

INSTRUCTIONS:

1. Read the questions carefully and write your answers in the space provided. If you need more space, clearly indicate WHERE the rest of the answer is located (for example, on the back of the same page). If there is something that you do not wish me to count, (for example, if you make an error) please cross it out.

2. Read each question carefully before starting to answer it so you don't overlook any additional instructions. If you get stuck on a question, go on to another question and return to the original question later. It is a good strategy to read over the entire exam and then select the questions you feel most confident about to answer first.

3. In your answers to problems that require you to calculate a numerical answer, you must show how you set up your calculation to receive full credit for your final numerical solution.

4. A blank sheet of paper has been provided for you at the end of the exam which you may use as scratch paper.

GOOD LUCK!

Question #1: _____ (30 pts.)

Question #2: _____ (20 pts.)

Question #3: _____ (15 pts.)

Question #4: _____ (19 pts.)

Question #5: _____ (18 pts.)

Question #6: _____ (13 pts.)

Question #7: _____ (19 pts.)

Question #8: _____ (16 pts.)

Bonus: _____ (5 pts.)

Bonus: _____ (5 pts.)

TOTAL: _____ (150 pts.)

NAME: _____ ID NUMBER: _____
Please **print** legibly

SIGNATURE: _____

1. For each of the following, choose the one alternative that best completes the statement or answers the question (2 pts. each, 30 pts total).

- All of the following happen in prophase I of meiosis except
A.) chromosome condensation
B.) pairing of homologs
C.) recombination
D.) independent assortment of chromosomes
E.) segregation of alleles
- Varieties of plants or animals that when crossed with each other always produce offspring that are identical to themselves are:
A.) true-breeding
B.) heterozygous
C.) homozygous
D.) F₁ hybrids
E.) A and C
- A child with type O positive blood could have which of the following parents?
A.) A+ and A-
B.) O+ and AB-
C.) O- and O-
D.) AB+ and A-
E.) A- and B-
- X, Y, and Z are linked genes. Based on testcross data, the frequency of recombination between genes X and Y was found to be 33.1 map units; between genes X and Z the distance was 11.8 mu; and between genes Y and Z the distance was 21.3 mu. What is the order of the three genes on the chromosome?
A.) X-Y-Z
B.) X-Z-Y
C.) Z-Y-X
D.) Y-X-Z
E.) unable to determine from the information given
- Which of the following nitrogenous bases found in DNA are purines?
A.) Adenine and thymine
B.) Thymine and cytosine
C.) Adenine and guanine
D.) Cytosine and guanine
E.) Adenine and uracil
- Which of the following is true of an allotriploid?
A.) it is the result of unequal crossing over
B.) has chromosomes from at least 2 different species
C.) has three chromosome sets from the same species
D.) is always fertile
E.) is always inviable
- Calico cats
A.) Are a demonstration of dosage compensation in females
B.) Can be males with Klinefelter syndrome
C.) Will have at least one Barr body in each somatic cell
D.) All of the above
E.) None of the above

----- A mutation that changes the amino acid sequence of the protein, but not the functioning of the protein is a ---- mutation.

- A.) neutral
- B.) nonsense
- C.) silent
- D.) both A and B
- E.) all of the above

----- Hfr strains are variants of F+ strains that:

- A.) have the F factor integrated into the bacterial chromosome
- B.) transfer certain genes to F1 cells with a high frequency
- C.) have picked up bacterial genes through infection by a virus
- D.) A and B only
- E.) A, B and C

----- The production of Dolly the sheep was important because

- A.) she was the first clone of an adult mammal that was produced
- B.) she was the first clone of a mammal that was produced
- C.) she was the first clone in which the "telomere" problem had been solved
- D.) she was the first mammal produced by in vitro fertilization
- E.) she was the first mammal to undergo germline gene therapy

----- Which of the following is true of the Polymerase Chain Reaction?

- A.) The reaction must be heated at the beginning of each cycle to denature the DNA polymerase
- B.) It uses a type of DNA polymerase that is resistant to denaturation by heat
- C.) You can start the reaction with little information about the DNA sequence you want to amplify
- D.) It is not very susceptible to contamination by other DNA sources
- E.) It uses *E. coli* as a host to copy DNA molecules

----- A DNA library

- A.) May consist of clones that together contain all the genomic DNA of an organism
- B.) May be searched by colony hybridization to find a gene of interest
- C.) Can be created by PCR
- D.) All of the above
- E.) A and B only

----- Cutting a 12kb fragment of DNA with EcoRI results in 2 fragments 8kb and 4kb, respectively. Cutting the same DNA with BamHI results in a 5kb and 7kb fragment. Cutting the fragment with both enzymes results in a 3kb, 4kb, and 5kb fragment. The order of these fragments and the restriction sites on the 12kb fragment is

- A.) - 4—B—5—E—3—
- B.) - 3—B—5—E—4—
- C.) - 5—B—3—E—4—
- D.) - 5—B—4—E—3—
- E.) - 5—E—3—B—4—

A probe is which of the following?

- A.) a virus used to transfer genes to a host cell
- B) a piece of radioactively labeled DNA used to find a specific gene
- C) an enzyme that locates specific restriction sites on DNA
- D.) a plasmid used in DNA cloning experiments
- E.) none of the above

Under strictly controlled conditions, a probe can be used which will hybridize only with its complementary sequence and not with other sequences that may vary by as little as one nucleotide. What are such probes called?

- A.) mutation-specific probes
- B.) VNTRs
- C.) allele-specific oligonucleotides (ASOs)
- D.) microsatellites
- E.) Restriction fragment length polymorphisms (RFLPs)

2. (continued)

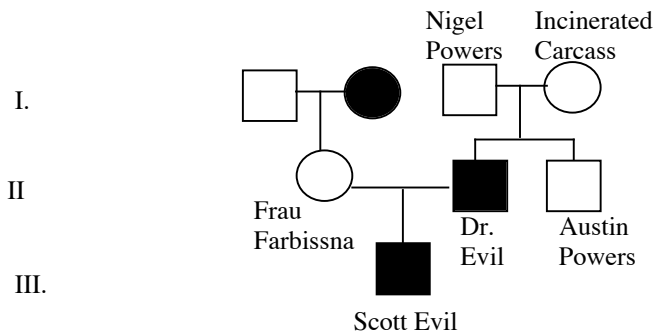
- (c) Mini-me was created as a clone using cells of **adult** Dr. Evil. Explain the procedure that may have been used to create Mini-me (5 pts.).
- (d) What do the results of Dr. Evil and Mini-me's DNA fingerprint indicate about their genetic relationship? (3 pts.)
- (e) If Mini-me is a clone of Dr. Evil, why do they not look and act exactly the same? Would you always expect two clones (i.e., like identical twins) to be exactly the same? Why or why not? (3 pts.)

3. Dr. Evil has a son with Frau Farbissna, Scott Evil. Dr. Evil and his son both suffer from male pattern baldness, a **sex-influenced** trait.

(a) In the table below, put an "X" in the box if the statement would be true for a X-linked, sex-influenced or sex-limited trait. Each statement may have more than one "X" (1 pt each, 5 pts. total):

	X-linked	Sex-influenced	Sex-limited
The gene is located on an autosome			
The trait is only seen in one gender			
Males are hemizygous for the gene			
Alleles of the gene affect an individual's phenotype in different ways in each sex			
Fathers will pass on their allele to all of their daughters, but none of their sons			

(b) Below is the pedigree of the Powers/Evil family showing the inheritance of male pattern baldness, a sex-influenced trait:



Indicate the genotype for male-pattern baldness of the following individuals (Use B=baldness, b=hair) (0.5 pts. each, 3 pts. total):

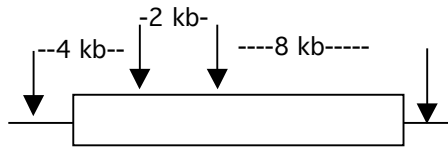
Nigel Powers: ----- Incinerated carcass: -----
 Austin Powers: ----- Frau Farbissna: -----
 Dr. Evil: ----- Scott Evil: -----

(c) Scott is colorblind, yet neither of his parents are colorblind and none of his grandparents are colorblind. Assuming that his colorblindness is not the result of a new mutation, how is this possible? (5 pts.)

(d) A female with three X chromosomes will have _____ Bar bodies, whereas a male with Klinefelter syndrome will have _____ Bar bodies (2 pts.)

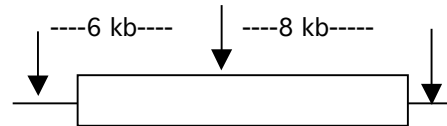
4.

- (a) Scott Evil, following in his father's footsteps to create diabolical plans against the human race, wants to make everyone in the world go bald. He therefore, decides to study the baldness gene. The diagrams below show the sites at which a certain restriction enzyme cuts the baldness allele and the nonbald allele respectively.



Baldness allele

Arrows indicate locations of sites where restriction enzyme cuts the DNA



Nonbald allele

The numbers between the arrows indicated the sizes of the restriction fragments produced when the DNA is cut at the restriction sites indicated

- (i) When different individuals within a population have different numbers of restriction sites within the same region of DNA, this is called what? (2 pts., half-credit for just the abbreviation.)
- (ii) In the baldness allele the DNA sequence at the sequence between the 4 kb and 2 kb sequence is 5'-CCTAGG-3'. In the nonbald allele, the same region of DNA has the sequence 5'-CCGAGG-3'. Would this mutation would be called a base substitution _____ or a frameshift mutation _____? (Check one) (2 pts.)
- (iii) A chemical mutagenic agent that causes this type of mutation is: (1 pt.)
- (iv) How does such a change in the DNA sequence cause a change in the numbers of restrictions sites found in the DNA fragment? (4 pts.)

4. (continued)

- (v) Based upon your answers to Part b) of this question, show the pattern of restriction fragments that would be produced if you took DNA samples from each of the individuals indicated below, cut it with the restriction enzyme used in Part (c), and carried out gel electrophoresis and Southern blotting of their DNA samples. Please write the genotype of each of the individuals indicated below the lane on the gel containing their DNA. (You already determined their genotypes in Part b). (1 pt. /individual; 7 pts. total.)



Genotype: ----- ----- ----- ----- ----- ----- -----

- (vi) Dr. Evil and Frau Farbissna decide to have another child, as they are so disappointed in Scott. When Frau becomes pregnant, the happy couple decides to have prenatal testing performed to determine if the child is likely to be bald. This unborn offspring is indicated on the gel above. What can you tell the couple about what the child's phenotype will be? (3 pts.)

5.

(a) For each of the following indicate if the statement is true of meiosis I (MI), meiosis II (MII), or both (B) (1 pt. each, 5 pts. total):

- Crossing over occurs
- Independent assortment takes place
- Sister chromatids separate
- Reduces the chromosome number by one-half
- Nondisjunction may occur

(b) For each of the following indicate if the statement is true of homologous chromosomes (H), sister chromatids (S), or both (B) (assume no crossing over has taken place) (1 pt. each, 4 pts. total):

- They are exactly identical
- Have the same genes at the same loci
- May have different alleles for the same gene
- Are the direct product of DNA replication

(c) For each of the following indicate if the statement is true of incomplete dominance (I), codominance (C), or both (B) (1 pt. each, 4 pts. total):

- For a cross between two heterozygotes, the genotypic and phenotypic ratios will be the same
- A heterozygote will have a phenotype that is intermediate between the two homozygotes
- One phenotype will never breed true
- Both alleles are expressed in the phenotype of a heterozygote

(d) For each of the following indicate if the statement is true of transcription (T), translation (R), or both (1 pt. each, 5 pts. total):

- Occurs in the cytoplasm of prokaryotic cells
- Occurs on ribosomes
- DNA is read in the 3' to 5' direction
- Begins with the recognition of a promoter region
- Occurs in the cytoplasm of eukaryotic cells

6. You have been assigned the task of mapping the order of 10 important genes in a bacterial strain. Using four Hfr strains (all derived from the same strain), you decide to carry out interrupted mating experiments, with the following results:

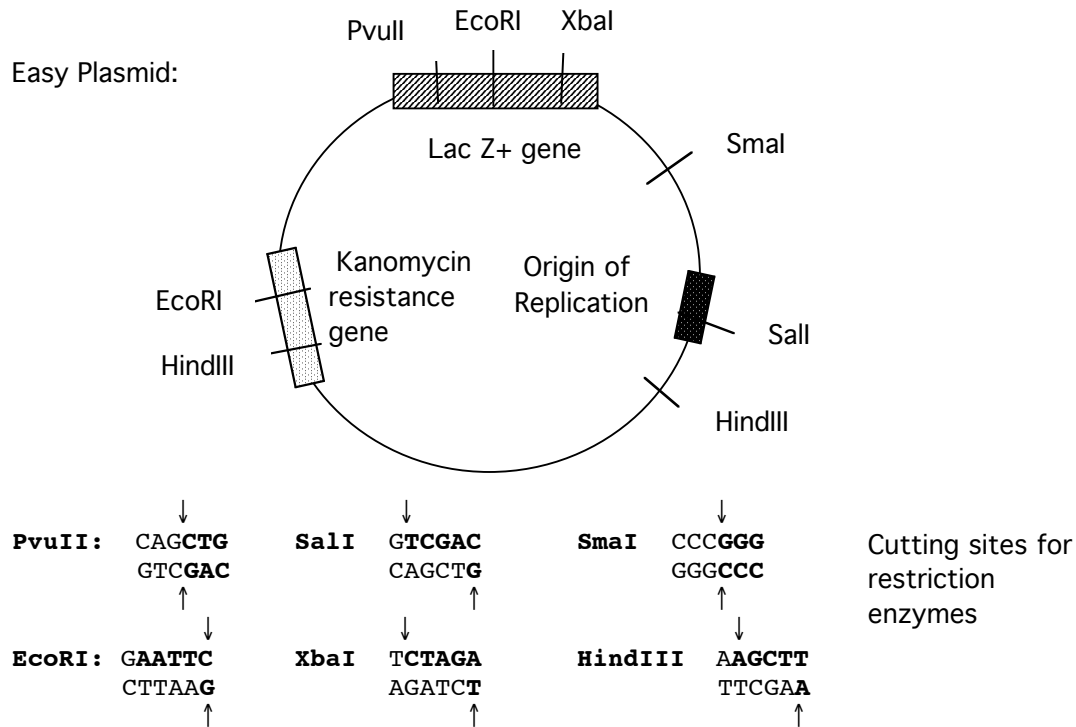
<u>Experiment #1</u> (Hfr1)		<u>Experiment #2</u> (Hfr2)		<u>Experiment #3</u> (Hfr3)		<u>Experiment #4</u> (Hfr4)	
Gene	Time transferred	Gene	Time transferred	Gene	Time transferred	Gene	Time transferred
C	15	B	10	H	10	G	15
I	20	F	30	A	25	I	25
G	30	A	35	F	30	C	30
J	45	H	50	B	50	D	45
E	50	E	60	D	60	B	55
H	60	J	65	C	75	F	75

- (A) Determine the order of all ten genes on the bacterial chromosome and draw a single map that shows the relative positions of each gene on the bacterial chromosome. Based on the data above, indicate the distances between each gene and its nearest neighbors on either side of it (expressed in minutes). Also show the location of each integrated F factor including the origin and direction of transfer for each Hfr. (10 pts.)

- (B) Fill in the following information about F+, F-, and Hfr cells. (1 pt. per line; 3 pts. total)

<i>Cell type</i>	<i>F plasmid location in the cell/is plasmid present/ and/or key features of cell or plasmid it contains</i>	<i>This cell can act as a Donor or Recipient of an F plasmid?</i>
F +		
F -		
Hfr		

7. A very important “reporter gene”, *lacZ*, has come into use over the past few years. This gene codes for a protein which reacts with X-gal. Normally, the bacterial colonies are white, but turn blue when the *lacZ* gene is expressed in the presence of X-gal. This gene is being used in gene cloning as a marker rather than a second antibiotic resistance gene. You need to express a novel gene in *E. coli*, and what you now know about *lacZ*, you decide to use the “EASY” vector system (see map below). **NOTE:** Your gene is flanked by all the restriction enzymes present in the “Easy Vector” system.



a) Which ONE restriction enzyme would you use to cut out your gene and cut your plasmid? (2 pts.)

b) State two specific reasons that you chose this particular restriction enzyme. (4 pts.)

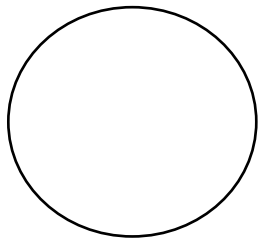
c) Prior to transformation with the plasmid, the *E. coli* bacteria into which the plasmid is inserted should have which of the following phenotypes? (CHECK ONE ONLY): (1 pt.)

- (i) kanomycin resistant, LacZ+ _____; (ii) kanomycin sensitive, LacZ+ _____; (iii) kanomycin sensitive, LacZ- _____; (iv) kanomycin resistant, LacZ- _____.

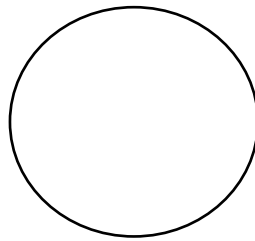
7. cont...

d) Outline the steps you would perform in order to clone your gene into an *E. coli* bacterial host. Be sure to include any additional enzymes you would use, any treatment of the bacterial cells, the genotype of the bacterial cells at the beginning of the experiment, etc (6 pts.).

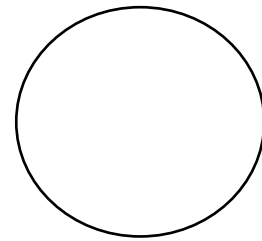
e) Once you have gone through the above procedure, you need to identify those cells that actually picked up your novel gene. In order to this, you will grow your *E. coli* on the following petri plates with the additions to the media shown.



i.) No drugs added



ii.) + kanomycin



iii.) + kanomycin
and X-gal

For each of the plates above, indicate which type of bacteria will grow (what type of plasmid, if any, they carry, the genotype of the bacteria) and what color they will be (white or blue) (2 pts. Each, 6 pts. Total).

(i.) No drugs added:

(ii.) + kanomycin:

(iii.) + kanomycin and X-gal:

8.

(a) Give the phenotypic ratios expected in each of the following crosses (1 pt. each, 5 pts. total):

AaBb X AaBb when A and B show recessive epistasis:

AaBb X aabb when A and B are 10 map units apart and the alleles start in coupling:

AaBb X aabb when A and B are 10 map units apart and the alleles start in repulsion:

AaBb X aabb when A and B show independent assortment:

AaBb X AaBb when A and B show independent assortment:

(b) For each of the following, underline the correct term to complete the statement (1 pt. each, 5 pts. total):

During DNA replication, the leading strand will be synthesized (**continuously** / **discontinuously**) by the enzyme (**DNA pol I** / **DNA pol III**). DNA is always synthesized by adding new nucleotides to the (3' / 5') end of a growing DNA strand. On the lagging strand, RNA primers will be removed by (**DNA pol I** / **DNA pol III**). Finally, Okazaki fragments will be joined together by (**DNA ligase** / **primase**).

(c) Answer the following (1 pt. each, 6 pts. total):

For the cross AaBBcc X aaBbCc, what percentage of offspring will have the genotype AaBBcc?

For the cross AaBBcc X aaBbCc, what percentage of offspring will show the dominant phenotype for all three genes?

How many different types of gametes could the AaBBcc parent produce?

A pedigree in which all the daughters, but none of the sons, of an affected male are also affected would indicate what mode of inheritance?

A pedigree in which all the sons, but none of the daughters, of an affected male are also affected would indicate what mode of inheritance? **Y-linked**

A child with type A blood has mother with type B blood. The mother's genotype must be:

SCRATCH PAPER