1. (8 points) The following is a list of mutational changes. For each of the specific mutations indicate which type of mutation best describes the change. Sometimes, more than one term could be used to describe each of the following statement (such as transition, transversion, translocation, insertion, deletion etc.).

   (1) An A-T base pair in the wild type gene is changed to a G-C pair.

   (2) An A-T base pair is changed to a T-A pair.

   (3) The sequence of AAGCTTATCG is changed to AAGCTATCG.

   (4) The sequence AAGCTTATCG is changed to AAGCTTTATCG.

   (5) The sequence AACGTTATCG is changed to AATGTTATCG.

   (6) The sequence AACGTCACACACACATCG is changed to AACGTCACATCG.

   (7) The gene map in a given chromosome arm is changed from bog-rad-fox1-fox2-try-duf to bog-rad-fox2-fox1-try-duf.

   (8) The gene map in a chromosome is changed from bog-rad-fox1-fox2-try-duf to bog-rad-fox1-met1-qui-txu-sqm.

2. (10 points) Design a mutagenesis screen to isolate mutations involved in the biosynthesis of cytocine in yeast? Note: such a mutant is expected to be lethal.
3. (20 points) Explain the difference between following terms:
   (1) auxotroph and prototroph

   (2) complete medium and minimal medium

   (3) mutagenesis screen and mutagenesis selection

   (4) haploinsufficient and dominant-negative mutations

   (5) Retrotransposons and transposons
4. (8 points) Wild type mouse with normal pigmentation is grey in color. The following mutations (m1, m2, m3, and m4) affecting pigment synthesis in mouse are identified. They all appear to affect the activity of the same gene. Given the following genotype as well as corresponding phenotype, could you describe the type of mutations using following terms: recessive, dominant, dominant-negative, hypomorphic, hypermorphic, and neomorphic.

(1) m1/+ grey mouse  
m1/m1 albino mouse
(2) m2/+ albino mouse  
m2/m2 albino
(3) m3/+ Black (darker than normal)  
m3/m3 Black
(4) m4/+ Redish brown (unusual color)  
m4/m4 Redish brown

5. (10 points) You have isolated five recessive maize mutants (d1-d5) which are defective in pigment biosynthesis. While wild type kernels are Red (R) in color; these d1-d5 mutant kernels are Yellow (Y) in color. To test if any of these mutations are allelic to each other, you did pairwise crosses among all five mutations and observed F1 phenotypes which are summarized in the table below. How many genes are represented by these five mutations? How are these five mutations grouped into different genes?

<table>
<thead>
<tr>
<th></th>
<th>d1</th>
<th>d2</th>
<th>d3</th>
<th>d4</th>
<th>d5</th>
</tr>
</thead>
<tbody>
<tr>
<td>d1</td>
<td>Y</td>
<td>R</td>
<td>R</td>
<td>Y</td>
<td>R</td>
</tr>
<tr>
<td>d2</td>
<td>Y</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>d3</td>
<td>Y</td>
<td>R</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d4</td>
<td>Y</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d5</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(R: red; Y: Yellow)
6. (14 points) The intermediates A, B, C, D, E, and F all occur in the same biochemical pathway. G is the product of the pathway and mutants 1 through 7 are all G- (i.e., fail to produce G). The following table shows which intermediates will promote growth in each of the mutants. Arrange the intermediates in order of their occurrence in the pathway, and indicate the step in the pathway at which each mutant strain is blocked. + in the table indicates that the strain will grow if given that substance, an O means lack of growth.

<table>
<thead>
<tr>
<th>Supplement</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutant 1</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>O</td>
<td>+</td>
</tr>
<tr>
<td>Mutant 2</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>+</td>
</tr>
<tr>
<td>Mutant 3</td>
<td>O</td>
<td>+</td>
<td>+</td>
<td>O</td>
<td>+</td>
<td>O</td>
<td>+</td>
</tr>
<tr>
<td>Mutant 4</td>
<td>O</td>
<td>+</td>
<td>O</td>
<td>O</td>
<td>+</td>
<td>O</td>
<td>+</td>
</tr>
<tr>
<td>Mutant 5</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>O</td>
<td>+</td>
<td>O</td>
<td>+</td>
</tr>
<tr>
<td>Mutant 6</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Mutant 7</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>+</td>
<td>O</td>
<td>+</td>
</tr>
</tbody>
</table>

7. (10 points) Ethylene is a plant hormone that facilitate fruit ripening. Two types of tomato mutants were isolated that either could not ripen even when exposed to ethylene treatment or could ripen even without ethylene treatment. To determine the epistatic relationship among these mutations, double mutants were constructed and their phenotypes were observed and summarized below.

**Gene names**

*never red (nrd)*: Form green tomatoes even after ethylene treatment

*never ripen (nrp)*: Form green tomatoes even after ethylene treatment

*always ripen (ar)*: Form red tomatoes even without ethylene treatment

*(nrd, and nrp are defective in different genes)*

**Gene names**

*nrd ar*: Form green tomatoes even after ethylene treatment

*nrp ar*: Form red tomatoes even without ethylene treatment

What is the regulatory relationship among these three genes? (Draw the regulatory pathway starting with “Ethylene” and ending with “tomato ripening”. Use arrows to indicate positive regulations and bars (—) to indicate negative regulations.)
8. (8 points) Briefly explain what type of transposon each of the following is:

(1). Ty1 transposon from yeast.

(2). P-element from drosophila,

(3). Ac/Ds from maize

(4). T-DNA from agrobacteria,

9. (12 points) What kinds of effect on DNA each of following mutagens could cause?

(1) UV irradiation

(2) X-ray

(3) EMS

(4) Proflavin

(5) Nitrous acid

(6) Transposon insertion