

**THE UNIVERSITY OF NORTH CAROLINA
AT
CHAPEL HILL**

Biology 422

Syllabus

Fall, 2009

Dr. Matthyse

**Summary Syllabus
Biology 422
Microbiology
Fall, 2009**

Lecture: Mon., Wed., and Fri. 10 a.m., Room 128, Wilson Hall

Text: Madigan et al, Biology of Microorganisms, 12th edition

Date	Lecture #	Topic	Text Chapter
Aug. 26	1	Introduction	1, 2
Aug. 28	2	Chemistry and Cell structure	3, 4
Aug. 31	3	The cell surface (motility and fimbriae) and spores	4
Sept. 2	4	The cell surface (motility and fimbriae) and spores	4
Sept. 4*	5*	Metabolism	5
Sept. 7		Labor Day	
Sept. 9	6	Bacterial growth	6
Sept. 11*	7*	Gene structure	7
Sept. 14	8	Regulation of gene expression	8 & 9
Sept. 16	9	Regulation of gene expression	8 & 9
Sept. 18*	10*	Bacterial viruses	10
Sept. 21	11	Bacterial viruses	10 & 19
Sept. 23	12	Animal viruses	10 & 19
Sept. 25*	13*	Animal viruses	10 & 19
Sept. 28	14	Plant viruses	19
Sept. 30		HOURLY EXAM I	Lectures 1-13
Oct. 2	15	Microbial genetics	11
Oct. 5	16	Microbial genetics	11
Oct. 7	17	Genetic engineering	12, 13, & 26
Oct. 9*	18*	Genetic engineering	12, 13, & 26
Oct. 12	19	University Day	-
Oct. 14	20	Host parasite interactions	28
Oct. 16*	21*	Human bacterial pathogen interactions	28
Oct. 19	22	Epidemiology	33
Oct. 21*	23*	The Immune System	29-31
Oct. 23	24	Fall break	
Oct. 26	25	The immune system	29-31
Oct. 28		HOURLY EXAM II	Lectures 1-23
Oct. 30	26	Bacterial and viral interactions with plants	
Nov. 2	27	Major Microbial diseases	34-37
Nov. 4	28	Major Microbial diseases	34-37
Nov. 6*	29*	Major Microbial diseases	34-37
Nov. 9	30	Emerging infectious diseases-guest lecture - Dr. Gilligan	
Nov. 11	31	Metabolic diversity	20, 21
Nov. 13*	32*	Metabolic diversity	20, 21
Nov. 16	33	Metabolic diversity	20, 21
Nov. 18		HOURLY EXAM III	lectures 1-32
Nov. 20	34	Microbial ecology	22-24
Nov. 23	35	Microbial ecology	22-24
Nov. 25-29		Thanksgiving	
Nov. 30	36	Biotransformation of pollutants-guest lecture - Dr. Pfaender	

Dec.	2	37	Microbial evolution	14
Dec.	4*	38*	Microbial evolution and Archaeobacteria	17
Dec.	7	39	Archaeobacteria	17
Dec.	9	40	Conclusion and Summary	
Dec.	16	8 AM	FINAL EXAMINATION	lectures 1-40

*There is a discussion session on this day.

No cell phones or texting devices are to be used in the class room at **any** time: before, during, or after class. Please go to the hall before turning on these devices.

The course will be graded as follows:

The two highest hour exams will count 25% each; the final will count 30%; and the discussion problems 20%. So that you can get used to the type of exams without penalty, you may drop the lowest of your three hour exam grades (if you miss an hour exam due to illness you may drop that exam or you may take an oral make-up exam). If you miss an exam for some reason other than illness (e.g. medical school interview) your absence must be documented and approved in advance. No student may take more than one make-up examination.

Because of their nature, it is not possible to arrange make-ups for discussion problems. However, students who will miss a discussion session (due to medical school interviews or other causes) may write out their answer to the question in complete form with references and give it to another member of their group or to Dr. Matthyse to be read aloud to the group. This will constitute their participation in the discussion and they will receive credit for that discussion (No credit will be given for answers which are not available at the time of the group discussion since you have not then contributed to your group's efforts). No credit will be given for students who come to discussion unprepared (as judged by an adequate written answer sheet available for inspection at the time of the discussion). The lowest 2 discussion group grades will be dropped (if you miss a discussion or come unprepared you may drop that discussion).

Please note that taking a makeup final exam requires permission from the dean's office and that makeup exams for the final will be given at some time during the spring semester. No one may take the final exam early.

Office Hours:

Dr. Matthyse

Coker Hall 103

Wilson 138

Wed. lab

Wilson 138

Tues. lab

Mon. 11-12, 2-3

Syllabus for Biology 422
Microbiology
Fall, 2009
Objectives for Lectures

Lecture 1 - Introduction - Chapters 1 & 2

You should be able to:

1. define the terms prokaryote and eukaryote
2. describe what is needed for a microorganism to grow
3. give examples of how growth requirements and abilities determine where a microorganism grows in nature
4. describe sterile technique and its importance
5. predict where a microorganism would grow if you know its growth requirements

Lecture 2 - Chemistry - Chapter 3

You should be able to:

1. define carbohydrate, fatty acid, nucleotide and amino acid.
2. define polysaccharide, lipid, nucleic acid, and protein.
3. describe how the compounds in #1 are linked to form the large molecules listed in #2.
4. explain the role in the life of the cell of each of these molecules.
5. predict the effects of mutations in the ability to make each of these molecules.

Lectures 2, 3 & 4 - Cell Structure - Chapter 4

You should be able to:

1. describe the structure and function of the bacterial plasma membrane.
2. describe the structure of the cell wall in gram-positive, and gram-negative bacteria.
3. describe the structure of the outer membrane in gram-negative bacteria.
4. describe the structure and function of bacterial flagellae.
5. describe the structure and function of a bacterial spore.
6. explain how you could determine if a bacterium was motile and was chemotactic to a certain substance.
7. describe bacterial spore formation and germination
8. compare the cell structure of a prokaryote and a eukaryote. Indicate places where these differences could be used to selectively inhibit the growth of one or the other.

Lecture 5- Metabolism - Chapter 5

You should be able to:

1. explain how redox reactions generate energy.
2. describe how bacteria obtain energy from fermentation
3. describe how bacteria obtain energy from aerobic respiration and electron transport.
4. describe how enzyme activity can be regulated.
5. describe how to grow bacteria in the laboratory.
6. predict whether mutations in regulatory activity could be obtained and, if so, describe how to obtain them.

Lecture 6 - Bacterial Growth and Its Control - Chapter 6

You should be able to:

1. use mathematics to describe the growth of a bacterial culture.
2. describe the effects of the environment on bacterial growth (temperature, pH, water, oxygen).
3. describe ways in which bacteria can be killed or removed from materials and evaluate their suitability for use under various conditions.

Lecture 7- Gene Structure and Function - Chapter 7

You should be able to:

1. describe DNA structure and how it can be analyzed.
2. describe how DNA is replicated.
3. describe the action and functions of enzymes that interact with DNA. Predict the effects of mutations in the genes for these enzymes.
4. describe the process of RNA synthesis.
5. describe the process of protein synthesis.
6. draw the structure of a typical bacterial gene and operon.

Lectures 8 & 9 - Regulation of gene expression - Chapters 8 & 9

You should be able to:

1. describe how gene expression is regulated including repressors, activators, catabolite repression, attenuation.
2. predict the effects of mutations in repressors, activators, attenuators.
3. describe how bacteria sense their environment.
4. describe two component systems.
5. describe the mechanisms and genes involved in chemotaxis.
6. predict the effects of mutations in various genes involved in sensing and responding to the environment.

Lectures 10 & 11- Bacterial Viruses - Chapters 10 & 19

You should be able to:

1. define a virus
2. describe different types of viruses
3. explain how to count virus particles
4. describe and explain the steps in viral growth
5. work problems in viral genetics
6. describe lytic and lysogenic viral growth. Predict the effects of mutations in the genes which regulate lytic and lysogenic growth.

Lectures 12 & 13 - Animal Viruses - Chapters 10 & 19

You should be able to:

1. describe different types of animal viruses and the diseases they cause.
2. compare animal and bacterial viruses.
3. describe some of the molecular mechanisms of animal virus infection and replication.

HOURLY EXAM I Lectures 1-13

The material to be covered on the hour exam includes the assigned reading, the material covered in lecture, the lecture objectives, and the discussion problems. You should be sure that you can meet all the lecture objectives and work the discussion problems before the exam. (Note that this course covers only viruses and bacteria; you are not responsible for text material on eukaryotic microbes).

Lecture 14 - Plant Viruses - Chapter 19

You should be able to:

1. describe different types of plant viruses and diseases they cause.
2. compare animal, plant, and bacterial viruses.
3. describe the molecular mechanisms of plant virus infection and replication.

Lectures 15, 16 & 17 - Microbial Genetics - Chapter 11

You should be able to:

1. explain how mutations arise.
2. work problems in bacterial genetics involving transformation, transduction, and conjugation.
3. describe different kinds of plasmids.
4. describe transposons.
5. explain how transposon mutagenesis works, and design a protocol to clone a gene or obtain a particular mutant using transposons.

Lectures 18 & 19- Genetic engineering - Chapters 12, 13, & 20

You should be able to:

1. describe plasmid- and phage-based cloning vectors and their use.
2. design a protocol for cloning a particular gene.
3. design a gene and vector which will give expression of the gene in *E. coli*.

Lecture 20 - Host Parasite Interactions - Chapter 28

You should be able to:

1. describe what a bacterium may obtain from an interaction with a macro-organism.
2. describe what a macro-organism may obtain which is beneficial from a bacterium.
3. describe the normal human flora.
4. describe the entry of a potential pathogen into a human or plant host.
5. state Koch's postulates and tell how you would use them to determine if a particular organism caused a particular disease.
6. predict what treatments might reduce or increase the ability of a potential pathogen to cause disease.

Lecture 21- Human-Bacterial Pathogen Interactions - Chapter 28

You should be able to:

1. define exotoxin and endotoxin. Define enterotoxin.
2. describe the effects of various bacterial toxins.
3. define virulence and attenuation.
4. describe the interactions of bacteria with phagocytic cells.
5. describe the process of inflammation.
6. describe the uses of antibiotics and the problems with antibiotic use.
7. predict the effects of bacterial mutations altering virulence functions.

8. predict the effects of alterations in, or lack of, host defense mechanisms.
9. identify major virulence factors for different bacterial pathogens.
10. design protocols to obtain mutants in these factors.

Lecture 22 - Epidemiology - Chapter 33

You should be able to:

1. describe how diseases are transmitted and how they persist and predict conditions that will favor or inhibit disease
2. describe public health measures to control the spread of various types of disease
3. design programs that limit the spread of, or eradicate, particular diseases in defined areas

Lectures 23 & 25 - The Immune System - Chapter 29-31

You should be able to:

1. define antigen and antibody
2. define B cells and T cells
3. explain how immunization works
4. design an immunization procedure for a disease
5. distinguish between innate and acquired immunity

HOURLY EXAM II Lectures 1-23

Once again, study the assigned reading, your lecture notes, the lecture objectives, and the discussion problems.

Lecture 25- Bacterial and viral interactions with plants

You should be able to:

1. describe how plant diseases are transmitted and how they persist
2. identify the major virulence factors for bacterial and viral diseases
3. predict the effects of bacterial and viral mutations altering virulence functions
4. suggest possibilities for the genetic engineering of plants for disease resistance
5. compare and contrast infections of plants with infections of animals

Lectures 26-30-Major Microbial Diseases-Chapters 34-37

You should be able to describe the epidemiology and general pathogenesis of:

1. Bacterial diseases transmitted via respiratory route
2. Viral diseases transmitted via respiratory route
3. Sexually transmitted bacterial diseases
4. Sexually transmitted viral diseases
5. Insect transmitted diseases
6. Food transmitted diseases
7. Waterborne diseases
8. Describe the molecular mechanisms underlying the pathogenesis of examples of each type of disease
9. Predict under what conditions each of these diseases will spread

Lecture 26 -Emerging infectious diseases

You should

1. be able to explain how and why new diseases emerge
2. give examples of emerging infectious diseases
3. be able to explain how microbiologists attempt to identify, track, and contain a new disease

Lectures 31, 32, & 33 - Metabolic Diversity - Chapter 20 & 21

You should be able to:

1. describe bacterial photosynthesis and to compare aerobic and anaerobic photosynthesis.
2. describe various other energy sources and how they are used by organisms such as sulfur bacteria, iron oxidizing bacteria, and ammonia and nitrite oxidizing bacteria
3. describe how bacteria take up and reduce nitrogen, sulfur, and carbon
4. describe various fermentations
5. design tests to determine whether bacteria can use particular energy sources

HOUR EXAM III

Once again, study the assigned reading, your lecture notes, the lecture objectives, and the discussion problems. Lectures 1-32.

Lectures 34 & 35- Microbial Ecology - Chapters 22-24

You should be able to describe:

1. how to isolate bacteria from nature
2. how to measure microbial activity in nature
3. various environments in which bacteria live
4. global biogeochemical cycles including the carbon cycle, the nitrogen cycle, the sulfur cycle, and the iron cycle and the role of bacteria in each
5. complex ecosystems such as the rumen
6. ecological interactions of bacteria with toxic compounds such as mercury

You should be able to predict:

7. the importance of microbial ecology in medicine
8. the effects of altering bacterial populations on biogeochemical cycles and on ecosystems
9. the effects of toxic compounds and alterations in the environment on bacteria

Lecture 36 - Biotransformations of Pollutants

You should be able to:

1. define mineralization and describe the likely products of mineralization of pollutants under aerobic and anaerobic conditions.
2. define cometabolism and describe its importance in biodegradation.
3. describe the differences between degradation under aerobic and anaerobic conditions.
4. evaluate possible fates of pollutants in the environment and the factors which may favor different outcomes.

Lecture 37- Microbial Evolution - Chapter 14

You should be able to:

1. describe the geological conditions under which life probably originated
2. describe the major groups of prokaryotes and their probable relationships to each other

3. describe the probable evolutionary relationships between prokaryotes and eukaryotic cells including nuclei, mitochondria and chloroplasts
4. predict in what types of rocks you would expect to find fossil bacteria of various types
5. design experiments to test various theories of bacterial evolution
6. design experiments to test for the presence of life in unusual environments such as on Mars.

Lectures 38 & 39 - Microbial evolution and Archaeobacteria – Chapter 17

You should be able to:

1. describe some of the extreme environments in which Archaeobacteria live and their adaptations to these environments
2. describe the peculiar structure of Archaeobacterial membranes and cell walls
3. describe the physiology of halophilic, methanogenic, and thermophilic Archaeobacteria

Lecture 40- Conclusion and summary

- Dec. 16- 8 AM FINAL EXAMINATION

The final exam will be comprehensive. The questions will cover material from all lectures 1-38. About 15% of the material will be from topics covered after the third hour exam since this material has not been tested on previously. The remainder of the material will be from the entire course. The exam format will be similar to the hour exams. You should study for it in the same manner as for the hour exams.

Biology 422
Fall, 2008
Discussion Groups

Discussion groups and discussion group problems will be an important part of this course.

Reasons for discussion groups. Science is currently a cooperative activity. Most scientists now work in groups. Medicine is also often practiced in groups, both in and out of hospital settings. Group discussions tend to aid the development of critical thinking and to foster the ability to design experiments and protocols. (Group discussions are not very useful for memory work; however, since this is an advanced course, memory work should not be the major aspect of your learning of this subject). Group discussions also provide an opportunity for you to hear new and diverse points of view.

Assignment to groups. You will be assigned to a discussion group of about 8 people. The members of each group will be chosen to represent a variety of scientific backgrounds and experience. At least one member of each group will be taking the laboratory (Biol 108L). Please remember that those students who have the least background have an important contribution to make. Because of their lack of previous background they tend to have fewer preconceptions and to ask fundamental, insightful, and interesting questions.

Procedure for group discussions.

1. Read the questions. Using the text and library materials as references work out and write out in legible form the answers as best you can **before** class. These answers will be checked during each discussion section. You will **not** receive credit unless you have a paper indicating that you have worked on the answer in advance.
2. In class, discuss the answers with your group and arrive at better answers by using everyone's thoughts and knowledge.
3. Record the group answers. This responsibility should be passed around so that everyone does this at least once and, if possible, twice. The recorded answers for each discussion should be handed in (printed) by the beginning of the next class to Dr. Matthyse. Label the answers with the group number, scribe's name, and date.
4. In case of difficulties, Dr. Matthyse, and the teaching assistants will be available to act as consultants.
5. Minority reports are possible, but should be rare. Hand them in with the group report.

Grading - Discussion group work will be graded on the basis of the group reports and the individual pre-discussion worksheets. Reports and worksheets will be graded for clarity and scientific correctness of the answers. Please note that most of the questions will have many possible correct answers. There will be bonus points for imaginative or creative answers. These bonus point answers may be entered separately from a more standard answer on the group report. No points will be deducted for incorrect attempts at bonus point creative answers. Pay careful attention to correct citing of sources and the use of quotation marks for copied material (e.g. material from the web which should be cited and placed in quotation marks). Failure to cite or use quotation marks constitutes plagiarism.

Guideline for Participation in Group Activity

Purposeful learning primarily is a task-oriented process. The obvious reason for pursuing it in a group format is to bring to bear a far greater variety of cognitive resources and affective supports for pursuits of the task than would be available for any one of the group members acting independently. Research indicates that small-group discussion is more effective than virtually any other educational technique for the acquisition of problem-solving skills and for fostering critical thinking.

In an effective group, the processes of discussion involve cooperation and sharing of ideas, thereby improving individual judgment. In effect, the pooling of ideas in the group allows individual members to correct deficiencies in evidence and reasoning better than they could on their own.

However, the advantages of small-group work can only be realized if certain conditions are met. First and foremost, effective discussion presuppose **adequate preparation**. The individual must share an equal part of the group burden to ensure distribution of the work and to benefit the most from the exercises.

Second, group members must decide to give the process a good-faith effort and avoid playing destructive roles. If you believe that group discussion is an unconscionable waste of your time, then it will become one. Keeping an open mind, cooperation with the group, and trying to make the technique work will return many benefits.

Third, small-group techniques necessitate developing skills in communication. Not only is clarity of expression important, but the art of listening--actually hearing what the other person is saying--must be practiced. Here are some helpful guidelines to assist you in this task.

1. Challenge opinions you do not agree with by offering your opinion and then supporting it with evidence from the course material. Specificity is important.
2. Be willing to change your mind when someone shows an error in your opinion or use of the facts.
3. Ask for clarification of any point or term you do not understand. Clarification is vital to your own learning and lack of it can cripple the group's effectiveness as well.
4. **Stick to the subject.** Do not introduce matters that have no connection to the problem being discussed. Staying on task is extremely important, for time is a precious resource.
5. **Listen carefully.** Preoccupation with your ideas is to be avoided; you should be able to give a summary of what others are saying.
6. If someone else makes more or less the same point you wish to make, **don't repeat it.**
7. **Don't continue to talk after you have made your point.**
8. Finally, remember that it is your responsibility to contribute to the solution of the task at hand. Non-participation will detract from your own learning and will seriously hamper the effectiveness of the group as a whole.

Discussion Questions
Fall, 2009

Each report should contain the group number, the scribe's name, the date and time the first draft was sent out, and a list of those who responded to the draft(s). **First drafts must be sent out by Sat. night.**

Sept. 4 - Discussion #1

You are a research doctor treating a patients with pneumonia caused by *Streptococcus pneumoniae* and *Klebsiella pneumoniae*. You know that prokaryotes and eukaryotes differ in their cell structure. How could you use these differences to kill the bacteria but not the patient? What inhibitors are used currently which actually act at the sites you proposed? In view of the increasing resistance of bacteria to currently used antibiotics can you suggest any possible new targets for new antibiotics?

Sept. 11- Discussion #2

Because of your expertise in Microbiology you are hired as a consultant to the Ranger Uranium Mine, the northern Territory, Australia. They wish to use bacteria to clean up and profitably extract uranium from the low grade ore left after they have processed the high grade ore. Could bacteria do this? Would it be easier to find bacteria which would reduce or oxidize the mineral? How fast would you expect these bacteria to grow? (Hint - look at Chapters 13 and 14 for help).

Sept. 18 - Discussion #3

You notice that the bacterium *Serratia marcesans* is white when grown at 37° and pink when grown at 25°. Propose 2 models for how this might work - one using a repressor and the other using an activator. A mutant *S. marcesans* was isolated which was pink at both 37° and 25°. Which of your models does the existence of this mutant tend to favor? Why? (Note: Colorless colonies of bacteria appear white due to reflected light. No white pigment is made). (It is unnecessary and probably unhelpful to look up the pathway for pigment synthesis in *S. marcesans*).

Sept. 25 - Discussion #4

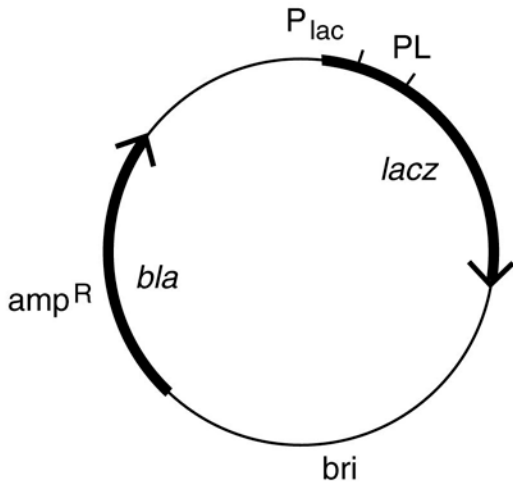
Suppose that you are working as a researcher for a drug company. The company asks you to inform them about possible sites (enzymes or processes) which could be inhibited to provide chemotherapy for virus diseases (naturally without harming the patient). They are particularly interested in possible new targets for chemotherapy for influenza viruses and for herpes viruses. Prepare a table of possible targets both currently used and new for each virus and the rationale for considering that site to be a target and whether your proposed therapy would harm the patient. Remember that your company is interested in chemotherapy not immunotherapy.

Oct. 9- Discussion #5

An outbreak of food poisoning has recently occurred in fast food restaurants. It was found to be caused by a newly identified strain of *E. coli*. This strain of *E. coli* was also found to cause food poisoning (diarrhea and severe dehydration) in mice. Design a protocol using transposon mutagenesis to attempt to identify the major genes responsible for pathogenesis of this organism. (Do not assume that these are the same pathogenesis genes found in other strains of *E. coli*).

Oct. 16- Discussion #6

Part 1. You wish to make a lot of diphtheria toxin to use to make toxoid for immunization against diphtheria. The toxin is a protein coded for by a single gene. Antibodies to diphtheria toxin are available commercially. Assume that the gene has not been cloned and that neither its base sequence nor the amino acid sequence of the protein is known. You have available *C. diphtheriae* DNA, restriction enzymes, ligases, etc., all necessary bacterial growth media and antibiotics, competent *E. coli* cells, and the expression vector shown below:



P_{lac} = lac operon promoter
lacz = β -galactosidase gene

PL = polylinker, 300 bp piece of DNA containing unique sites for *EcoRI*, *SacI*, *SmaI*, *SalI*, and *HindIII*. The polylinker adds some amino acids to the early part of the β -galactosidase protein but has no stop codons and does not cause a frame shift.

Using these materials devise a protocol for cloning the diphtheria toxin gene into *E. coli* and obtaining toxin from *E. coli*. Note: it is unnecessary to look up the sequence for the toxin gene.

Part 2. Your diphtheria toxin clone is successful. A local outbreak of a new type of pneumonia has occurred caused by the recently described bacterium *Pneumophillia carolinsus*. Various clinical observations suggest that this bacterium may make a toxin related to that of *C. diphtheriae* although antibodies to the two toxins don't cross react. How could you use your cloned toxin gene to find the putative toxin gene in *P. carolinsus*?

Oct. 21- Discussion #7

You have joined the Peace Corps and been sent to an isolated village in a tropical region. The village lacks all modern public health measures. What bacterial and viral diseases do you expect to encounter there? What measures could you suggest to reduce the incidence of these diseases in the village? (Remember you have very little money. You also should be realistic about changing human behavior patterns).

Nov. 6 - Discussion #8

The world health organization was able to eradicate the disease smallpox. What are the characteristics of this disease which allowed its successful eradication? What other diseases potentially could be eradicated? List the factors which make this possible for each of these diseases (be realistic in terms of human behavior). Note that you are asked about complete eradication and not simply reducing the incidence of the disease.

Nov. 13 - Discussion #9

Many seed companies dust legume seeds with the appropriate rhizobia before the seeds are sold so that the farmer need not apply N-containing fertilizer. You have been hired as a microbiologist with a good knowledge of genetic engineering by a company producing corn seed (note that corn is NOT a legume, but instead a monocot). They wish you to design a **bacterium** which they can apply to corn to provide fixed N to the plant. What are the major issues to be addressed in the design of such a bacterium? What properties must it possess? Describe the bacterium that you propose to create for this purpose. Remember you can use natural field isolates as well as laboratory strains. (You do not need to give details of cloning, just state which genes are to be moved into what organism and how you will test the resulting organism to be sure it is what you intended to make).

Dec. 4 - Discussion #10

As a result of the findings of previous Mars landers NASA decides to send another landing vehicle to Mars. The vehicle will be equipped to examine the question of whether there is life on Mars. Since microbial life seems the only possibility they ask you as a microbiologist interested in evolution to propose tests for life on Mars. They tell you not to worry about the mechanics of the test as they have access to good engineers, etc. What kinds of tests do you propose? Specifically what would these tests attempt to find or measure? You should design two types of tests: one assuming that life on Mars has some distant similarity to life on earth and the other assuming that life on Mars is completely different from life on earth.