

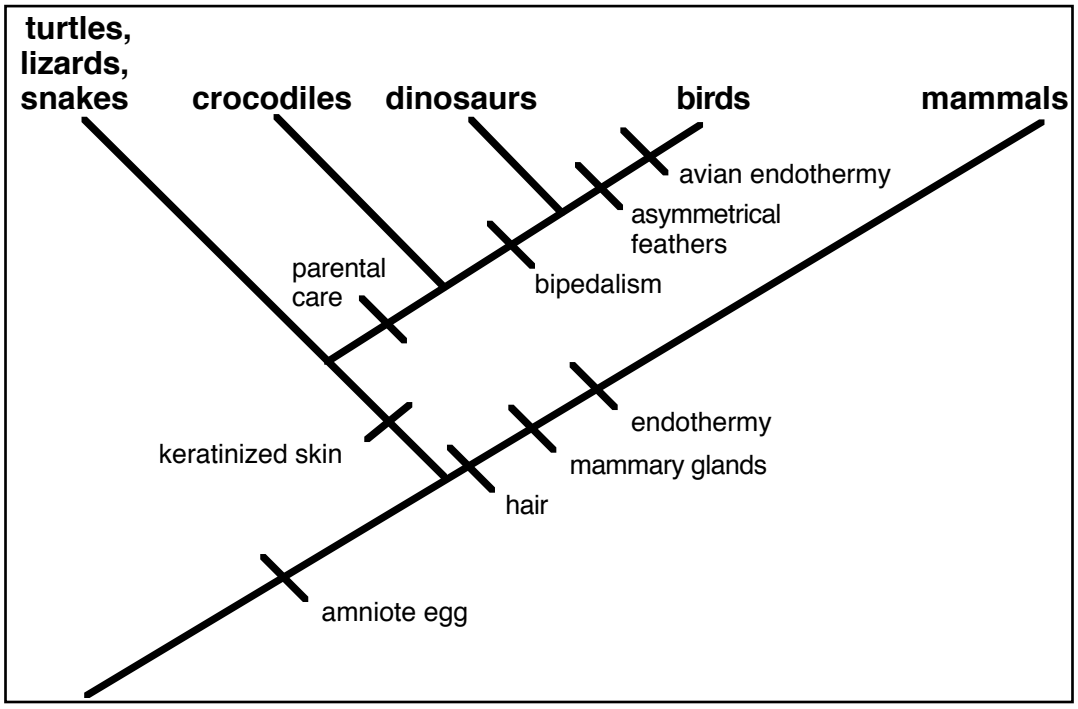
QUESTIONS AND PRACTICE PROBLEMS

Be prepared to answer the questions and solve the problems given below in front of the class during your laboratory period or discussion.

Questions about characters and cladograms

Use the cladogram shown in Figure P to answer questions 1-17.

Figure P. A cladogram of the amniotes with characters shown.



1. Name five characters possessed by birds. Which are apomorphies? Which are plesiomorphies?

2. Name two characters possessed by reptiles/birds (the group comprised of turtles, lizards, snakes + crocodiles + dinosaurs + birds; including their common ancestors). Which is an apomorphy? Which is a plesiomorphy?

3. Name four characters possessed by mammals. Which are apomorphies? Which one is a plesiomorphy?

4. Can a character be both an apomorphy and a plesiomorphy? Explain your answer.

5. Identify all of the synapomorphies shown in the cladogram.

6. What's the function of a synapomorphy in a cladistic analysis?

7. Identify all of the autapomorphies shown in the cladogram.

8. What's the function of an autapomorphy in a cladistic analysis?

9. According to the cladogram, which character evolved first: the amniote egg or hair?

10. According to the cladogram, which character evolved first: the amniote egg or keratinized skin?

11. According to the cladogram, which character evolved first: keratinized skin or hair?

12. How many cladogenic events are there?

13. The cladogram shows how many real ancestors?

14. Does the group comprised of dinosaurs and birds (including their common ancestors) constitute a monophyletic group? Why or why not?

15. Do the traditional reptiles (turtles, lizards, snakes + crocodiles + dinosaurs, including their common ancestors) constitute a monophyletic group? Why or why not? If not, how must the reptiles be redefined to create a monophyletic group? Why?

16. Does the group comprised of birds and mammals constitute a monophyletic group? Why or why not?

17. Endothermy in birds and endothermy in mammals really represent two different characters. They are what kinds of characters? How did they evolve?

Questions about groups of taxa

For each of the cladograms (1-8) shown in Figure Q, tell whether the shaded group is monophyletic, paraphyletic, or polyphyletic. Also, draw an arrow indicating the most recent common ancestor of the taxa composing the group.

1.

2.

3.

4.

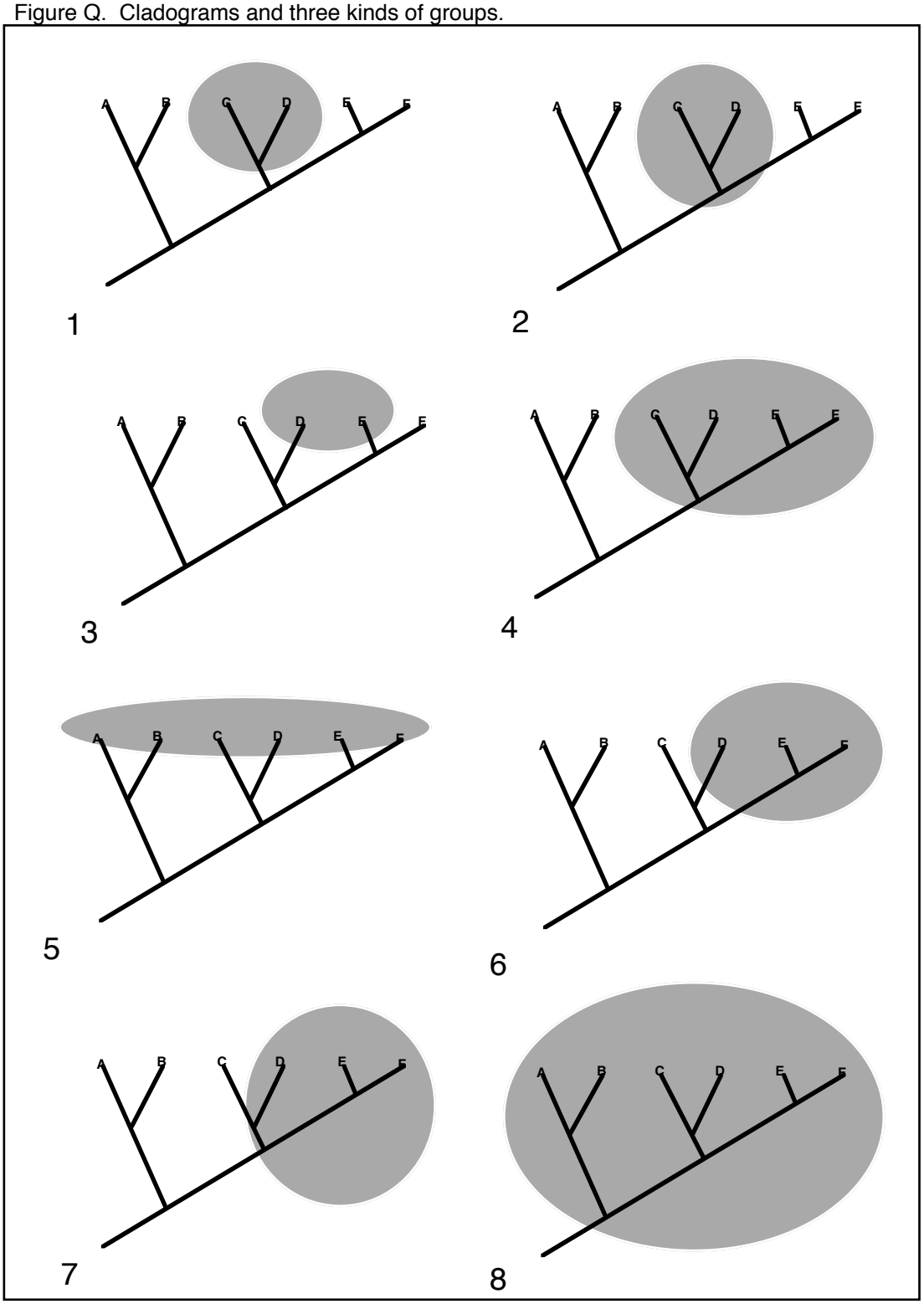
5.

6.

7.

8.

Figure Q. Cladograms and three kinds of groups.



Constructing a Cladogram, Practice Exercise, Part 1: Three Domains of Life

Using the Venn diagram method as outlined in the "Introduction to Cladistics" handout, construct a cladogram of the 3 domains of life (*this page*), and some groups of insects (*following page*). Remember to group taxa only according to their derived characteristics or synapomorphies (i.e., character state '1').

A) *CHARACTERS*

1. **Membrane-bound organelles** 0: absent; 1: present
2. **Peptidoglycan in cell wall** 0: present; 1: absent
3. **Protein synthesis initiator** 0: formyl-methionine; 1: methionine
4. **Introns** 0: absent; 1: present
5. **Histones with DNA** 0: absent; 1: present
6. **Circular chromosome** 0: yes; 1: no
7. **Grows in temperatures > 100° C** 0: no; 1: yes

B) *MATRIX*

	1	2	3	4	5	6	7
Bacteria	0	0	0	0	0	0	0
Archaea	0	1	1	1	0	0	1
Eukarya	1	1	1	1	1	1	0

C) *VENN DIAGRAM*

D) *CLADOGRAM*

Constructing a Cladogram, Practice Exercise, Part 2: Some Insects

A) *CHARACTERS*

1. **Wings** 0: absent; 1: present
2. **Three Body Regions** 0: absent; 1: present
3. **Social** 0: absent; 1: present
4. **Complete Metamorphosis** 0: absent; 1: present
5. **Head Mobile** 0: absent; 1: present
6. **Flattened Body** 0: absent; 1: present

B) *MATRIX*

	1	2	3	4	5	6
Millipede	0	0	0	0	0	0
Human body louse	0	1	0	0	0	1
Beetle	1	1	0	1	0	0
Assassin bug	1	1	0	0	0	0
Bee	1	1	1	1	1	0
Ant	1	1	1	1	1	0

C) *VENN DIAGRAM*

D) *CLADOGRAM*

Constructing a Cladogram, Practice Exercise, Part 3: Mollusks

As explained in the Introduction to Cladistics (p. 8-10), we can use the method of *Outgroup comparison* to determine character polarity, and hence the apomorphic versus plesiomorphic states of characters. The following example will give you practice doing this. The first step is to define the ingroup and outgroup – these are labeled for you below.

		Mantle Cavity	Beak-Like Jaw	Marine	Tortion
OUTGROUP	**Earthworm**	*Absent*	*Absent*	*Absent*	*Absent*
INGROUP	**Nudibranch**	Present	*Absent*	Present	Present
	Clam	Present	*Absent*	*Absent*	*Absent*
	Squid	Present	Present	Present	*Absent*
	Octopus	Present	Present	Present	*Absent*

Now, assuming the outgroup contains the plesiomorphic (i.e., ancestral) state of each character, fill in the matrix so that '0' represents the ancestral state, and '1' represents the derived state.

		Mantle Cavity	Beak-Like Jaw	Marine	Tortion
OUTGROUP	**Earthworm**				
INGROUP	**Nudibranch**				
	Clam				
	Squid				
	Octopus				

VENN DIAGRAM

CLADOGRAM

Constructing a Cladogram, Practice Exercise, Part 4: Green Plants

A matrix representing characteristics of green plants is shown below.

	Terrestrial	Sporophyte Dominant?	Branching Sporophyte	Cuticle	Vascular Tissue	Non-motile Sperm	Independent Gmpht.&Sphyt.	Pollen	Secondary Growth	Seeds	Flowers	Fruit
Green Algae	*Absent*	*Absent*	*Absent*	*Absent*	*Absent*	*Absent*	*Absent*	*Absent*	*Absent*	*Absent*	*Absent*	*Absent*
Bryophyte (moss, liverwort)	Present	*Absent*	*Absent*	Present	*Absent*	*Absent*	*Absent*	*Absent*	*Absent*	*Absent*	*Absent*	*Absent*
Pteridophyte (fern)	Present	Present	Present	Present	Present	*Absent*	Present	*Absent*	*Absent*	*Absent*	*Absent*	*Absent*
Gymnosperm (Pine)	Present	Present	Present	Present	Present	Present	*Absent*	Present	Present	Present	*Absent*	*Absent*
Angiosperm (flowering plants)	Present	Present	Present	Present	Present	Present	*Absent*	Present	Present	Present	Present	Present

Fill in the matrix so that '0' represents the ancestral state, and '1' represents the derived state.

		Terrestrial	Sporophyte Dominant?	Branching Sporophyte	Cuticle	Vascular Tissue	Non-motile Sperm	Independent Gmpht.&Sphyt.	Pollen	Secondary Growth	Seeds	Flowers	Fruit
OUTGROUP	**Green Algae**												
INGROUP	**Bryophyte (moss, liverwort)**												
	Pteridophyte (fern)												
	Gymnosperm (Pine)												
	Angiosperm (flowering plants)												

Now complete the Venn diagram and cladogram on the following page.

Green Plants, continued

VENN DIAGRAM

CLADOGRAM

Constructing a Cladogram, Practice Exercise, Part 5: Conifer Families

In the following example, the outgroup comparison has already been done for you. All you need to do is to construct the Venn diagram and the cladogram. Note that this matrix includes one character that is not a true reflection of evolutionary descent, and conflicts with the rest of your data (i.e., this character is an *analogy* or *homoplasy*).

A) *CHARACTERS*

1. **Cone size** 0: >4 cm long; 1: <4cm long
2. **Cones Egg-shaped** 0: no; 1: yes
3. **Number of Cone Scales** 0: <10; 1: >10
4. **Scales Opposite** 0: yes; 1: no
5. **Scale Tip Mushroom like** 0: yes; 1: no
6. **Teeth on Scale tip** 0: yes; 1: no
7. **Groove on Scale face** 0: no; 1: yes
8. **Scale Edge reflexed** 0: no; 1: yes

B) *MATRIX*

		1	2	3	4	5	6	7	8
OUTGROUP	Japanese Umbrella Pine	0	0	0	0	0	0	0	0
INGROUP	False Cypress	1	1	1	1	1	0	1	1
	Incense-Cedar	1	1	1	1	1	0	1	1
	Cypress	1	1	1	1	0	0	1	1
	Sugi	1	1	0	0	0	1	1	1
	Dawn Redwood	1	0	0	1	0	0	0	1
	Giant Sequoia	0	0	0	0	0	0	0	1

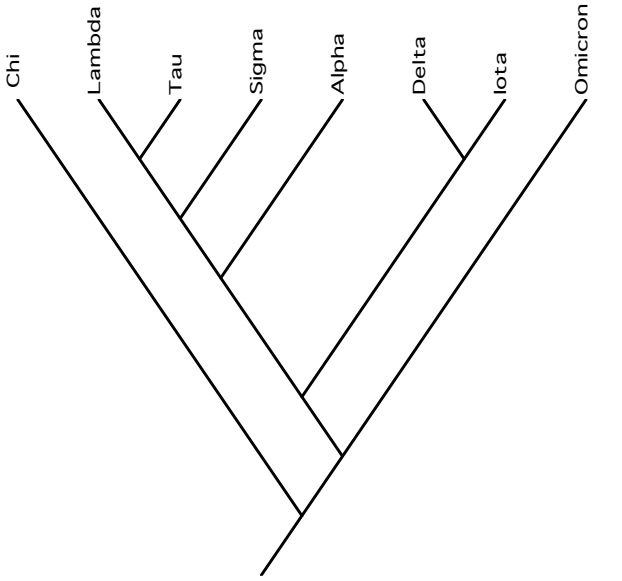
C) *VENN DIAGRAM*

D) *CLADOGRAM*

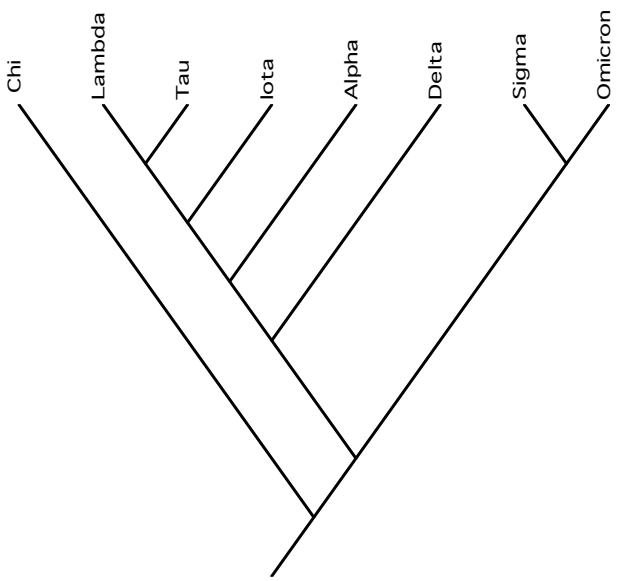
Determining the Most Parsimonious Cladogram, Practice Exercise 1

On this and the following page, use the method outlined in the "Introduction to Cladistics" handout (p.16-18) to determine the most parsimonious cladogram(s). Remember that you may need to consider 'evolutionary reversals' in determining the most parsimonious scenario (p.18).

Cladogram 1



Cladogram 2



The CHARACTER MATRIX

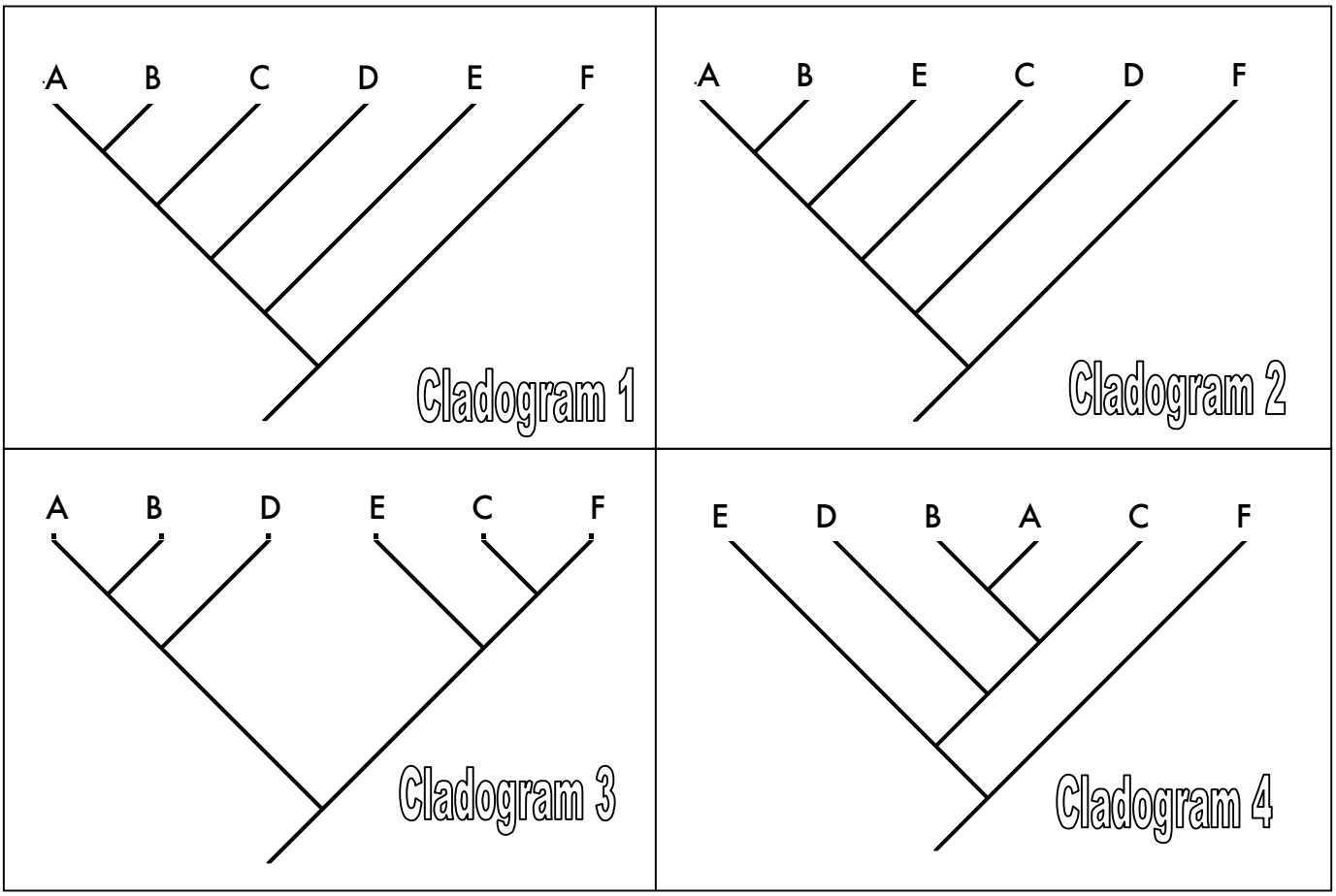
	Head/ Thorax	*3 toes*	*6 legs*	*Frown*	*Antennae*	*Horns*	*Grey Abdomen*	*Classes*
Chi	0	0	0	0	0	0	0	0
Lambda	1	1	1	1	1	0	0	1
Alpha	1	1	1	0	0	0	0	0
Delta	1	1	0	0	0	1	1	0
Iota	1	1	0	1	0	1	1	0
Sigma	1	1	1	0	1	0	0	0
Tau	1	1	1	1	1	0	1	1
Omicron	1	0	0	0	0	0	0	0

Based on the character matrix above, list the number of evolutionary changes on each cladogram:

CLADOGRAM 1 _____ CLADOGRAM 2 _____

Therefore, the MOST PARSIMONIOUS CLADOGRAM(s) is/are:

Determining the Most Parsimonious Cladogram, Practice Exercise 2



The CHARACTER MATRIX

	α	β	γ	δ	θ	σ	λ	π
A	0	1	1	1	0	1	1	1
B	0	1	1	1	0	1	1	1
C	0	1	0	1	0	1	1	0
D	0	0	0	1	1	1	0	0
E	1	0	0	1	0	0	0	1
F	0	0	0	0	0	0	0	0

Based on the character matrix above, list the number of evolutionary changes on each cladogram:

CLADOGRAM 1 _____ CLADOGRAM 2 _____

CLADOGRAM 3 _____ CLADOGRAM 4 _____

Therefore, the MOST PARSIMONIOUS CLADOGRAM(s) is/are: _____