Genetics

I. Basics of Mendelian Genetics (Whole-Class Prelab Discussion)

The study of genetics enables us to understand how biological characteristics encoded on the chromosomes can be transmitted from parent to offspring, and how variability in these characteristics occurs. In this exercise you will study the results of genetic crosses, examine some of the ways in which genes express themselves and solve a variety of genetics problems. In addition, each member of your group will prepare to present a solution to a unique problem generated by the Virtual Genetics Lab software at a later laboratory meeting.

Genes controlling a given trait occur at corresponding positions (gene loci) on homologous chromosomes (pairs of chromosomes—one maternal, one paternal—received from one's parents). There may exist two or more expressions (light, dark, etc.) for any characteristic. These alternate forms of a gene at a particular locus are called alleles (you have two alleles for most characteristics).

If the pair of alleles an individual received are identical, the individual is said to be homozygous for that trait. In a heterozygous individual, the alleles that code for a trait are different, which means that an individual developed from an embryo formed by the fusion of gametes bearing dissimilar alleles for that gene. In the heterozygous condition one allele may be dominant and totally mask the presence of the other (thus recessive) allele.

To determine what types of offspring may be produced, we can look at the parental genotypes for the particular traits we wish to observe. If we are looking at just one trait, we call it a **monohybrid cross**. For example, let us assume that curly hair (symbol C) is dominant over straight hair (c); and that two parents are both heterozygous (Cc) for curly hair. What kind of offspring and what proportion of each, would they be expected to have?

To solve this problem, it is best to set up a **Punnett Square** as seen below. The gametes formed by the female contain either gene C or c, in equal proportions. These are written across the top of the square:

In this case, the gametes of the male are the same and are written on the outside of the box and along the left hand column (**do this now**). To determine the offspring, we simply combine the gametes that contribute to form each square. For example, in the upper left square, C and C are combined to give CC offspring. In this particular cross, three out of four offspring would be expected to have curly hair,

	C	c
_____		
_____		

and one out of four should have straight toenails. Of the ones with curly hair, two out of three would be expected to be heterozygous for the trait. The proportion of offspring expected to exhibit a certain trait is usually written as a fraction: that is, ¾ would be expected to have curly hair, and ¼ straight hair. Bear in mind that these are probabilities, based on **expected** results in a large population. Not every family has four children, and even if there were four children, they would not necessarily follow the expected probabilities.

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Another type of inheritance pattern can be found with **sex-linked traits**. A sex-linked characteristic is encoded by a gene on a sex chromosome, usually the X chromosome. Note that there is no homologue for the X chromosome in the male; therefore, whatever genes are present on the X chromosome (whether they are dominant or recessive) are expressed in his phenotype.

Some humans are born without a critical protein, which results in their development of so-called male pattern baldness. The defective allele **b** is found on the X chromosome (coded as $X^{\mathbf{b}}$). Use a Punnett square to predict the possible offspring, male and female, of a couple in which the man has male pattern baldness and his wife has normal hair even though her father had male pattern baldness (the woman's genotype is written in for you). What is the probability that their children will have male pattern baldness? Why do you think this trait, like all human sex-linked traits, is more common in males than females?

	X^B	X^b
______		
______		

II. Paper & Pencil Problems

Gain some skill with the genetic problems below. You'll need the practice, because afterwards you'll put these skills to work solving problems on the Virtual Genetics Lab software. You will be individually responsible for managing the computer on at least 1 problem in VGL. Work with your team on the problems below but be prepared to explain it yourself. As with any word problem, it is helpful to first write down what you know, then solve for what you know. Make sure your solution to each problem is clear.

1. One version of a gene directs the assembly of an enzyme that breaks down a complex amino acid called phenylalanine into simpler components. Both Ken and Barbie have that version. But the hospital where Barbie has just had their new baby informs them that their daughter Scooter doesn't have it. She only has altered versions of the gene that are incapable of assembling the enzyme correctly. She won't be able to metabolize phenylalanine and will almost certainly become severely mentally retarded if she is not kept on a diet low in that amino acid for the first three years of her life. Write the probable genotypes for all three of them.

2. Achondroplasia, a form of dwarfism, is inherited as a dominant condition. Two dwarfs, both of whom had one parent of normal height, marry and plan to a have child. Their first child is born and is a dwarf. What is the probability that this child is heterozygous for achondroplasia?

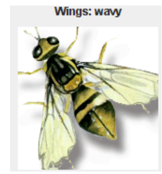
3. A pair of dominant alleles influence coat color in cattle wherein homozygotes for one allele have red coats, homozygotes for the other allele have white coats, and heterozygotes have roan coats that are produced by an intermix of both red and white hairs. When two or more different dominant alleles could occur at the same locus we call them "codominant" since each is fully expressed when present.

   Suppose that you start with a herd of 20 red cows, 40 roan cows, 20 white cows, one red bull, two roan bulls, and one white bull. Understanding that you can choose which bulls will mate with which cows and which will become hamburger, write a plan to manage your herd and achieve the following goals:

a. Maximize the number of roan calves produced. (Could you achieve 100%?)
b. Minimize the number of roan calves produced. (Could you achieve 0%?)
c. Produce only roan and red calves.

4. Red-green colorblindness is a recessive sex-linked trait on the X chromosome. A woman, whose father had red-green colorblindness, marries a man who is colorblind. What is the probability that any son born will have red-green colorblindness?

These instructions and problems are based on an earlier set formulated by Brad Paschal and Michael Bucher.



III. Teamwork in the Virtual Genetics Lab (VGL 1.4.2)

Form a team of no more than three people. Teams will be reporting the results of their most challenging problem solutions.

Use the File>New Problem command (first icon on the left) and locate the folder Skyline VGL. It contains practice problems (names begin with "01") in which the genetic *model is given* (*e.g.* autosomal codominance or X-linked simple dominance). Once you have built some confidence solving problems in VGL and asking your instructor to verify your results, your team will take on the challenge level problems ("02challenge.prb" and "03challenge.prb") in which problems may be simple dominance or codominance, autosomal or sex-linked. Your team will report solutions to 4 Challenge problems.

VGL offers 12 possible genetic models, but we will focus on only 3. A model with a single gene and two alleles may show Simple Dominance (the heterozygote has the same phenotype as the dominant homozygote) or Incomplete Dominance (the heterozygote has a different phenotype than either homozygote, possibly an intermediate). The gene involved might also be located on an autosome or on a sex chromosome so it is inherited differently in different sexes.

The genetic models you might encounter in VGL are:
Model 1: Simple Dominance; Autosomal
Model 2: Co-Dominance; Autosomal
Model 3: Simple Dominance; XX/XY Sex linked
During the ABO blood typing exercise, you will see an example of a different kind of model: a trait involving 3 different alleles.

In solving the VGL problems you should state what genetic model is involved, how you know and draw a Punnett square for a cross that demonstrates the solution (see report sheet). This would include: for a case of simple dominance identifying the dominant and recessive; for a case of incomplete dominance identifying the heterozygous phenotype.

IV. Virtual Genetics Lab Report on Four Different Genetic Problems

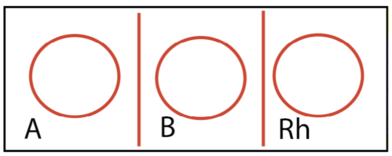
Now you will work in your team to solve 4 random problems generated by VGL. Each time you start the problems called “**02challenge.prb**” and “**03challenge.prb**” a new problem will be generated. Mate flies to determine whether the traits are sex-linked or autosomal, dominant or co-dominant. Give a Punnett square below showing a cross that supports your conclusions. Switch team members between problems so each performs crosses and solves at least 1 question.

You may download VGL for free for additional practice on your computer by going to <u>http://intro.bio.umb.edu/VGL/download.htm</u>

V. Genetics & Your Blood Type

Two different genes work together to determine your blood type. One gene determines if you have A, B, AB or O blood. The other gene determines if your blood is Rh + or –. These blood types differ in the types of protein-carbohydrate molecules that stick off their membranes. Today you will test to see if your blood cells have the A, B, or Rh molecules on their membranes.

1. Use wax pencil to divide a microscope slide into 3 sections. Draw a circle in each section. Flip the slide over. Now label the sections A, B, and Rh.



2. Clean the tip of one of your fingers with an alcohol swab
3. Use a new lancet to prick your finger. Dispose of used lancets in red container!
4. Place a drop of blood in each section of your slide
5. In the “A” section, place a drop of “Anti-A” and mix
6. In the “B” section, place a drop of “Anti-B” and mix
7. In the “Rh” section, place a drop of “Anti-D” and mix
8. View slide on light box and look for *clumping* of blood.
9. The *Anti*body mixtures will cause your blood to clump if they recognize their specific protein-carbohydrate molecule on the surface of your cells.

There are 3 different gene versions (alleles) possible in the ABO gene. O (i) is the recessive version, and A (I^A) & B (I^B) are co-dominant versions. Each of us has 2 copies of the gene: one copy from our mother and one copy from our father. Listing the 2 versions found in your cells gives you your genotype.

Phenotype (blood type)	Genotype	Antibodies in serum
A	**$I^A I^A$** or **$I^A i$**	**Anti-B**
B	**$I^B I^B$** or **$I^B i$**	**Anti-A**
AB	**$I^A I^B$**	**None**
O	**i i**	**Anti-A** and **Anti-A**

Name ________________________

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II. Paper & Pencil Problems

Use the space below to answer the Paper & Pencil Problems

Michael Bucher, College of San Mateo
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Problem File Opened = 02challenge.prb Fly Trait Studied: .... ☐ Autosomal or ☐ X-linked Trait Versions: AA= .... Aa= ....… aa=……………..…. Dominance: ☐ Simple or ☐ Co-dominant These conclusions are supported by the cross and Punnett Square to the right—> (Additional squares on back if necessary) Team Member Performing Crosses ………………………………………	Father's Trait: ……………… Mother's Trait: ……………..
Problem File Opened = 02challenge.prb (open 2nd time for new problem) Fly Trait Studied: .... ☐ Autosomal or ☐ X-linked Trait Versions: AA= .... Aa= ....… aa=……………..…. Dominance: ☐ Simple or ☐ Co-dominant These conclusions are supported by the cross and Punnett Square to the right—> (Additional squares on back if necessary) Team Member Performing Crosses ………………………………………	Father's Trait: ……………… Mother's Trait: ……………..
Problem File Opened = 03challenge.prb Fly Trait Studied: .... ☐ Autosomal or ☐ X-linked Trait Versions: AA= .... Aa= ....… aa=……………..…. Dominance: ☐ Simple or ☐ Co-dominant These conclusions are supported by the cross and Punnett Square to the right—> (Additional squares on back if necessary) Team Member Performing Crosses ………………………………………	Father's Trait: ……………… Mother's Trait: ……………..
Problem File Opened = 03challenge.prb (open 2nd time for new problem) Fly Trait Studied: .... ☐ Autosomal or ☐ X-linked Trait Versions: AA= .... Aa= ....… aa=……………..…. Dominance: ☐ Simple or ☐ Co-dominant These conclusions are supported by the cross and Punnett Square to the right—> (Additional squares on back if necessary) Team Member Performing Crosses ………………………………………	Father's Trait: ……………… Mother's Trait: ……………..

V. Genetics & Your Blood Type

My blood type is: _______

My blood cells have the following glycoprotein complexes on them (circle): A B Rh

I could receive blood donations from people with the following blood types (Note you *cannot* receive blood from someone with surface molecules that you *do not* have):

____

Given your blood type, what could your *genotype* be? ____________________

For you to inherit these genes, what are all the possible *blood types* your *mother (or father)* could have? _________________________

Baby Daddy?

You're watching *Maury* while staying home from school sick one day. There's a mother on the show who is trying to prove that her boyfriend is the father of her son. The boyfriend is also on the show and denies everything. The mother knows that both *she and her son have Type A blood*. Genetic tests are revealed on the show, and the *boyfriend has Type B blood*. The boyfriend immediately rejoices, saying he *knew* the tests would prove he wasn't the father.

From a genetic standpoint, is the boyfriend correct in his conclusion? Explain your opinion and include a Punnett square to prove your point.

Be sure to check your instructor's website for extra credit questions and announcements.