NAME_____TA_____Section #_____

7.013 Spring 2005 Problem Set **1Solutions**

FRIDAY February 11, 2004

Problem sets will NOT be accepted late.

Question 1

a) Circle the correct answer.

i) Homo sapiens emerged _____years ago.

5,000 [50,000] 500,000 5,000,000 50,000,000

ii) There are _____billion letters (bases) in the human genome.

one [three] thirty 3 hundred

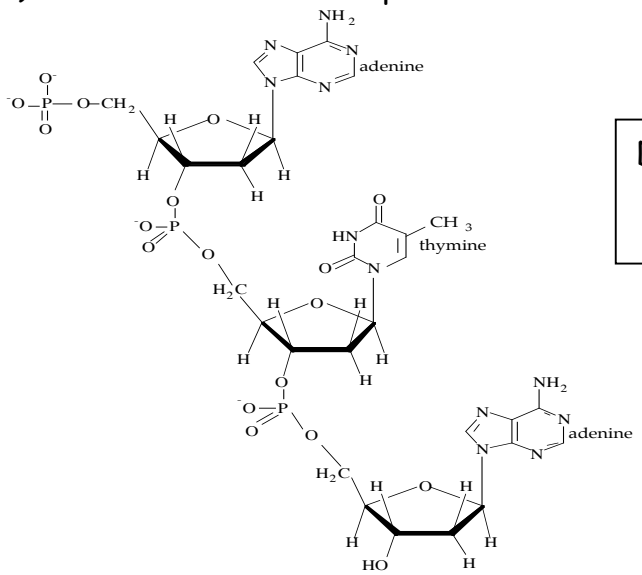
iii) An alpha helix is an example of _____structure.

primary [secondary] tertiary quarternary

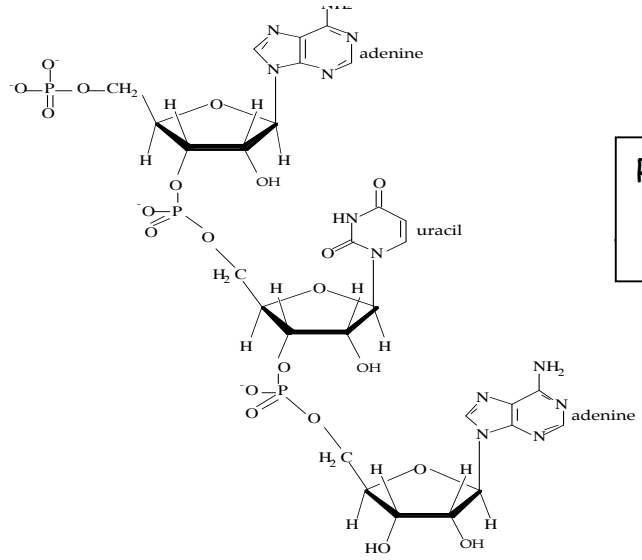
b) What are the four **major** types of biological molecules discussed in lecture? What monomers make up these molecules? Give one important function of each type of biological molecule in the cell.

Name of molecule	Monomer	One function of the Polymer
Lipid	Fatty Acid, Triglyceride	Hormones, Membranes, Energy storage
Nucleic Acids	Nuceleotide	Carry information
Carbohaydrate	Sugar	Energy, Protein Modification,
Protein	Amino Acid	Enzymes, motility, structural roles

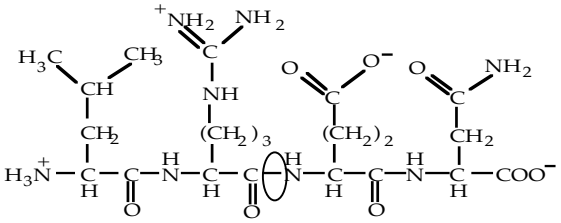
c) Name the molecules depicted below.



DNA



RNA



Peptide, protein, polypeptide

d) Circle one peptide bond if there is any in the figures above.

Question 2

a) Draw the energy profile for this reaction. Refer to Chapter 6 in the textbook.

A + B ---------> C + D $\quad\quad$ $\Delta G^{o'}$ = **-3.4 kcal/mol**

On the diagram be sure to…

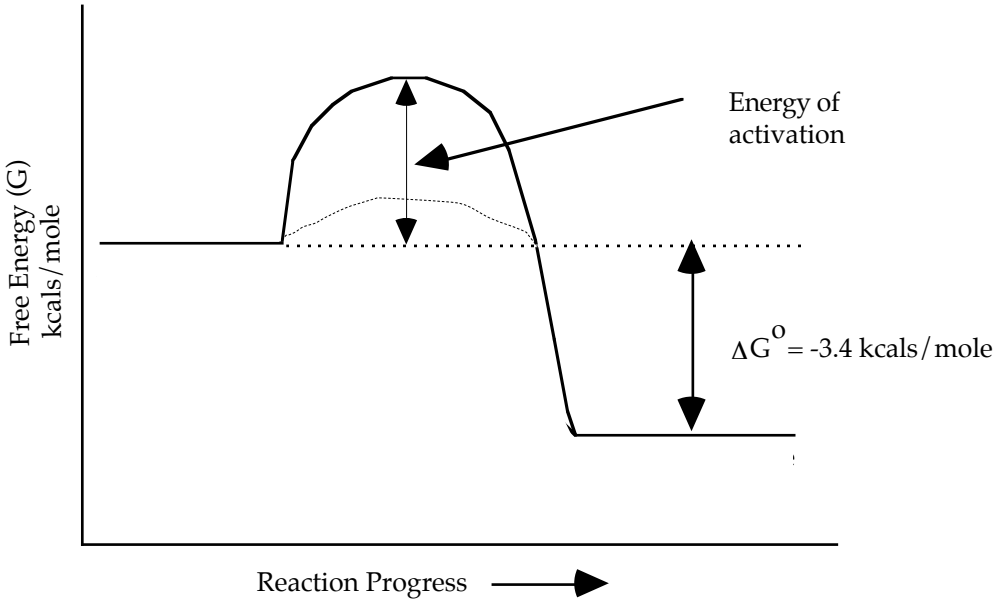
1) show relative energy levels of the reactants and the products.

2) label the axes.

3) label reactants and products.

4) indicate the energy of activation.

5) indicate ΔG.



b) An enzyme _____ the activation energy of a reaction.

lowers $\quad$ raises $\quad$ does not affect

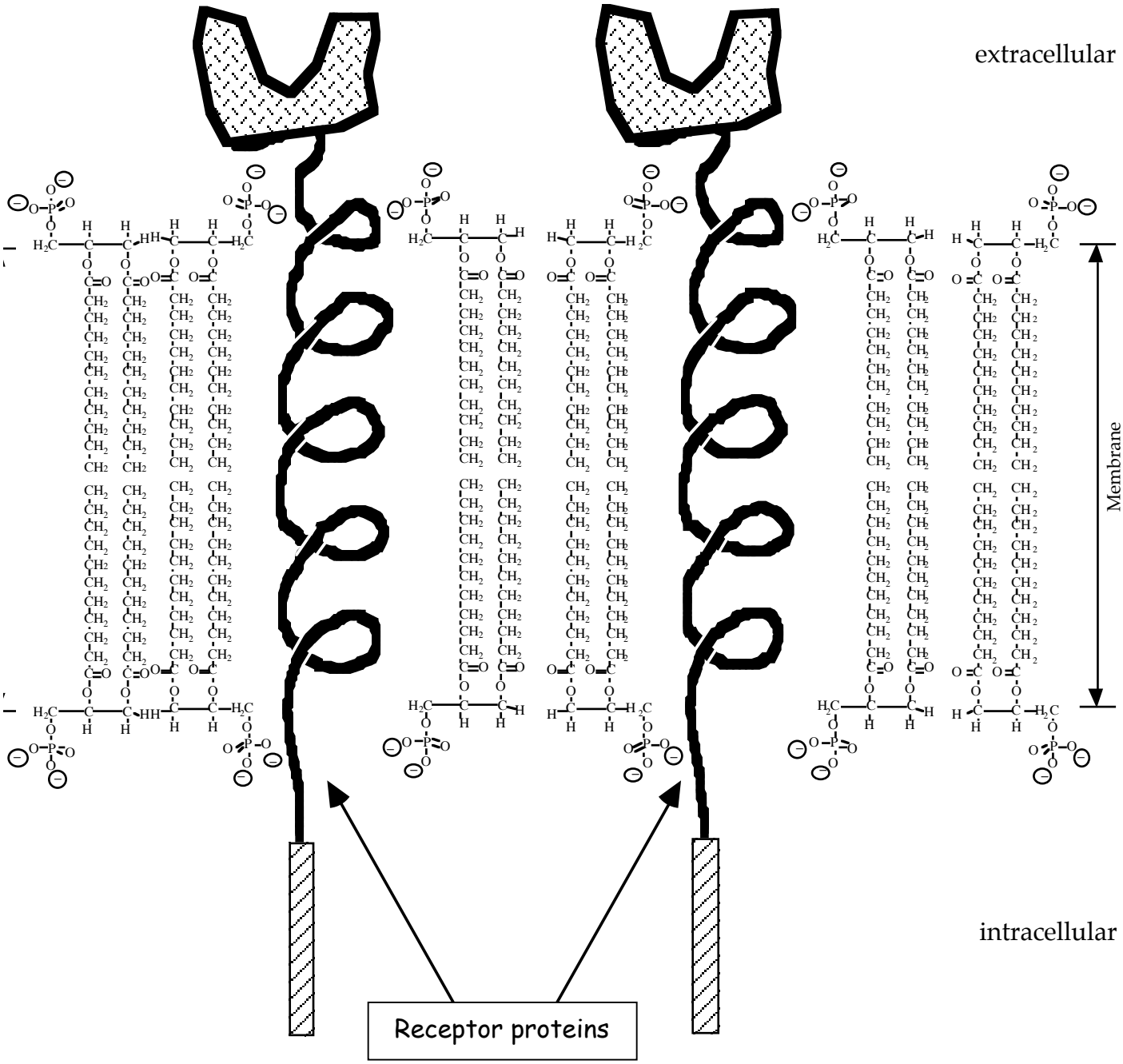
c) An enzyme _____the ΔG of a reaction.

lowers $\quad$ raises $\quad$ does not affect

d) Using a dashed line in the above diagram, draw the energy profile in the presence of an enzyme.

Question 3

Some receptors are transmembrane proteins found on the cell surface.

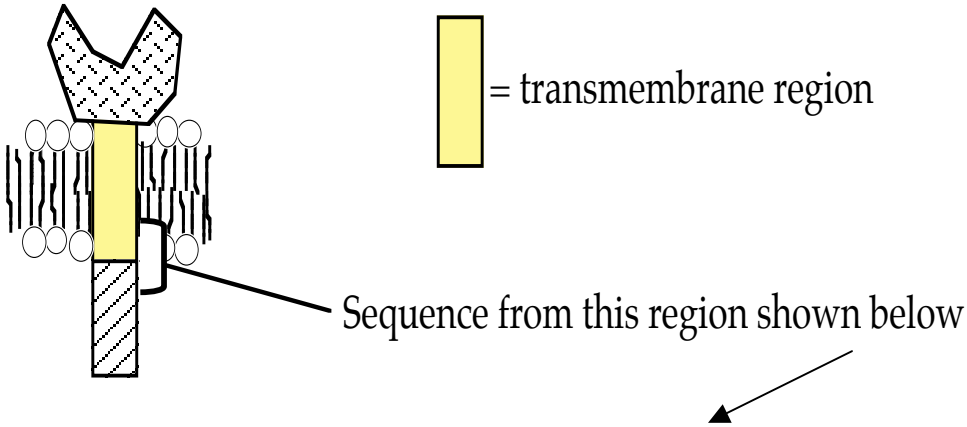


a) The majority of the molecules that constitute a membrane belong to what

class of macromolecules? _____Lipid, Phospholipid_____

b) Explain the important qualities/properties of these molecules that allow them to form membranes. *Phospholipids possess hydrophilic "heads" and hydrophobic "tails" that allow them to assemble into a bilayer containing a hydrophobic core when in an aqueous environment.They are Amphipathic. One hydrophilic end that faces the aqueous solution, and one hydrophobhic end that faces another hydrophobic moiety on another molecule.*

A smaller schematic of the receptor is shown here.

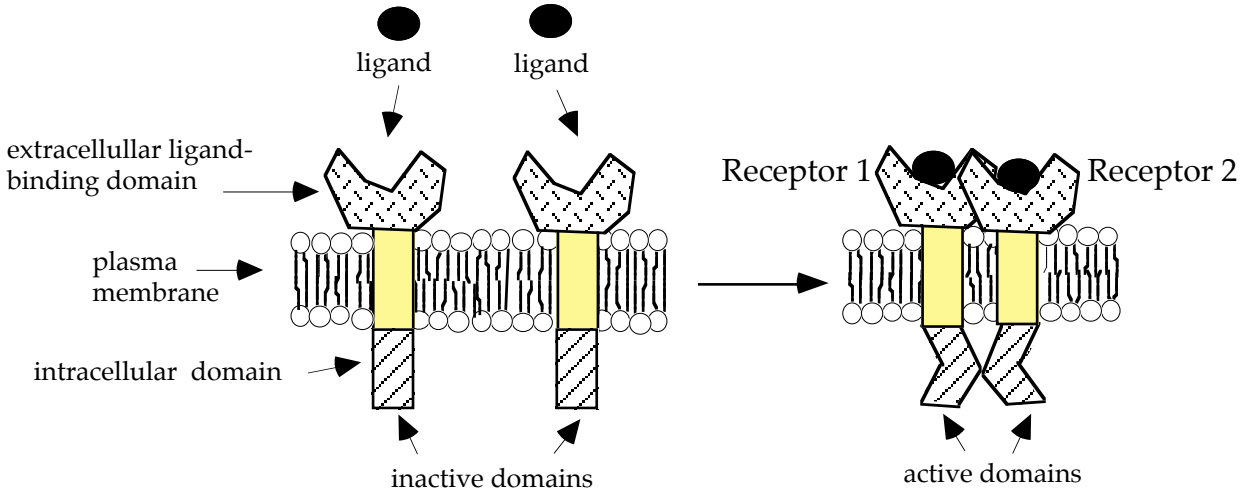


$NH_3^+ \cdots$ Ile-Val-Phe-Leu-Ala-Val-Trp-Met-Phe-Arg-Lys-Thr-His $\cdots COO^-$

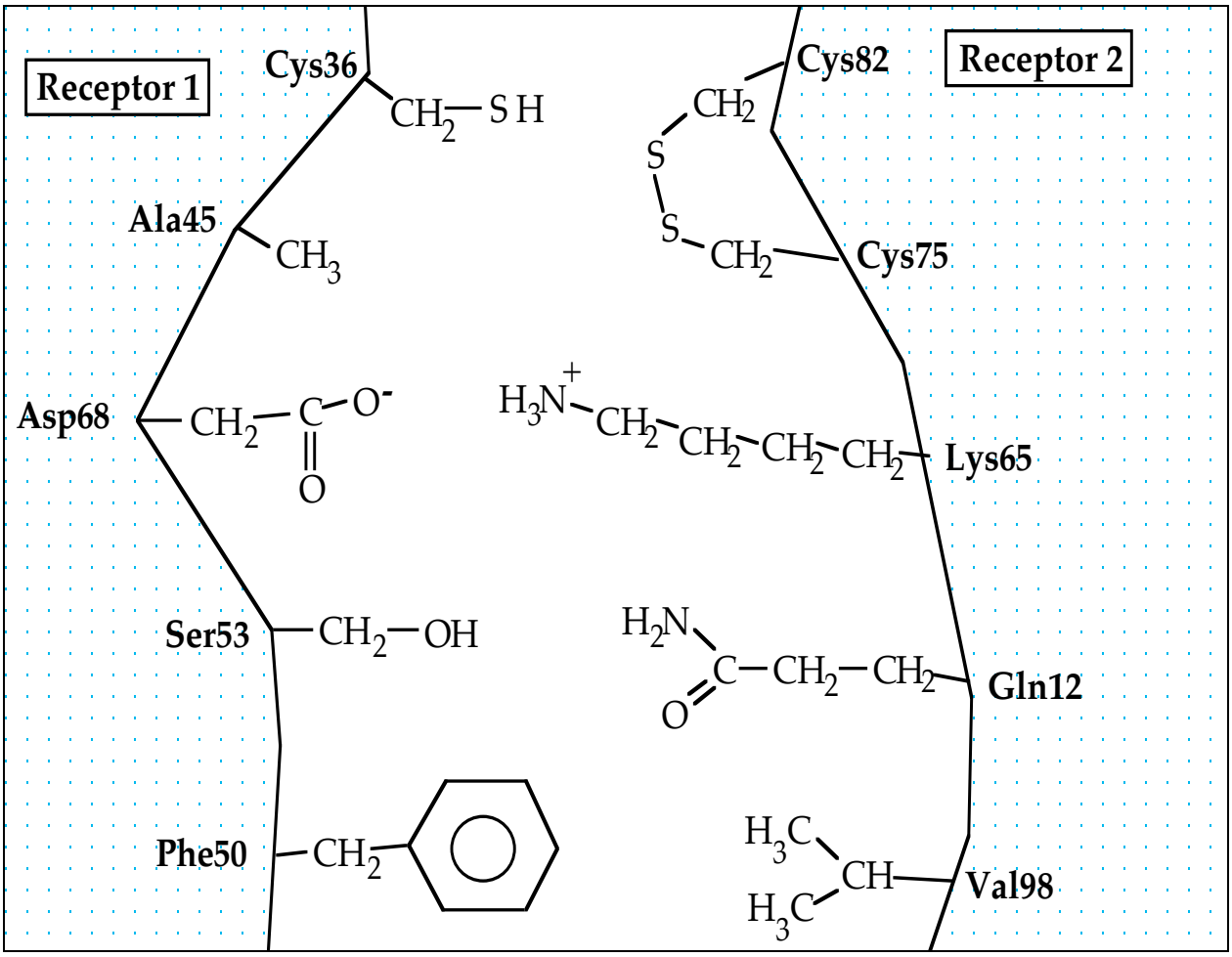
c) Which stretch of amino acids in the above sequence is within the interior of the transmembrane region of the receptor? Circle these amino acids and briefly explain your reasoning below.

The circled amino acids have hydrophobic side chains that reside within the hydrophobic interior of the membrane.

When a "LIGAND" binds to the extracellular domain of the receptor, a conformational change occurs in the receptor. Ligand binding causes dimerization of two adjacent receptors in the cell membrane. Upon dimerization, the intracellular domains of the receptors become activated. See schematic below.



c) Regions of the two receptors that interact upon dimerization are drawn below. In parts (i - iv) below, name the **strongest** type of interaction (choose from; **hydrogen bond**, **ionic**, **covalent**, **van der Waals**) that occurs between the side chains of the amino acids indicated.



Interacting Side chains	Type of interaction
i) Phe50 : Val98	***van der Waals***
ii) Asp68 : Lys65	***ionic***
iii) Cys75 : Cys82	***covalent***
iv) Ser53 : Gln12	***hydrogen***

d) Gln12 is the 12th amino acid in primary sequence. Val 98 is the 98th amino acid in the primary sequence. Explain how these amino acids are far apart in the primary sequence of the protein yet are close to each other in the region of the protein diagrammed above.

When the protein folds into its final form, amino acid residues that are far apart in the primary structure can be closely aligned to one another.

e) Molecular interactions between the two receptors are important for dimerization. Thus, substitution of certain amino acids in the protein can affect receptor dimerization.

Predict whether the receptors will or will not be able to dimerize given the substitutions (i - iv) below. EXPLAIN your reasoning.

i) Asp68 → Arg

*The receptors will **not** be able to dimerize because this substitution replaces a negatively charged amino acid with a positively charged amino acid. The ionic bond between Asp68 and Lys65 is disrupted, and a repulsion occurs.*

ii) Ser53 → Thr

*The receptors **will** be able to dimerize because this substitution replaces a polar amino acid that can participate in hydrogen bonds with another such amino acid.*

iii) Phe50 → Asn

*The receptors **will** be able to dimerize even though this substitution replaces a hydrophobic acid with a polar amino acid because the van der Waals forces remain. (Within the region diagrammed, the close proximity of the charged species makes it unlikely that hydrophobic interactions are a key force in the interaction between the two receptors.)*

iv) Val98 → Ile

*The receptors **will** be able to dimerize because this substitution replaces a hydrophobic acid with another hydrophobic amino acid and the van der Waals forces remain.*

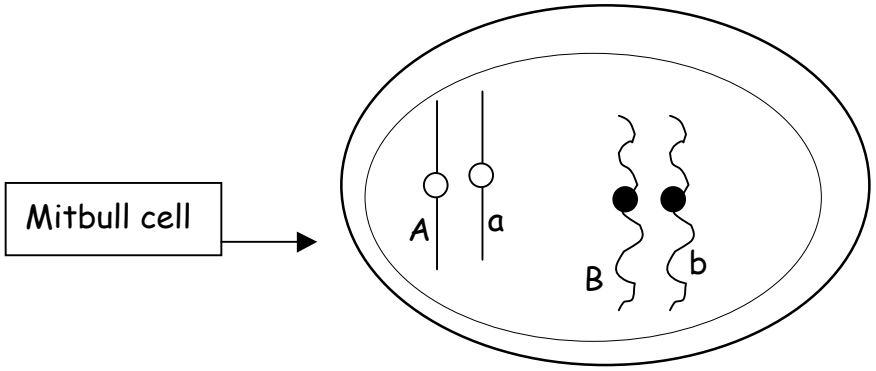
f) Substitution of one amino acid, Cys75 → Gly, leads to dimerization of the receptors with or without ligand. Provide a brief explanation for this observation.

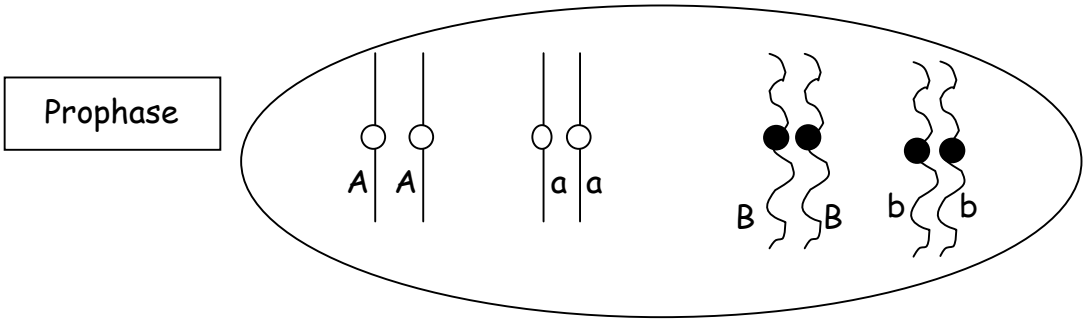
This substitution positions two cysteine residues opposite each other. These two residues can form a disulfide bond and thus covalently link the two receptors together.

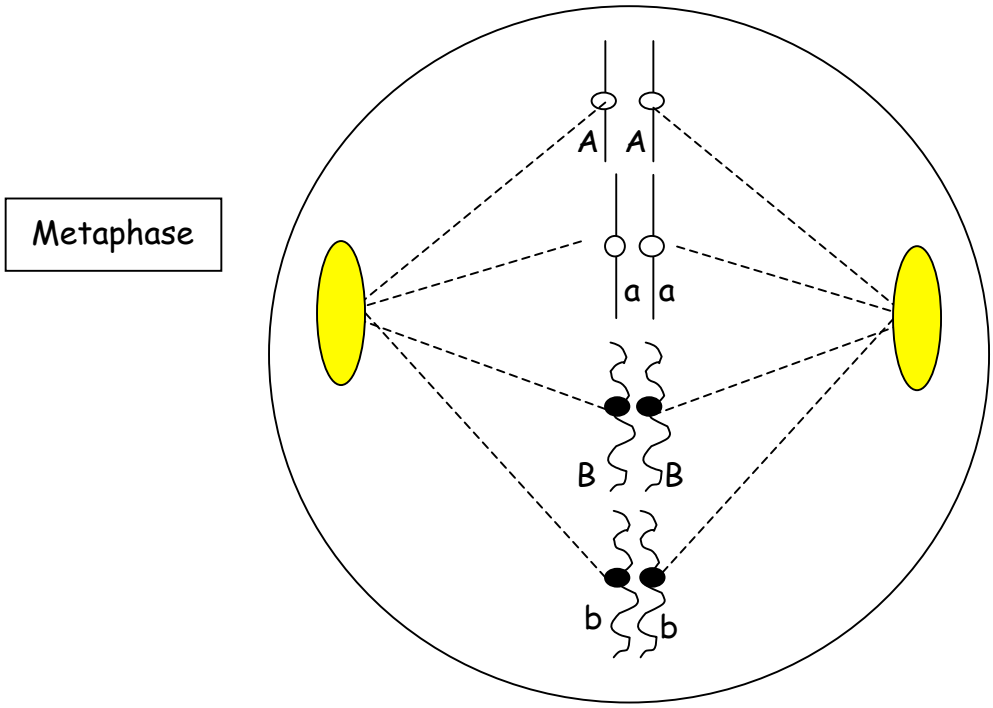
Question 4

You have identified a new, rapidly reproducing species of dog that you have named the "mitbull". The mitbull is diploid and two autosomal chromosomes are shown. One chromosome carries gene *A* with two alleles designated *A* and *a*. The other chromosome carries gene *B* with two alleles designated *B* and *b*.

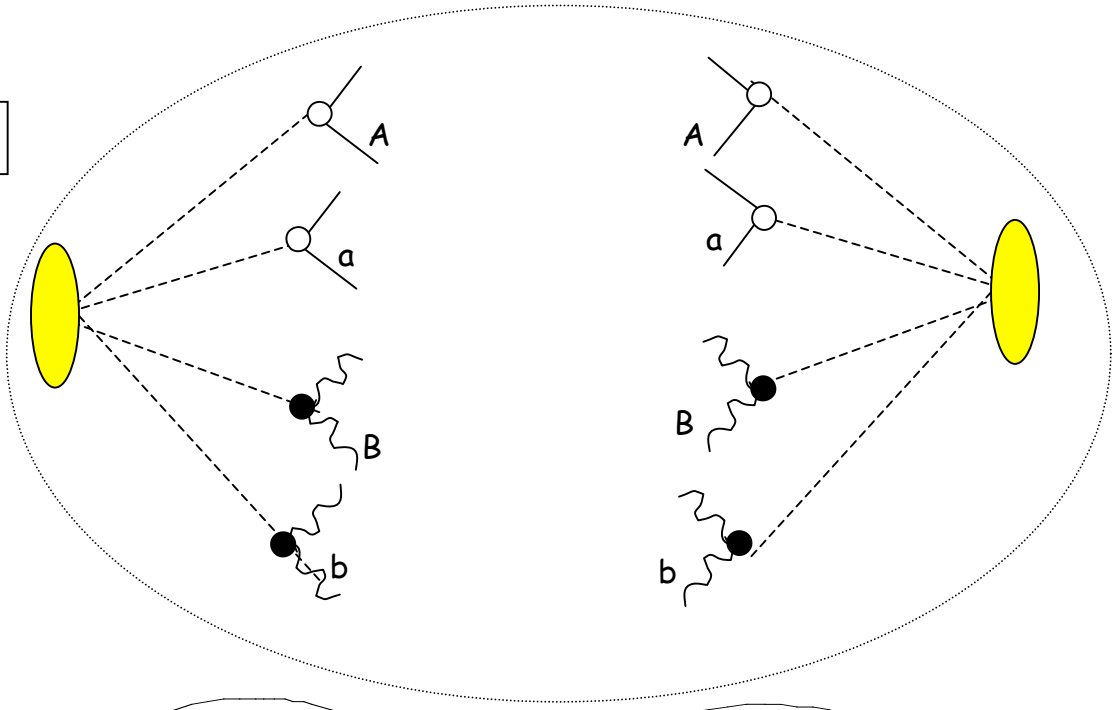
a) Diagram mitosis in a heterozygous (*AaBb*) mitbull cell shown below. Draw your diagrams in the outlines of the ovals adjacent to the stages. Include the alleles and the mitotic spindle in your diagrams.



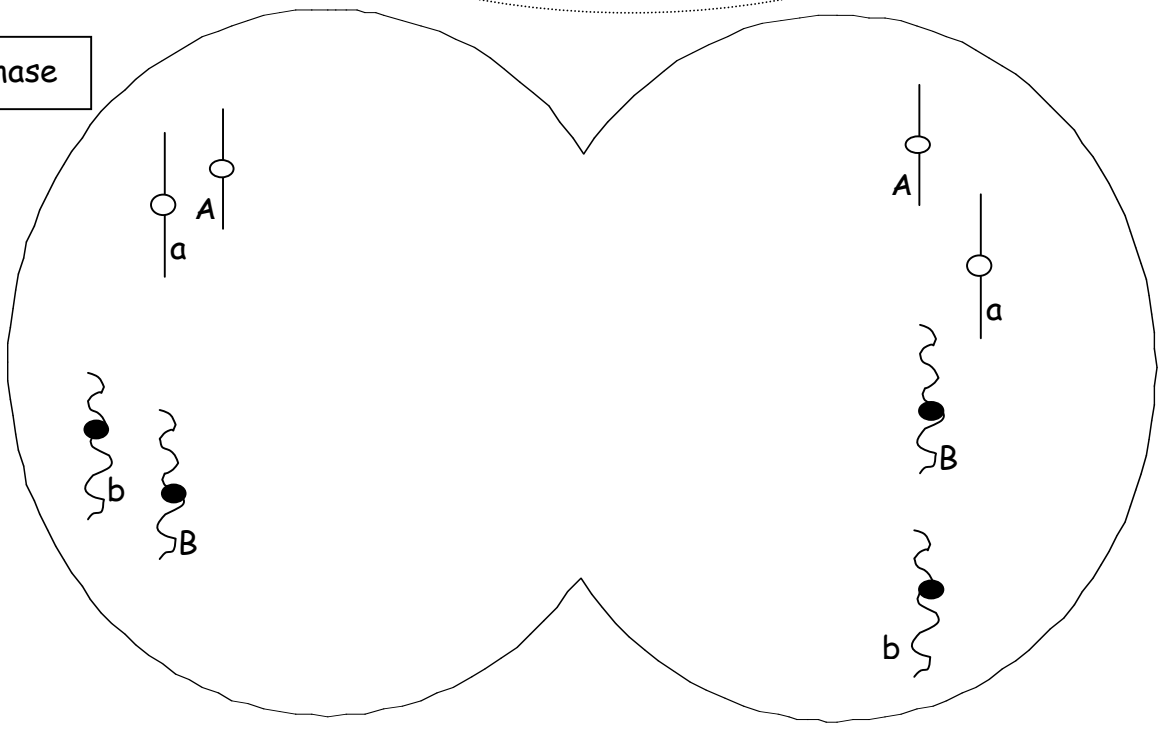




Anaphase

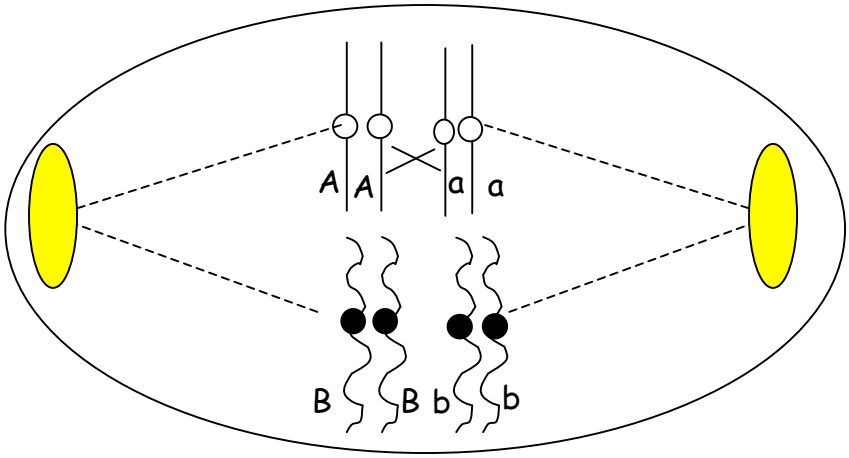


Telophase

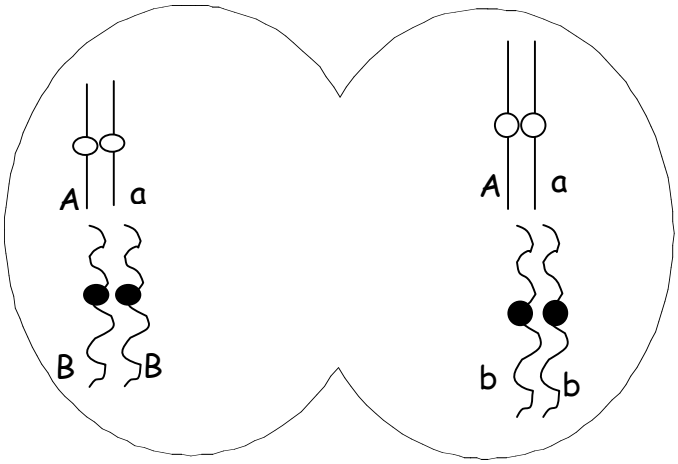


b) Indicate the genotype of cells that would result after telophase. _____AaBb_____

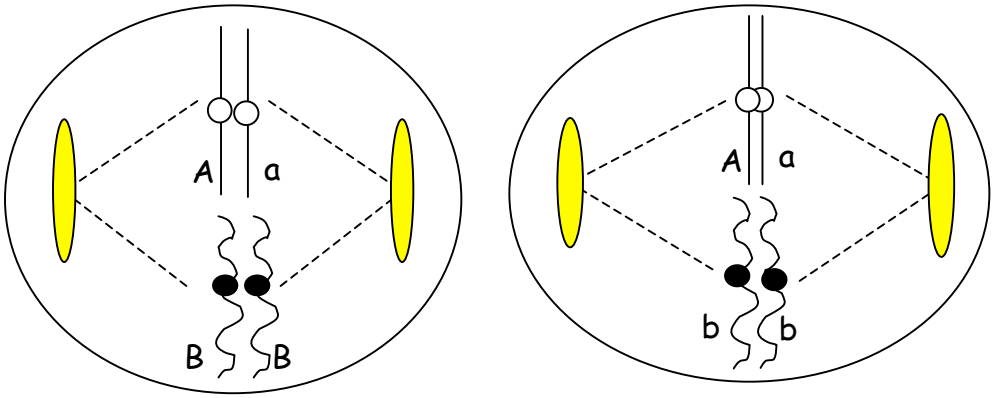
c) A cell in Metaphase I is shown below where a crossover event takes place. Diagram the indicated stages in meiosis. Designate the alleles and the spindle.



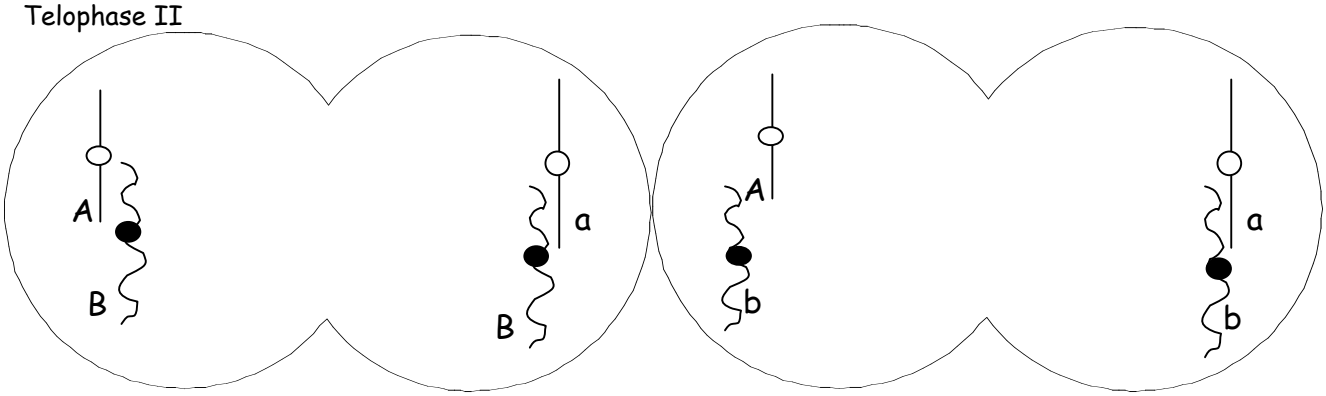
Telophase I



Metaphase II

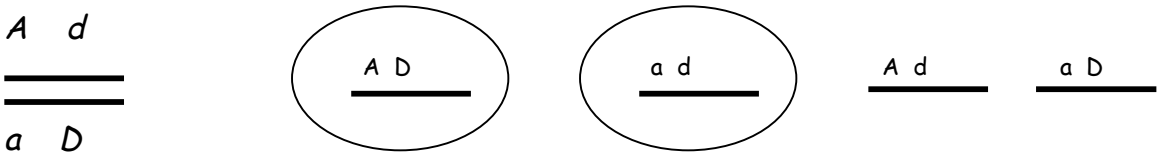


Telophase II



d) You determine another gene, gene D, maps 20 cM or map units away from gene A.

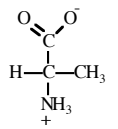
i) Given the cell with chromosome configuration below, what would be the genotypes of all the gametes if a recombination takes place between A and D?

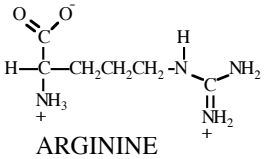


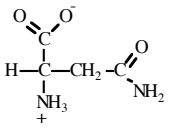
ii) Circle the genotypes of the recombinant gametes above.

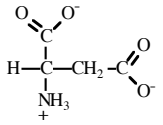
iii) At what frequency do you expect each of the recombinant genotypes to occur? ___10%___

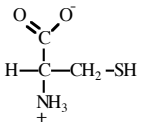
STRUCTURES OF AMINO ACIDS at pH 7.0

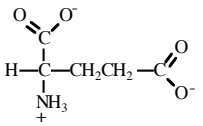

ALANINE
(ala)

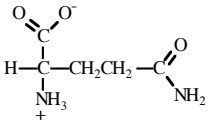

ARGININE
(arg)

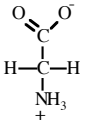

ASPARAGINE
(asn)

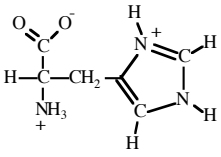

ASPARTIC ACID
(asp)

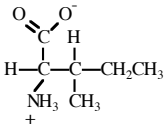

CYSTEINE
(cys)

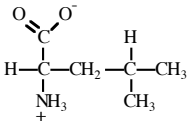

GLUTAMIC ACID
(glu)

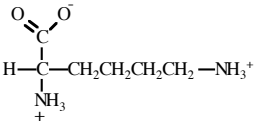

GLUTAMINE
(gln)

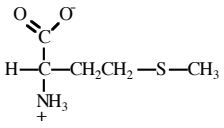

GLYCINE
(gly)

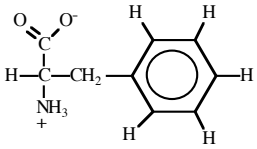

HISTIDINE
(his)

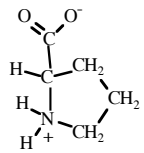

ISOLEUCINE
(ile)


LEUCINE
(leu)


LYSINE
(lys)


METHIONINE
(met)


PHENYLALANINE
(phe)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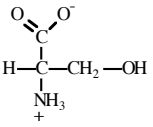
(pro)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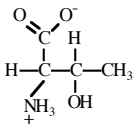
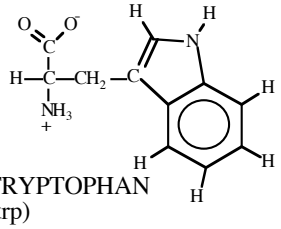
(ser)


THREONINE
(thr)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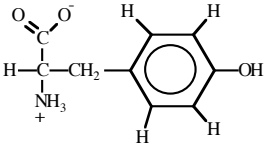
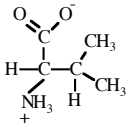

TYROSINE
(tyr)


VALINE
(val)