7.012 Section Solutions

You are a microbial biologist and you isolate seven different strains (A - G) of chemosynthetic bacteria. To put the seven strains on a phylogenetic tree you perform two different experiments.

1st Experiment: you test whether different bacterial strains have similar metabolic processes or can carry out similar functions. The results lead you to group the seven strains as follows:

> group 1:   A, C, F
> group 2:   B, E
> group 3:   D, G

a) What are the limitations of using only functional or structural information in establishing evolutionary relationships?

Functional or structural comparisons can be uninformative.
**Functional or structural comparisons can be misleading. Examples: all that swims is not a fish, and bats and birds are quite unrelated even though they both have wings.**

2nd Experiment: You isolate DNA from each strain and sequence the 16S rRNA. A comparison of the DNA sequence is shown below. Matches (identity) to sequence A are indicated by –. (Assume that there is no back mutation.)

```
A :    ATGGCTCGTTTAGTCCGATCCCGATATTGCTAATCGCGGGCTCAT
B :    ------------C----------T----------T----------
C :    --------G---C--------------------------------
D :    ----------A-C----C-----T----------T-----A---A
E :    T-----A-----C----C-----T----------T-G---A---A
F :    --------G---C---------T--------------------C-
G :    -C--------A-C----C--G--T----------T--T--A---A
```

b) Beginning with A in the position shown, fill in the blanks with the appropriate strains.
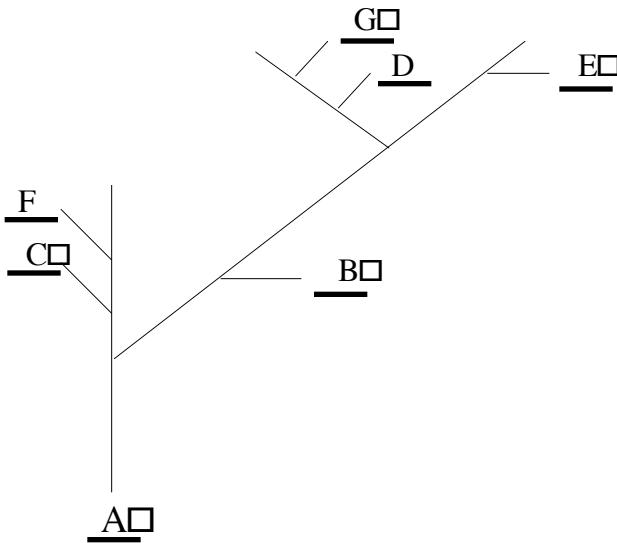
c) On this alignment (this is identical to the one above), circle a stretch of nucleotides that you predict may serve an important function in 16S rRNA? Explain your answer.

```
A : ATGGCTCGTTTAGTCCGATCCCGA TATTGCTAAT CGCGGGCTCAT
B : ------------C----------T----------T----------
C : --------G---C---------------------------------
D : ----------A-C----C-----T----------T-----A---A
E : T-----A-----C----C-----T----------T-G---A---A
F : --------G---C--------T----------------------C-
G : -C--------A-C----C--G--T----------T--T--A---A
```
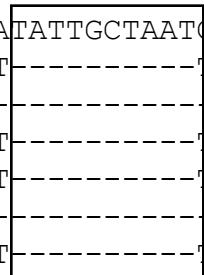
Conservation of DNA or protein sequence across evolutionary distance can indicate that the conserved region specifies an important functional domain.

d)   i) Experiment 1 (performed twice, each time beginning with the above population): chlorine is added to kill 99.99% of the bacteria, the chlorine is washed out and the remaining cells are supplied with fresh medium (no chlorine) and allowed to grow. You find the populations are now composed of the following percentages of bacterial cells:

trial 1		trial 2	
B:	5%	B:	40%
D:	35%	D:	3 %
E:	30%	E:	10%
G:	10%	G:	37%
C:	20%	C:	10%

What evolutionary mechanism (agent of change) is responsible for the observed changes in the bacterial population? Explain how this occurred.
Because each of the trials resulted in two different populations, the evolutionary mechanism is the Bottleneck Effect. Chlorine indiscriminately kills cells of all different bacterial strains. Although there was no selective advantage to any particular strain, it just so happened (chance events) that more of the particular strains survived than other strains. The two trials resulted in two different   populations.

ii) You perform a similar experiment but instead of adding chlorine to kill the bacterial cells you expose them to high doses of UV radiation. You find the populations are now composed of the following percentages of bacterial cells:

trial 1		trial 2	
B:	5%	B:	4.5%
D:	42.5%	D:	41%
E:	5%	E:	5%
G:	42.5%	G:	43%
C:	5%	C:	6.5%

What evolutionary mechanism (agent of change) is responsible for the observed changes in the bacterial population? Explain how this occurred.
Natural Selection. The bacterial strains D and G are resistant to UV radiation. More cells from the D and G strains survived and in both trials they are represented in greater numbers.