wrong	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
right	118	117	116	115	114	113	112	111	110	109	108	107	106	105	104	103	102	101	
score	100	99.2	98.3	97.5	96.6	95.8	94.9	94.1	93.2	92.4	91.5	90.7	89.8	89	88.1	87.3	86.4	85.6	

Cladistics Seminar

Name_____

An important part of any modern course in organismal biology is to understand cladistics. This is perhaps not the most obvious or easily understood concepts in biology, so we will work into it gently. We will use a modification of a published exercise designed for non-majors (David W. Goldsmith. 2003. The great clade race: presenting cladistic thinking to biology majors and general science students. *The American Biology Teacher* 65: 679-682). For this exercise, work with one partner to carry out each part of this project.

Simple Classification

Our warm-up exercise will involve a group of eight cards with human names on them. All of the names consist of three letters. The names are not to be used in the classification as the names are artificial common names. You may not imply gender or other characteristics from the names. Rather, using only the graphical symbols on the cards, classify the cards. You may make as many groups as you want, but each group of cards should show or possess a particular theme. In the remaining space, discuss and defend your classification.

The groups we have defined and their membership:

The rules separating the individuals into these groups:

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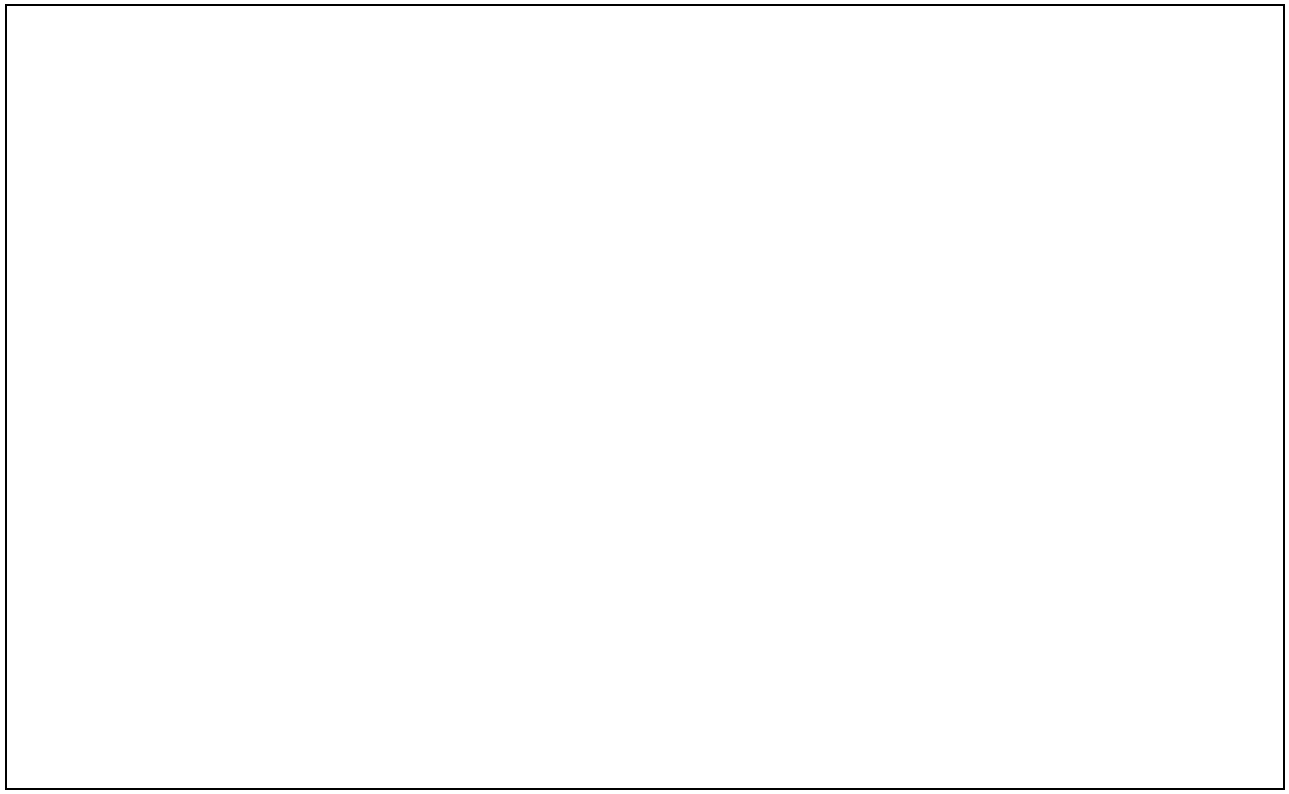
Koning, Ross E. 1994. Cladistics Seminar. *Plant Information Website*.
http://plantphys.info/organismal/labdoc/cladisticslab.doc

Cross Country Meet

The cards you have classified are the products of a fictitious cross-country meet carried out in a forest. This race was governed by the following rules:

1. All runners enter the woods at a single entrance at the south end of the forest. But there are several trails within the forest. (REK modification)
2. Runners may not stop part of the way down a trail or retrace their path.
3. When a trail branches, it only branches into two new trails, never three or more.
4. Once trails have branched apart, they do not reunite later in the race.
5. Check-in stations are located along the straight sections of the trail, never at a branch point. Runners must have their card punched at each station. The workers at the stations work quickly so the sequence of punches means nothing; only the shape of the punch out matters. (REK edit)
6. All runners must complete the race and emerge out the north edge of the forest through one of several different exits. (REK modification)
7. Using the punch-cards turned in by the runners, draw a map of the trails, check-in stations, and exits used by each of the runners. Put a hash-mark across the trail where each station is located.

Finish



Start

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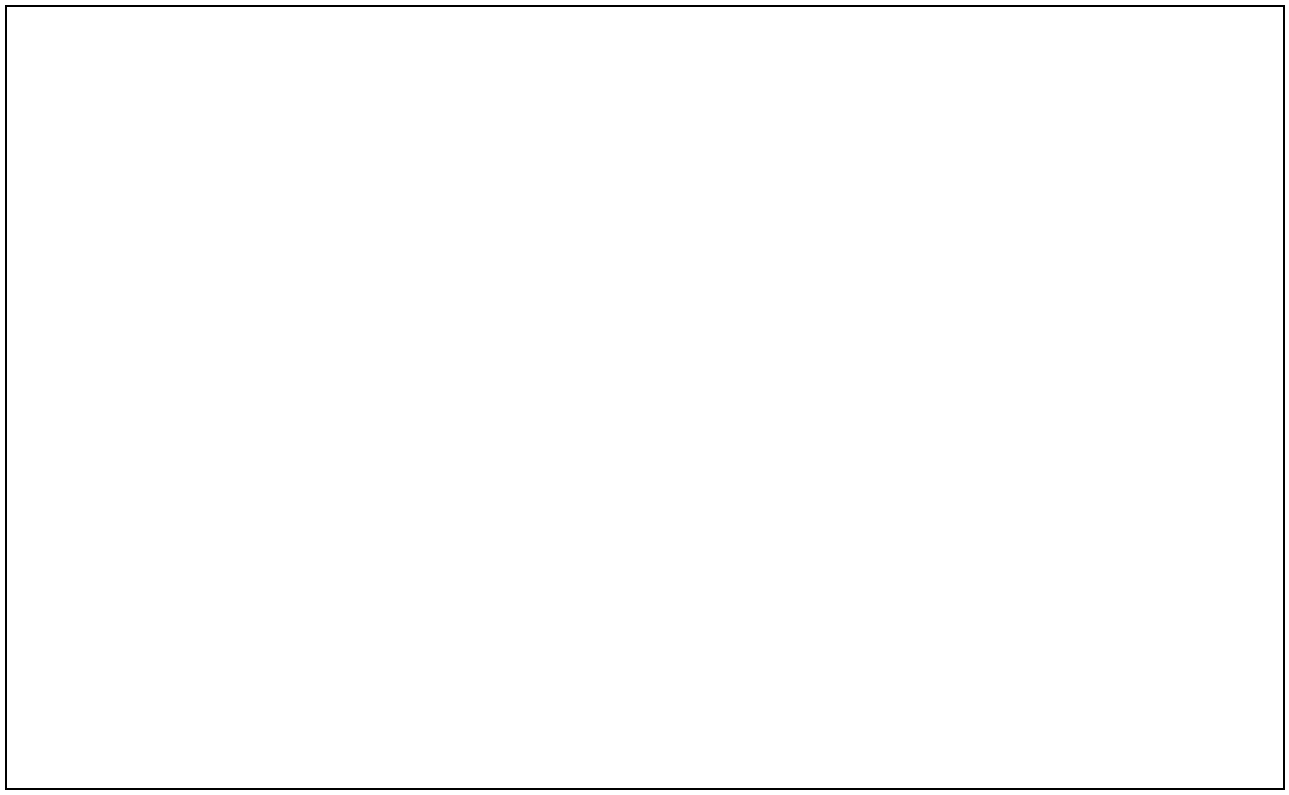
A Late Finisher!

Oh No! We have received news that a ninth runner has just finished the race…coming in very late! You will receive a ninth card. Remap your race with the information included on this ninth entry. Perhaps there are multiple explanations? Beneath the map showing the whole race and particularly highlighting the possible pathways and stations for this last runner, write a few sentences to explain your best guess about how all of this fits together.

Finish



Start

Explanation:

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Cladistics with "Clade Critters"

Now for something a bit more direct. You and your partner will receive a new set of 6 cards. These have pictures of Clade Critters on both sides. The correct side (for now) shows smaller critters **without antennae**! Using the characteristics of the organisms, put together a matrix of the characteristics you observe. Polarize the character states based upon the phenotype of the out-group critter. For each character, put 0 in the matrix for those taxa with the plesiomorphic state and a 1 in the matrix for those taxa with the apomorphic state.

Character: Apomorphic State Taxon:	OG	A	B	C	D	E
1 Eye size:						
2 Eye color:						
3 Neck width:						
4 Body width:						
5 Body color:						
6 Wing width:						
7 Wing length:						
8 Leg length:						
9 Leg thickness:						
10 Stinger length:						

Using the concepts of parsimony and synapomorphy and the space below, construct a cladogram for the six taxa of clade critters. Be sure to write in the numbers for the apomorphic character state transitions, draw a small hash mark across the evolutionary path where the transitions occur. Be sure your critters are all extant!

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A Newly-Discovered Species!

A scientist has just found a new species of clade critter. We will need to revise our cladogram to include this new species: taxon F. You need to re-enter the characters and states from your matrix on the previous page, but you will need to add the new column for species F.

Character: Apomorphic State Taxon:	OG	A	B	C	D	E	F
1 Eye size:							
2 Eye color:							
3 Neck width:							
4 Body width:							
5 Body color:							
6 Wing width:							
7 Wing length:							
8 Leg length:							
9 Leg thickness:							
10 Stinger length:							

Using the concepts of parsimony and synapomorphy and the space below, reconstruct a cladogram for the seven taxa of clade critters. Be sure to write in the numbers for the apomorphic character state transitions, draw a small hash mark across the evolutionary path where the transitions occur. Be sure your critters are all extant! And circle any homoplasies you include.

Write a short comment explaining what you make of any homoplasy.

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The Final Example

OK, so now you are getting pretty good at this. The final set of clade critters to decipher is on the other side of the cards of your previous critters. These larger critters **have antennae**, so are completely unrelated to the clade critters you have observed previously.

Character: Apomorphic State Taxon:	OG'	A'	B'	C'	D'	E'
Antenna						
Antenna						
Body						
Body						
Stinger						

Using the concepts of parsimony and synapomorphy and the space below, reconstruct a most biologically parsimonious cladogram for the six taxa of these clade critters. Be sure to write in the apomorphic character state names and draw a small hash mark across the evolutionary path where the state changes. Be sure your critters are all extant! And circle any homoplasies you include.

Write a short comment explaining why the homoplasy in your cladogram is biologically the most-parsimonious possible.

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Your project with the cross-country meet is very much like cladistic analysis of organisms. Give answers below that translate the meet into cladistics ideas:

Interpret the rules about how the race operates:

1. All runners enter the woods at a single entrance at the south end of the forest. But there are several trails within the forest.

2. Runners may not stop part of the way down a trail or retrace their path.

3. When a trail branches, it only branches into two new trails, never three or more.

4. Once trails have branched apart, they do not reunite later in the race.

5. Check-in stations are located along the straight sections of the trail, never at a branch point. Runners must have their card punched at each station. The workers at the stations work quickly so the sequence of punches means nothing; only the shape of the punch out matters.

6. All runners must complete the race and emerge out the north edge of the forest through one of several different exits.

7. Using the punch-cards turned in by the runners, draw a map of the trails, check-in stations, and exits used by each of the runners.

What do biologists call the runners who finished the race? _____
Biologically, what do we call the group of all runners who passed by one station but then traveled in various pathways from that station? _____
What do biologists call a group of just some of the runners who passed by one station?_____
When a pathway branches in the woods, what do cladists call that evolutionary event? _____
When there are multiple stations along a particular pathway, what would cladists call that evolutionary event? _____

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