METABOLISM PROBLEMS

1. John, a biochemist, is working out a metabolic pathway in an *E. coli* cell. There are seven compounds in the pathway: B, K, S, C, Da, V and Do. He has learned the following details about the enzymatic reactions that convert these compounds into one another:

   K and S can be interconverted (K into S and vice-versa); C and Do can be interconverted; and Da and V can be interconverted.

   B can be converted into Da (but not vice-versa); S can be converted into C; Da can be converted into K; Do can be converted into B; and Do can be converted into S.

   A. If there is no C present (and none is made), are the following conversions still possible:
      i) B into S?
      ii) K into Da
      iii) K into Do?
      iv) S into Da?
      v) V into Do?

   B. If John feeds K to the bacteria, and he finds that they are producing Da (and we can assume all the Da is made by this pathway), what is the smallest number of other compounds that must have also been produced?

   C. If the bacterium has no Da and none is formed, what other compound cannot be produced by this pathway?
      i) B,
      ii) K,
      iii) S,
      iv) C,
      v) V.

2. Chung-Kyoon is studying the appearance of defense compounds in plant cells that are infected with pathogenic bacteria. The compounds—EE, RL, AMH, AMC, MR, AS, and JN—are all intermediates in a metabolic pathway. From the scientific literature, he has found the following facts about the pathway in other plants:

   EE is a precursor to RL (i.e., EE must be formed before RL).
   Both AMH and RL must be present before MR can be formed.
   Both RL and AMC must be present before AS can be formed.
Chung-Kyoon hypothesizes that the same metabolic pathway is present in his cells.

A. If Chung-Kyoon's hypothesis is true, and if exactly four compounds appear, which of the following must also be true?
   i) If EE appears, it must appear first.
   ii) If AMH appears, it must appear before RL.
   iii) If RL appears, it must appear second.
   iv) If JN appears, it must appear before AMC.
   v) If MR appears, it must appear last.

B. If Chung-Kyoon's hypothesis is true, and if exactly three compounds appear, which of the following cannot appear: AMH, RL, AMC, JN, MR?

C. If Chung-Kyoon's hypothesis is true, and if exactly five compounds appear, and if JN and AMC are the first two to appear, which one of the following is an acceptable sequence in which the remaining three can appear?
   i) EE, RL, MR
   ii) EE, RL, AS
   iii) AMH, RL, MR
   iv) AMH, RL, AS
   v) RL, MR, EE

3. Camilla has established that four compounds--B,E,H, and W--are interconverted in the cells she is studying. by feeding the cells radioactive-carbon compounds and looking for radioactivity in other compounds, she has established that the cells can catalyze these enzymatic reactions:

   B-->E; B-->H; B-->W; W-->B; E-->H; H-->E; E-->W; W-->H

A. If radioactivity originally in compound H is to appear in E and involve as few intermediates as possible, which pathway must it take?
   i) Directly from H to E
   ii) Via B but no other intermediate
   iii) Via W but no other intermediate
   iv) Via B and W, in that order
   v) Via W and B, in that order

B. Which one of the following lists all of the compounds that could be made from W without involving any other intermediates?
   i) B ii) H iii) B, H iv) E, H v) B, E, H

C. Which one of the following describes a way in which radioactivity originally in compound E could appear in other compound and then reappear in E?
   i) From E to B, from B to E.
ii) From E to H, from H to B, from B to W, from W to E.
iii) From E to H, from H to W, from W to B, from B to E.
iv) From E to W, from W to B, from B to H, from H to E.
v) From E to W, from W to H, from H to B, from B to E.

D. If each of the reactions takes the same amount of time, then which of the following conversions would take the longest time?

4. Cornelia, a cell biologist, is trying to determine the intracellular location of the seven intermediates (D,S,A,G,O, R, and E) of a pathway. She knows that there are six intermediates present in bat cells, three in the mitochondria, three in the cytoplasm. She also knows the following things:

D must be present, and it must be in the mitochondria.
S must be present, and it must be in the cytoplasm.
R and S cannot be present in the same compartment.
R and G cannot be present in the same compartment.
A and E must be present and be in the same compartment.

With hard work she can determine the location of E; she would like to avoid having to actually detect the others, if possible.

A. If E is in the mitochondria, which of the following pairs of compounds must be in the cytoplasm?
   i)  A and G;
   ii)  G and O;
   iii) D and S;
   iv)  O and R;
   v)  A and R.

B. If E is in the cytoplasm, which of the following pairs of compounds must be in the mitochondria?
   i)  A and G;
   ii)  A and O;
   iii) A and R;
   iv)  G and R;
   v)  O and R.

C. Which compound does Cornelia have to be able to detect (because it might or might not be present)?
   i)  A;
   ii) D;
5. Jason Jackson has discovered that six compounds in tobacco cells--W, M, B, T, S, and E--form an unbranched metabolic pathway. Because he knows the structures of the compounds, he knows that B cannot be directly converted to T or vice versa. He also knows that M can be (and is) directly converted into E. He has just discovered that W is the fourth compound in the pathway.

A. If M is the second intermediate in the pathway, which one of the following must be true?
   i) W comes after T in the pathway.
   ii) B comes before S in the pathway.
   iii) S comes after W in the pathway.
   iv) B is the last (sixth) compound in the pathway.
   v) T is the first compound in the pathway.

B. If M is the first compound in the pathway, S must be
   i) immediately before W.
   ii) immediately before T.
   iii) at some point before B.
   iv) at some point after W.
   v) at some point after T.

C. If T is the sixth compound in the pathway, which one of the following lists all of the points in the pathway into which B could fit?
   i) First
   ii) First, second
   iii) First, third
   iv) First, second, third
   v) Second, third, fifth

D. If both B and S follow W in the pathway, T must be
   i) first.
   ii) second.
   iii) third.
   iv) first or third.
   v) second or third.

E. Which one of the following is an acceptable sequence of intermediates in the pathway?
   i) M, S, T, W, B, E
   ii) M, E, S, W, T, B
   iii) B, S, T, M, E, W
iv) T, S, B, W, M, E
v) S, B, T, W, M, E

F. T can be any one of the following intermediates EXCEPT
   i) first. ii) second. iii) third. iv) fifth. v) sixth.