Study Guide
MICROBIAL DIVERSITY

NAME:

Readings for today: TOL Chapter 1, 2

Chapter 1 focuses on the ways in which phylogenetics – the study of the evolutionary relationships among living organisms – are important for society. Chapter 2 highlights the connections between the tree of life and human health, and the myriad interconnections that make human life possible on earth.

Chapter 1

1. When did *Hantavirus* first emerge in the Southwestern US?

    a. What was the mortality rate among people who acquired the disease?

    b. What was the (ironic) name of this new strain of *Hantavirus*?

    c. What organism is the reservoir for this virus?

        i. What is meant by a 'reservoir' for the virus?

    d. What led researchers to infer that the rodents and *Hantavirus* strains shared a long co-evolutionary history?

    e. Imagine that you are studying mice in the family Muridae, and you find a new species of *Calomys* (a genus of murid mice) in South America. You screen it for *Hantavirus*, and indeed, it is carrying a strain of the virus that has never been seen before. People at your study site have now been diagnosed with the disease caused by this virus. Now, imagine that a vaccine has been developed for all of the known varieties of *Hantavirus* except for the varieties carried by *Calomys*. Based on the information in Fig. 1.2, which vaccine would you choose to treat people in your study site (circle one):

        a. Vaccine from *Hantavirus* strain in *Rattus norvegicus*
        b. Vaccine from *Hantavirus* strain in *Akodon azarae*
        c. Vaccine from *Hantavirus* strain in *Oryzomys palustris*
        d. Vaccine from *Hantavirus* strain in *Oligoryzomys microtis*

    Why?

2. West Nile virus is one of the more newsworthy viruses of the last six or so years. Human deaths in the US led researchers to examine the RNA sequences of this virus. Use Fig. 1.4 to answer the following questions:

    a. What virus is most closely related to the New York 1999 strain?

    b. What is the phylogenetic term for this relationship? (We discussed this term in class on Jan. 19)?

c. True or false: Italy 1998 and Kenya 1998 are more closely related to each other than to New York 1999.

d. True or false: outbreaks in a given country often involve very different strains at different times.

e. Why do you think this makes sense (consider the reservoir/vector of the virus).

3. The lowland rainforests of the Amazon are world-famous for their tremendous biodiversity: insects, fungi, vertebrates, and plants are extremely diverse in this large river basin. A major (and unanswered) question in tropical biology is…why are there so many species of these organisms in the tropics? Interestingly, Amazonian forests have a dynamic history: they have expanded across the landscape -- and have shrunk into small geographic areas -- multiple times over evolutionary time as a result of trends in global warming and cooling: warmer temperatures led to geographic expansion of forest cover; cooler temperatures led to shrinking of forest cover.

   It has long been proposed that Amazonian forests are so diverse because they persisted in refugia (refuges) when the planet cooled. In other words: instead of dying out during the ice ages, many species in the Amazon persisted in many little pockets of forest across the continent (or refugia). These refugia were sheltered in a way that protected them from cooler conditions, and the forest persisted well there. Importantly, these little pockets were isolated from one another, so there was no (or little) gene flow between pockets. As a result, lineages of organisms in each pocket began to follow different evolutionary trajectories. When conditions warmed, the forest cover expanded – and there was a great diversity of species thanks to evolutionary divergence of organisms in refugia.

   One of the powerful aspects of phylogenetic biology is that we can use molecular divergence times (molecular clocks) to estimate the timing of evolutionary events. That is, we can estimate the number of changes that occur in a gene sequence over a given amount of time, and extrapolate to estimate dates of evolutionary events. By doing so, researchers such as Glor, Moritz, and Richardson have shown that most species did not diversify during the highly dynamic climate events of the Pleistocene, but instead underwent speciation much later. Thus, phylogenetics helped resolve a long-standing controversy in tropical biology and helped us understand that the tremendous diversity of the Amazon is dynamic and new – and still diversifying, even though our planet is warm.

   You won't be tested on this, but I thought it was an interesting example of the use of phylogenetic biology. Tuck it away in your memory bank.

4. Name one reason for which work on desiccation tolerance in ancient liverworts (a lineage of non-vascular plants) is important in the context of global change.

5. Give one example of a way in which phylogenetic inference has the potential to help improve one of the world's most important food crops: corn. (Give the name of the wild relative of corn, and be sure to differentiate between the two types of genes discussed.)

6. Name one invasive species, and describe briefly how phylogenetic biology might be involved in helping to eradicate it.

7. Name a bacterium that has revolutionized the field of molecular biology.

    a. What product of this organism is used in molecular biology?

    b. What is that product used for in molecular biology?

    c. This bacterium is a member of the Deinococcus lineage. Revisit BROCK ch. 2 . What other bacterium in this lineage is of note, and why?

        i. Look in BROCK CH. 2 and name a physical characteristic of *Deinococcus* that may help it cope with extreme conditions.

NOTE that the wording in this ToL chapter is a little confusing at this point (page 14, upper left). The bacterium addressed in question 7 is indeed a bacterium, not an archaean. We'll explain more about this in class.

Chapter 2

1. Who coined the term 'the Tree of Life'?

    a. What did he mean by this term?

    b. When was this term first used?

    c. Describe two or three other things that were going on in microbiology at about the same time? (see class notes re. golden ages)

2. What is meant by the term 'biocomplexity'?

3. Describe the work by Hedges, published in 2002. Draw a phylogenetic tree with three species (human, fly, worm) showing the relationship proposed by Hedges.

4. What is special about the gene that causes tomatoes to plump up?

5. What was the first free-living, self-replicating organism to have its full genome sequenced?
    a. What domain of life does this belong to?
    b. When was this genome sequencing completed?

6. How many cells of bacteria might one find in a milliliter of seawater?
    a. And about how many individual viruses?

7. Which domain of life is most common among human pathogens?
    a. What other groups of microorganisms also include species that infect and sicken humans?

8. What organism causes cholera in humans?
    a. What domain of life does this belong to?
    b. Describe the relationship between cholera outbreaks and El Niño climatic events. Be sure to explain the non-human host of this pathogen.
    c. Who pioneered this work?
    d. Can the pathogen be eradicated?
    e. How might global warming lead to ‘emerging’ diseases?

9. What organism described in this chapter is an endosymbiont of aphids?
    a. What domain of life does it belong to?
    b. How old is this endosymbiosis?

c. What did Moran and Ochman find when they compared the genome of this organism with the genome of *E. coli?*

\

d. The phenomenon they found is not unique to endosymbionts; it also occurs in….?

e. How can the study of this endosymbiont inform our understanding of human health?

10. Rhodopsin is a photopigment (light-absorbing pigment) that contains opsin (a protein) and retinal (the light-absorbing molecule, which is a derivative of vitamin A). When activated by light, retinal provides energy to some microorganisms, and helps them locate light (**phototropism**). We thought that rhodopsin was present only in one lineage of archaea (the unfortunately named halobacteria, which are actually archaea).

    a. However, Beja, DeLong, and others showed that _____ containing a molecule similar to rhodopsin are widespread in Earth's oceans.

    b. Different bacteria, which inhabit different areas of the ocean characterized by different wavelengths of light, have slightly different versions of the molecule that are

    _____.

    c. These bacteria are highly abundant. Their high abundance, coupled with their phototrophy, may point to a significant and previously unexplored

    _____.

11. What is NEON?

12. What is the most extensive ecosystem on our planet?

    a. What is a potential cost of exploring hydrothermal vents in this area?

    b. What is a potential benefit of exploring those hydrothermal vents?

Disclaimer: this handout is a guide, not a practice test! You will be asked to synthesize this sort of information on the exams. I am certain that you will do well if you can answer these questions thoroughly and carefully, AND if you give similar attention to the lecture notes.