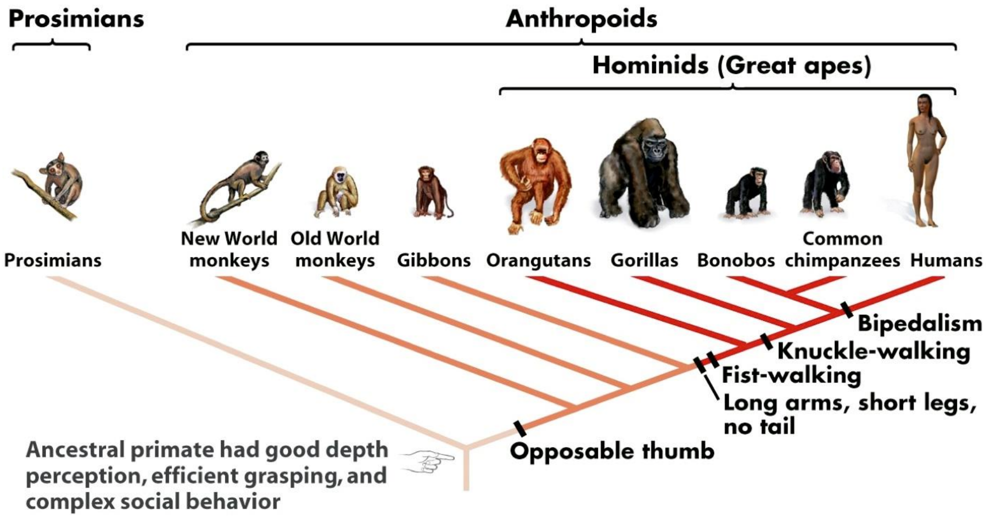


Figure 33-35c Biological Science, 2/e
© 2005 Pearson Prentice Hall, Inc.

a) How many clades, or monophyletic groups can you identify on the tree (counting also the terminal branches = most recent portion of each lineage)? **(1 mark)**

17

b) According to the tree, what characteristics did the most recent common ancestor of gorillas, bonobos, chimps and humans have? (Note: this questions assumes that fist-walking, knuckle-walking, and bipedalism are all three different variants of one trait: walking.) **(2 marks)**

Opposable thumb, long arms, short legs, no tail, knuckle walking.

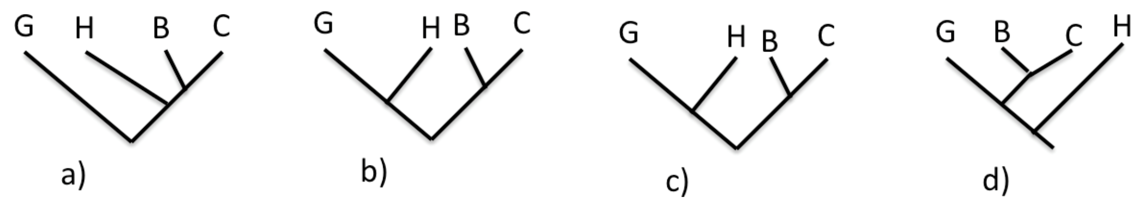
c) On the tree, circle the most recent common ancestor of all Great Apes. **(1 mark)**

(It is the node where the orangutans branched off).

d) A previous BIOL121 student stated:
"This tree cannot be true because it shows that chimps and bonobos are more evolved than humans." Do you agree or disagree with this statement?
If you agree, justify your answer using evidence from the tree. If you disagree, explain where the previous student went wrong. **(3 marks)**

This statement is inaccurate.
The tree does not show that chimps and bonobos are more recent than humans (1); instead, the tree shows that the most recent common ancestor of chimps and bonobos is more recent than the common ancestor of humans and chimps, or humans and bonobos (1.5), and therefore bonobos and chimps are more closely related to each other than humans and chimps or humans and bonobos (0.5).

e) Consider each of the trees below and explain for each one whether or not it shows the same genealogical relationships among gorillas (G), bonobos (B), chimps (C) and humans (H) as the tree above (on the previous page). **(6 marks)**



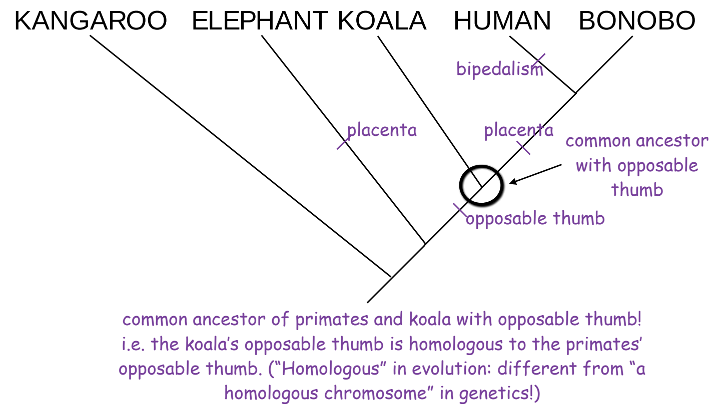
Tree a) shows that bonobos and chimps are the most closely related, that bonobos and chimps are equally closely related to humans, and that gorillas are the most distantly related from humans, chimps and bonobos. These relationships are the same as in the tree above. (1.5)

Trees b) and c) are actually identical; they show exactly the same evolutionary relationships. (0.5)
Trees b) and c) show that chimps are most closely related to bonobos, and gorillas are most closely related to humans (1). This is different from the tree above and from tree a), as in the tree above humans are more closely related to chimps and bonobos than to gorillas. (1)

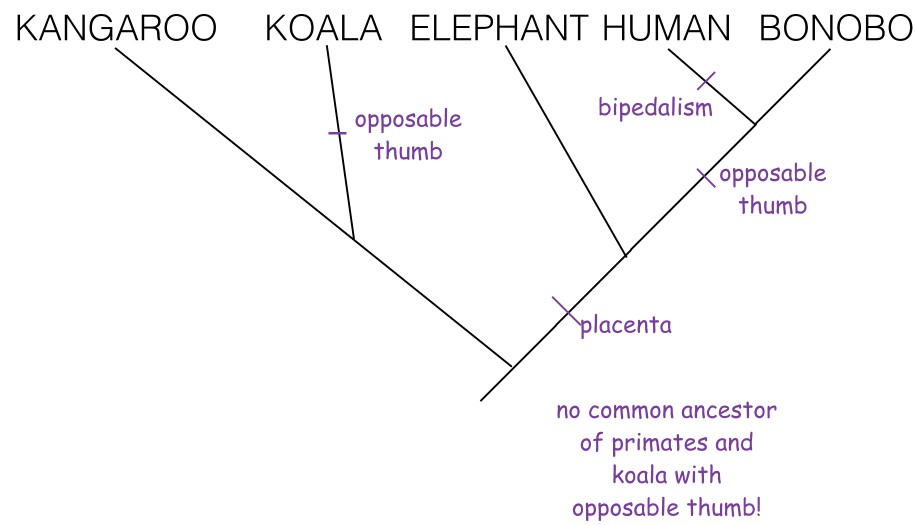
Tree d) shows chimps being most closely related to bonobos, gorillas being most closely (and equally) related to chimps and to bonobos, and chimps and bonobos more closely related to gorillas than to humans (1). This is different from the tree above, as in the tree above humans are more closely related than gorillas to chimps and bonobos. (1)

f) Primates are not the only animals with opposable thumbs: koalas have two opposable digits (looking like two thumbs). Koalas are the only animals, other than primates, who have opposable thumbs. Koalas are members of the marsupial clade, like kangaroos, wallabies, and other "pouched" mammals. Unlike the babies of placental mammals, marsupial babies are born very "premature" and develop in their mother's pouch.

i) Draw a phylogeny that includes koalas, kangaroos and the placental mammals humans, bonobos and elephants, under the hypothesis that the opposable thumb of primates is homologous to (i.e. inherited from the same common ancestor as) the opposable thumb of koalas. Use the rule of maximum parsimony (smallest number of changes). **(2 marks)**



ii) Now draw a phylogeny that includes koalas, kangaroos and the placental mammals humans, bonobos and elephants, under the hypothesis that the opposable thumb of primates and the opposable thumb of koalas arose independently. Use the rule of maximum parsimony (smallest number of changes). **(2 marks)**



Question 3

A large population of nematode worms live in the soil at Tynehead Park in Surrey, BC. Some of the worms carry the Dpy- mutant allele (Dpy+ is the wild-type). Dpy+ is dominant to Dpy-, and individuals who are homozygous for the mutant allele have a shorter and "fatter" body shape.
Explain, and illustrate with specific examples how and under what circumstances this particular population could be affected by:

a) Genetic drift **(3 marks)**

Example: there is a change in the environment that kills of most of the worms randomly, e.g. some toxic waste is dumped in the park (1), causing a big drop in population size. If the proportion of individuals with the mutant (vs. WT) allele among the survivors is different from the proportion/frequency in the original population, e.g. there are more

WT than in the original populations(1) the allele frequencies in future generations, and in the new population that will establish itself, will be different from the original, with the WT becoming more frequent and the mutant less frequent than it used to be (1)
NOTE: could also use an example with founder effect.

b) Gene flow **(3 marks)**

Someone dumps a whole bunch of yard trimming and/or soil from their backyard in the park, and there are nematode worms in there (1). If the worms in the dumped soil/trimmings have a different allele frequency than the worms in the park (e.g. more mutants) (1), as the two populations intermix and mate together, the frequencies of the two alleles in this mixed population will be different from the original one, with the frequency of the mutant allele increasing (1).

c) Selection **(3 marks)**

A sudden drop in temperature makes the environment close to the minimum that is tolerable for the worms. (1) However, homozygous mutant worms have a smaller body surface area, which allows them to better withstand the stressful conditions and therefore have a higher chance of producing offspring (1). This allows them to pass on their (mutant) alleles more often than the wild-type worms, thus increasing the frequency of the mutant allele in the population and by consequence the frequency of the mutant body phenotype (1).

In the Lake Erie region of Ontario there are two kinds of non-poisonous water snakes. On the shores of the lake most of the snakes have a banded colouration while on the islands in the lake most are not banded. You have been hired by the Ontario government to work on a project designed to protect these snakes from becoming endangered.

a) The first thing you have to do is to determine whether banded and unbanded snakes represent different morphological forms (morphs) of one species or are two separate species. What would you do to determine if they were one species with two morphs or two species? (2 marks)
Observe in the wild or capture them and keep them in the lab to see if they mate (1) and have viable offspring (1)

b) Suppose you determine that they are in fact one species. What could be causing the difference in distribution of the two morphs? (2 marks)
many answers are possible; they just have to be logical and biologically possible. e.g., perhaps the environment on the shore or on the island is such that the less common morph is more visible to predators (2)

c) Suppose you determine that they are in fact two species. What are two reproductive isolating mechanisms that could be causing them to remain separate species? (2 marks)
any two of: habitat isolation, behavioural isolation e.g. courtship behavior, temporal Isolation, d) mechanical isolation, e) gametic isolation, Postzygotic barriers such as reduced hybrid fertility

d) In some snake species, a male will fight with another male for access to a reproductive female. This involves a wrestling match where the snakes raise the front of their bodies off the ground and attempt to topple each other over. They do not bite each other. Rather the winner is the snake that successfully forces the other snake to the ground through strength and dexterity.

i) What is the fitness benefit to the males of engaging in ritual combat? (2 marks)

Increases the likelihood of a mating opportunity for the winning male. More reproductive success = higher fitness.

ii) What is the fitness benefit to the female of mating with the winner of the match? (2 marks)

Offspring will inherit "good genes" from their father increasing their chances of successfully competing for a mate, i.e. the offspring will have higher fitness. Female fitness is linked to the fitness of her offspring.