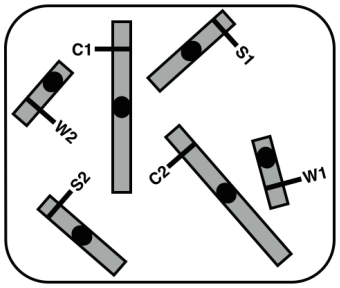
GENETICS PRACTICE QUESTIONS

Please note there are many practice questions spread throughout the genetics lecture notes. Try those too!

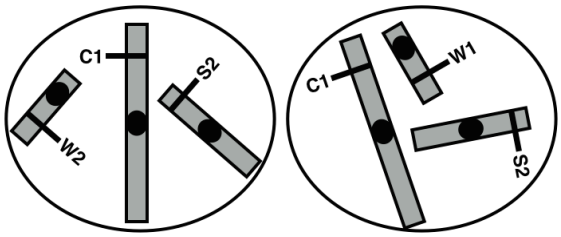
1. In corn, the *colour* gene has two alleles, *C1* and *C2*. *C1* is dominant to *C2* and results in yellow kernels. The *starch* gene also has two alleles, *S1* and *S2*, and *S1* is dominant to *S2* and results in highly starchy corn. Finally, the *wax* gene also has two alleles, *W1* and *W2*. These three genes are on three different chromosomes.

a) A corn plant has the genotype *C1/C2; S1/S2; W1/W2*, as shown in the diagram below.



What is the maximum number of different gamete genotypes that can be produced when a single sex cell from this plant undergoes meiosis? (1 mark)

b) A sex cell from this corn plant undergoes meiosis and produces four gametes. Two of these four gamtes are represented in the diagrams below:



Based on the gametes show above, draw clear diagrams showing the chromosomes of the original corn sex cell that produced these two gametes:

i) at G2 (after DNA replication, before the start of meiosis): (4 marks)

ii) at metaphase of meiosis I, clearly indicating the direction in which the chromosomes will segregate/move: (4 marks)

2.

Yes, this horn shape is about unicorns. It is a ridiculously fake example. The purpose is to practice your genetics problem solving.

You have been hired to investigate the inheritance of horn shape and ear shape in unicorns. Two horn shape phenotypes exist in nature: smooth (the wild-type) and spiral (rare, mutant). For ear shapes there are three known phenotypes: pointy (the wild-type), round (rare, mutant) and blunt (also rare, mutant). Under optimal laboratory conditions, unicorns can produce large litter of about 16 babies.

a) You first focus on horn shape. Under controlled laboratory conditions you set up three crosses (1-3) using six different parent unicorns in total. The results are as follows:

Cross #	Parent unicorns	F1
1.	smooth horn X spiral horn	100% have spiral horn
2.	smooth horn X spiral horn	50% have spiral horn 50% have smooth horn
3.	spiral horn X spiral horn	75% have spiral horn 25% have smooth horn

i) Define the letters or symbols that you use to denote your alleles, then complete the table by assigning genotypes to each of the parent and F1 unicorns from cross 3. (6 marks)

Unicorns	**Genotypes**
First spiral horn parent in cross 3:	
Second spiral horn parent in cross 3:	
Spiral horn F1 unicorns in cross 3:	
Smooth horn F1 unicorns in cross 3:	

ii) What is the dominance relationship between the smooth and spiral horn *phenotypes.* Explain your answers and specifically refer to the data to support your view. (4 marks)

b) You then go on to investigate the inheritance of ear shape by performing five more crosses (4-8) in the lab. The results are reported below.

Cross #	Parent unicorns	F1
4.	pointy ears X pointy ears	100% have pointy ears
5.	pointy ears X round ears	100% have blunt ears
6.	round ears X round ears	100% have round ears
7.	blunt ears X blunt ears	50% have blunt ears, 25% have pointy ears, 25% have round ears
8.	round ears X blunt ears	50% have round ears, 50% have blunt ears

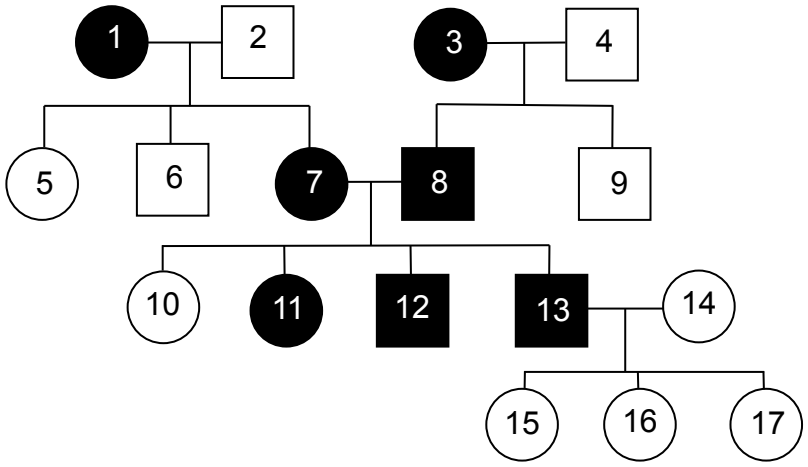
i) Define the letters and numbers you use for each allele, then fill out the table below by assigning genotypes to each of the unicorns listed. (5 marks)

Unicorns	**Genotypes**
Pointy ears parent in cross 5:	
Round ears parent in cross 5:	
Blunt ears F1 unicorns in cross 5:	
Round ears parent in cross 8:	
Blunt ears F1 unicorns in cross 8:	

ii) What are the dominance relationships among *the alleles* that you defined in part i)?
Explain your answers and specifically refer to the data to support your view. (4 marks)

c) In a further investigation you set up a cross between two unicorns homozygous for both traits; one has a spiral horn and pointy ears and the other has a smooth horn and round ears. You then take males and females F1 individuals from this cross and mate them together to obtain a F2. What are the expected phenotypes and their proportions in this F2? Show all your work for full credit. (6 marks)

3. For this pedigree, determine the mode of inheritance and the possible genotypes for each individual. Assume the alleles B1 and B2 control the expression of the trait.
(16 marks total)



a.

	Possible or impossible?	**If impossible:** provide support for your answer making specific reference to the relevant individuals in the pedigree.
Autosomal dominant		
Autosomal recessive		
X-linked dominant		
X-linked recessive		

b. Define which of the two alleles (B1 or B2) is the dominant allele.

Give the possible genotype/s for the following individuals: **(3 marks)**

3 ___ ___ 6 ___ ___ 8 ___ ___

10 ___ ___ 11 ___ ___ 13 ___ ___

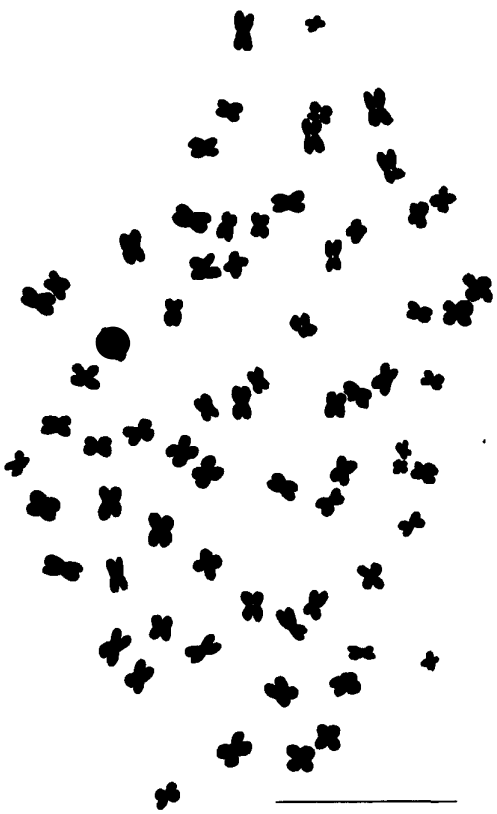
c. If individuals 13 and 14 have a 4th child, what is the probability that it will be an affected son? State the genotypes of both parents and the child. **(3 marks)**

4. The image on the right shows all 68 chromosomes from one root tip cell of a plant called *Campanula rotundifolia* after DNA replication.

a) How many chromatids does one of these chromosomes have?

b) How many DNA double helices is each one of chromosomes made of? (1 mark)

c) It is very difficult to recognize homologous chromosomes on the picture, but knowing that *Campanula rotundifolia* is diploid, how many pairs of homologous chromosomes are present in one of its root tip cells? (1 mark)



5. Ben and Todd are brothers. Todd has a tendency to speak very loudly on his cell phone on the bus (we'll call this phenotype "annoying loud talker". Ben talks very quietly on his cell phone on the bus ("not annoying"). A geneticist wonders if this trait is genetic. He compares the genome sequences of Ben and Todd, looking for differences in sequences known to be involved in two behaviours: 1) voice volume, and 2) self-consciousness.

a. Propose at least 3 different possible results of the sequence comparisons that might suggest that "annoying loud talking" is a genetic trait? Note that you can make wild assumptions about gene function if that helps in your explanation (although it is not necessary).

b. Upon completing the DNA sequence comparison they find that Ben and Todd do not have any different alleles of the genes involved in voice volume or self-consciousness. However, they do notice that Todd has three copies of a gene involved in a *lack* of self-consciousness. Why is this unusual, and how could these three gene copies explain his "annoying loud talker" phenotype?

6. In hogs, a dominant allele *B* results in a white belt around the body (phenotype is called belted) and *b* results in unbelted. At a separate locus the dominant allele *S* causes fusion of the two parts of the normally cloven hoof resulting in a condition known as syndactyly, and the recessive allele, *s*, causes hoofs to be cloven.

a. Summarize what you know about the genes and alleles (dominance relationships), by clearly defining genes and alleles:

b. A belted syndactylous female was crossed to an unbelted cloven-hoofed male, and in the litter there were:

18 belted syndactylous
21 belted cloven
19 unbelted syndactylous
20 unbelted cloven

Analyze the offspring phenotypes and proportions. What are the genotypes of the parents and offspring? Show all of your work, especially the work you have done to prove that your predicted parent genotypes can give the offspring phenotypes and proportions above.

c. From the offspring given in part b, if two belted syndactylous animals were mated, what would you expect if there were 112 F2s? (phenotypes and number of each)

d. Now imagine that the B and S genes were very close together on the same chromosome, such that no crossing over happens between them. You have two heterozygotes, as in part c, that mate and generate 112 F2. If one of the heterozygotes is BS/bs and the other is Bs/bS how do you expect the F2 phenotype numbers to change?

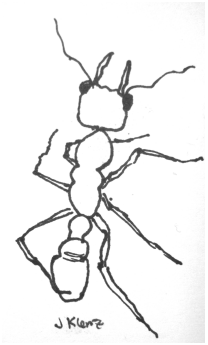
7. In a maternity ward, four babies become accidentally mixed up. The ABO phenotypes of the four babies are known to be: baby #1 O, baby #2 A, baby #3 B, and baby #4 AB. The ABO phenotypes of the four sets of parents are:

Parents:
(a) AB × O
(b) A × O
(c) A × AB
(d) O × O

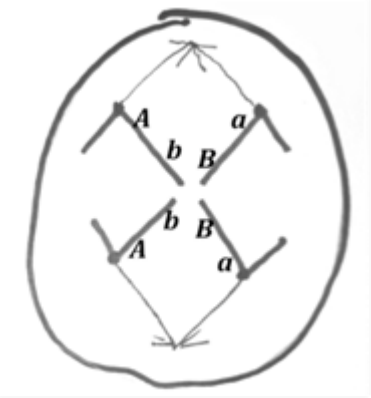
a. Analyze this information to predict which parental set (a-d) could be the parents of each baby. Show your work, and then complete the table below. Use the following symbols for alleles: O – i^O, A – i^A, B – i^B, remember that the dominance relationship is A>O, B>O, A and B are not dominant to one another (blended/see both)

Phenotype	Genotype or possible genotypes	Possible parental set(s):
Baby #1 - O		
#2 – A		
#3 – B		
#4 - AB		

c. Draw a cell from an AB parent before DNA replication, after DNA replication, and in metaphase of meiosis I (homologous chromosomes lined up to separate). Label chromosomes with alleles, chromatids, homologous pairs. What are the resulting gamete genotypes, and in what proportions, from this meiotic division?



8. The jack jumper ant (*Myrmecia pilosula)* is 2n = 2. An ant has the genotype *aB/Ab* (the A and B loci are on the same chromosome). It was produced from two pure-breeding parents with the genotypes *aB/aB* and *Ab/Ab* respectively.



i) Based on the structures separating in this figure to the left, what stage of **meiosis** is cell this.

ii) Given your answer to part i, and knowing that the genotype of our 2n=2 jack jumper ant, what is incorrect about this cell, and what, if anything is correct.

b) For the stage shown in a) draw what the meiotic cell SHOULD correctly look like for the ant described above. (3 marks)

9. The ability to taste the chemical phenylthiocarbamide is an autosomal dominant phenotype, and the inability to taste it is recessive. A taster woman with a non-taster father marries a taster

man who, in a previous marriage, had a non-taster daughter. The taster man and woman are going to have a child. What are the possible genotypes and phenotypes, including probabilities, of their child?

10. Loppins (*Loppinicus loopy*) are fictitious, but very useful diploid invertebrates with a total of 6 chromosomes in their somatic cells. Of those 6 chromosomes, 4 are autosomes and 2 are sex chromosomes. Like humans, male loppins are XY while females are XX.

The gene that determines loppins' blood type is called *bt* and is on chromosome 1, the gene that determines the presence or absence of eyelashes is called *eye* and is on chromosome 2, and the gene that determines ability to digest cellulose is called *cel* and is on the X chromosome.
bt^A, bt^B; eye^W, eye^D, *celWT* and *celM* are alleles of these three genes.

a) A female loppin is a triple heterozygous with the genotype bt^A/bt^B; eye^{WT}/eye^D; X^{celWT}/X^{celM}. Her mother was homozygous for bt^A, for eye^D and for *celWT*.
Draw a somatic cell of our triple heterozygous female loppin in G1 stage of the cell cycle (that is, before DNA replication). Make sure that the chromosomes are properly drawn and clearly label all the relevant genes and alleles. **(4 marks)**

b) What alleles did the triple heterozygous female loppin inherit from her mother, and what alleles did she inherit from her father? **(2 marks)**

c) For research purposes you remove three meiocytes from the triple heterozygous female, you let them undergo meiosis, and you analyze the genotype of the gametes that are produced. The first

meiocyte produces two gametes of genotype bt^{A}; eye^{WT}; X^{celWT} and two gametes of genotype bt^{B}; eye^{D}; X^{celM}.

i) Draw this meiocyte at metaphase of meiosis I (this is when the homologous chromosomes are paired and lined up in the centre of the cell). Make sure to clearly label all the relevant genes and alleles. **(3 marks)**

ii) The second meiocyte produces two gametes of genotype bt^{B}; eye^{WT}; X^{celWT} and two gametes of genotype bt^{A}; eye^{D}; X^{celM}. Explain what must have happened differently in this meiocyte compared to the one in part i) to produce this result. You may refer to the diagram that you drew above to illustrate your rationale. **(1 mark)**

iii) If we looked at the gametes produced by 100 different meiocytes from this triple heterozygous female loppin, what are all the genotypes that we would expect to find, and in what proportions? *(Note: 100 different meiocytes will produce a total of 400 gametes)*

11. ABO blood type in mice is similar to that in humans where there are 3 alleles of the I gene: $I^{A} = I^{B} > i$, where the first two alleles are co-dominant to each other and both are dominant

to the recessive i allele (when homozygous results in blood type O). Two mutant mice of blood type AB are obtained from the same litter and mated.

a. What are the expected results obtained from repeated crosses of these two mice in terms of ABO blood types?

b. A tough one!
Repeated crosses between the two mice, each with blood type AB, gave the following phenotypic ratios of:

3/16 type A
4/16 type O
3/16 type B
6/16 type AB

Based on your analysis of the data provide a detailed explanation for the resulting phenotypes and ratios observed in the progeny of the cross including complete genotypes of both the original parents and their progeny. Show your work.

12. A mutant allele in mice causes a big ears. Six pairs of mice were crossed. Their phenotypes and those of their progeny are given in the following table. N is normal phenotype; B is big ears phenotype. The symbol with the upward arrow is male, the symbol with the circle and + is female.

	Parents		*Progeny*	
Cross	♀	♂	♀	♂
1	N	B	All B	All N
2	B	N	1/2B, 1/2N	1/2B, 1/2N
3	B	N	All B	All B
4	N	N	All N	All N
5	B	B	All B	All B
6	B	B	All B	1/2B, 1/2N

a. What is your hypothesis about the inheritance of the big ears trait (mode of inheritance, dominance relationships). Explain what data you have used to formulate this hypothesis. Be sure to define gene and allele symbols.

b. What is the genotype of the parent mice for cross #6?

c. If you only had cross 2 would you have come to the same conclusion? Explain.