EXTENSION - GENETICS AND EVOLUTION EXAM REVISION SOLUTIONS

DNA	Deoxyribonucleic Acid – a polymer comprised of nucleotide monomers. DNA is found in the nucleus of living cells and contains the code for genes.
gene	A segment of DNA that codes for the production of a particular protein; these proteins produce our characteristics.
allele	An alternative form of a gene, resulting in a different trait. E.g. different alleles coding for different eye colour – blue or brown. Same gene; different alleles.
chromosome	Long strands of DNA wound around histone proteins.
diploid	Having a double set of chromosomes. Most cells in the human body have 46 chromosomes (23 pairs); this is the diploid number; represented as "2n".
haploid	Having a single set of chromosomes. Gametes in humans, have only 23 chromosomes, NOT 46. "23" is the haploid number in humans, represented as "n".
Interphase	The stage of a cell's life cycle that most cells are experiencing. Non-dividing stage. Cell undergoes growth and replication of the DNA.
Replication	DNA is replicated (copied) prior to cell division. The process of copying a cell's DNA is termed "replication"
Centriole	An organelle in animal cells only that produces spindle fibres for cell division.
Centrosome	The combination of centrioles and their spindle fibres.
Centromere	The point at which chromatids join on a chromosome.
Chromatid	One of the replicant arms on a chromosome.
Homologous Chromosomes	A pair of chromosomes of the same number; For example, both #21 chromosomes; one of each pair comes from the individual's biological mother, and the other comes from the individual's biological father.
Autosomal trait	A trait that is inherited from a chromosome that is not one of the X or Y chromosomes.
Mitosis	Cell division enabling the repair, growth and maintenance of an organism. It results in two diploid daughter cells.
Meiosis	Cell division enabling the production of haploid gametes (sperm and ova). Each daughter cell contains half the chromosome number as the parent cell. Only occurs in testes or ovaries

	(gonads).
2n	The diploid number (46 in humans).
n	The haploid number (23 in humans).
crossing over	A process that only occurs during meiosis where homologous chromosomes swap adjacent sections/ genes.
Karyotype	A photographic representation of all the chromosomes from a human cell.
Karyokinesis	Division of the nucleus
sex chromosomes	Most individual have a pair of sex chromosomes; females have two X-chromosomes (XX) and males have one X- and one Y-chromosome (XY).
Cytokinesis	Pinching off of the Cytoplasm during cell division to the point where it separates into two cells.
Nucleotide	The basic unit from which DNA is composed - a nucleotide is composed of deoxyribose sugar, a phosphate and one of four nitrogen bases.
Template	A pattern for the construction of an item; the original, parent strands of the DNA is the template strand.
Complement	Something that makes up or completes another thing; nitrogen bases are said to be complementary. The complement DNA strand is the replicated strand.
Incomplete dominance	Two organisms may show this when breeding for colour for example - it results in a blend of two colours. E.g. pink snapdragons.
Co dominance	Two organisms may show this when breeding for colour for example - it results in a patches or spots of the two colours. E.g. Tortoise shell cats.
Species	Two organisms are said to be of the same species if they can interbreed to produce fertile offspring.
Mutant	The individual that has a mutation.
Mutagen	The process, or influence that produces a mutation; UV radiation is a mutagen for skin cancer.
Mutation	A change in the DNA sequence caused by mutagens producing changed characteristics; the vast majority (all except for 1 minor mutation) are damaging.
Epigenetics	The study of the way in characteristics are inherited
Evolution	The process that explains the development of species through natural selection by way of beneficial mutations

heterozygous (hybrid)	Having two different alleles for a particular gene. E.g. (Aa)
Homozygous (true breeding)	Having two of the same alleles for a particular gene. E.g. (AA or aa)

Explain, using diagrams, all the phases that a cell that is dividing by the process of mitosis will go through in its cell cycle**. Chromosome number 2n = 4**

<u>INTERPHASE:</u> DNA REPLICATES, MAKES AN IDENTICAL COPY	
MITOSIS – PROPHASE Nuclear membrane disappears. Chromosomes become visible. Spindle forms and chromosomes attach to spindle	
METAPHASE Chromosomes align in the middle of the cell.	
ANAPHASE Centromeres split and chromatids (daughter chromosomes move to opposite poles of the spindle)	
TELOPHASE Chromosomes coil up into a double helix again. Nuclear membrane reforms around chromatin network. Cytoplasm divides into two	

1. When will a cell undergo **meiotic cell division?**

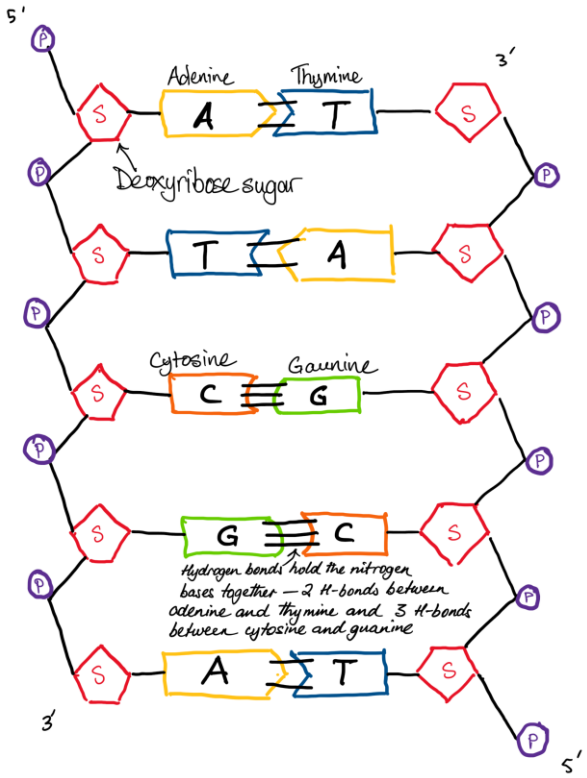
To produce sex cells (gametes)

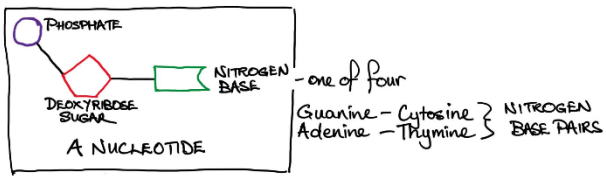
2. List 5 ways in which meiosis differ from mitosis.

MITOSIS	MEIOSIS
Required for growth and repair.	**Required to produce sex cells.**
One cell division occurs.	**Two cell divisions occur.**
Two genetically identical cells are produced.	**Four genetically different cells are produced.**
Two new cells contain the diploid (complete set of chromosomes).	**Four new cells contain haploid (half the number of chromosomes).**

3. What does DNA stand for?
   Deoxyribonucleic acid

4. Sketch a labeled diagram of DNA molecule. (Use pencil)





5. Why does a cell need to replicate its DNA?

   To make identical copy of its genetic material, in order to ensure there is enough genetic material available for new daughter cells when a cell divides.

6. During which phase of a cell's life cycle will a cell replicate its DNA?

   Interphase

8. . Outline, stating examples, the difference between monogenic inheritance, codominant inheritance, incomplete dominant inheritance and X-linked inheritance.

Monogenetic: **Mono – one, gene – characteristic or trait. Monogenetic is inheritance of one characteristic.**

Codominant inheritance : **Both alleles (codes for a specific gene) will be expressed e.g. white flower crossed with a red flower will give you a red and white flower.)**

Incomplete dominance : **Blending of alleles e.g. a red and white flower will give you a pink flower.**

Sex-linked or X-linked inheritance : **The code for a specific gene (characteristic) is found on a sex chromosome, usually the X chromosome in humans because the Y chromosome is too small to carry any more traits than those that determine male characteristics.**

9. . Use a punnett square to explain what happens when red and white flowers are crossed during codominance.

R – red **P1 RR X WW**

W- white

F1

	R	**R**
W	**RW**	**RW**
W	**RW**	**RW**

Genotype: 100% RW

Phenotype: 100% red and white

10.. Use a punnett square to explain what happens when red and white flowers are crossed during incomplete dominance.

R – red **P1 RR X WW**

W- white

F1

	R	**R**
W	**RW**	**RW**
W	**RW**	**RW**

Genotype: 100% RW

Phenotype: 100% pink

11. Determine the possible genotypes and phenotypes of the offspring if two heterozygous bronze turkeys are crossed, given that in turkeys bronze colour is dominant to red colour.

B = bronze **P1 Bb x Bb**

b = red

F1

	B	**b**
B	**BB**	**Bb**
b	**Bb**	**bb**

Genotype: 25% BB: 50% Bb : 25% bb

Phenotype: 75% Bronze : 25% red

12. In fowls, red plumage is recessive to black plumage. Determine the possible offspring genotypes and phenotypes if a heterozygous black fowl is crossed with a red fowl.

B = black **P1 Bb x bb**

b = red

F1

	B	**b**
b	**Bb**	**bb**
b	**Bb**	**bb**

Genotype: Bb 50% : bb 50%

Phenotype: 50% Black : 50% red

13. In cattle, the horned cattle are recessive to no-horned cattle. What are the probabilities of offspring genotypes and phenotypes if a homozygous recessive horned bull is crossed with a heterozygous no-horned cow?

H = No horned **P1 Hh x hh**

h = horned

F1

	H	**h**
h	**Hh**	**hh**
h	**Hh**	**hh**

Genotype: Hh 50% : hh 50%

Phenotype: 50% horned : 50% no horned

14. Determine the possible genotypes and phenotypes of the offspring if two heterozygous red tomatoes are crossed, given that in tomatoes red coloured fruit is dominant to yellow coloured fruit.

R = red **P1 Rr x Rr**

r = yellow

F1

	R	**r**
R	**RR**	**Rr**
r	**Rr**	**rr**

Genotype: Rr 50% : rr 25% : RR 25%

Phenotype: 75% Red : 25% yellow

15. In guinea pigs, a homozygous dominant yellow crossed with a homozygous white produce cream coloured offspring. Determine the possible genotypes and phenotypes of the offspring if a cream coloured guinea pig is crossed with a yellow coloured.

Dominance type: **Incomplete dominance**

Y = yellow **P1 YW x YY**

W = white

F1

	Y	**Y**
Y	**YY**	**YY**
W	**YW**	**YW**

GENOTYPE: 50 % YW: 50% YY

PHENOTYPE: 50% Cream : 50% yellow

16. In pigs, a homozygous black crossed with a homozygous white produce black-and-white coloured piglets. Determine the possible genotypes and phenotypes of the offspring if a black-and-white pig is crossed with a black coloured pig.

Dominance type: **CO DOMINANCE**

B : BLACK **P1** **BW X BB**

W: WHITE

F1

	B	**W**
B	**BB**	**BW**
B	**BB**	**BW**

GENOTYPE: 50% BW : 50% BB

PHENOTYPE: 50% BLACK : 50% BLACK AND WHITE

17. In four-o'clock plants, if a homozygous red flowered plant is crossed with a homozygous white flowered plant, the offspring have pink flowers. Determine the genotypes and phenotypes of the offspring if a pink flowered four-o'clock plants is crossed with a red flowered plant.

Dominance type: **INCOMPLETE DOMINANCE**

R = RED P1 RR X RW

W = WHITE

F1

	R	**R**
R	**RR**	**RR**
W	**RW**	**RW**

GENOTYPE: 50% RR : 50% RW

PHENOTYPE: 50% RED : 50% PINK

18. In short-horned cattle, a homozygous red crossed with a homozygous white produce "roan" (white and red haired) offspring. Determine the possible genotypes and phenotypes of the offspring if a pure-breeding, red coated short-horned bull is crossed with a roan coated, shorthorn cow.

Dominance type: Co-dominance

R = RED **P1 RR X RW**

W = WHITE

F1

	R	**R**
R	**RR**	**RR**
W	**RW**	**RW**

GENOTYPE: 50% RR : 50% RW

PHENOTYPE: 50% RED : 50% ROAN

19. In humans muscular dystrophy is a sex-linked disease which is recessive. Determine the possible genotypes and phenotypes of the offspring if a normal man marries a woman who suffers from the disease.

X^D - NORMAL **P1 X^DY x X^dX^d**

X^d - muscular dystrophy

F1

	X^D	**Y**
X^d	**X^DX^d**	**X^dY**
X^d	**X^DX^d**	**X^dY**

Genotype: females 100% X^DX^d : males 100% X^dY

Phenotype: females 100% normal: males 100% muscular dystrophy

20. In humans muscular dystrophy is a sex-linked disease which is recessive. Determine the possible genotypes and phenotypes of the offspring if a normal man marries a woman carrier.

X^D - NORMAL **P1 X^DY x X^DX^d**

X^d - muscular dystrophy

F1

	X^D	Y
X^D	X^DX^D	X^DY
X^d	X^DX^d	X^dY

Genotype: females 50% X^DX^d : 50% X^DX^D : males 50% X^dY: 50% X^DY

Phenotype: females 100% normal : males 50% normal: 50% muscular dystrophy

21. In humans colour blindness is a sex-linked disease which is recessive. Determine the possible genotypes and phenotypes of the offspring if a normal man marries a colour blind woman.

X^C - NORMAL **P1 X^CY x X^cX^c**

X^c - colour blind

F1

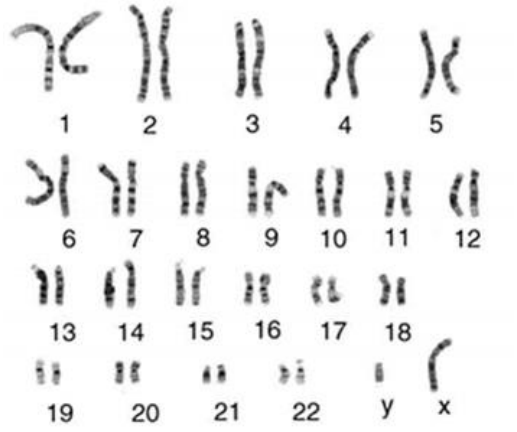
	X^C	Y
X^c	X^CX^c	X^cY
X^c	X^CX^c	X^cY

Genotype: females 100% X^CX^c : males 100% X^cY

Phenotype: females 100% normal: males 100% colour blind

Question 22 refers to the diagrams below

A



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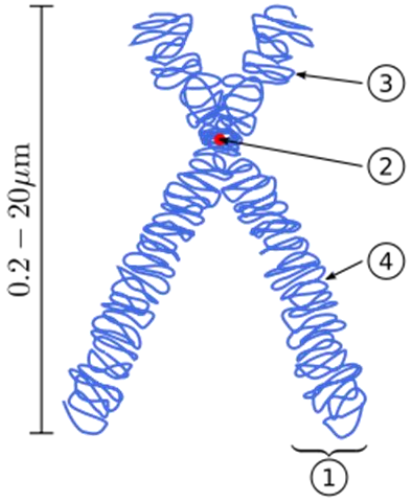

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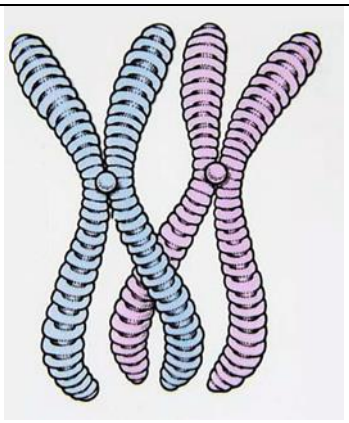

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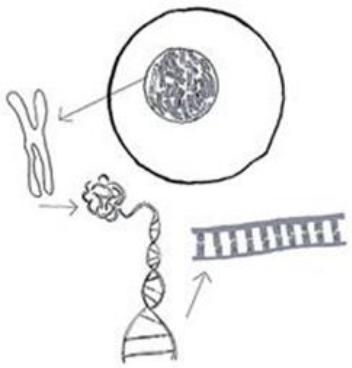


23.

a) Which of the images shows a homologous pair of chromosomes? **C**

b) Which of the images shows a karyotype? **A**

c) In a root cell of a pea plant there are 14 chromosomes. How many chromosomes would there be in the nucleus of a pollen grain of a pea plant? **7**

d) What causes most of the variation between individuals of the same species?

Sexual reproduction, process of meiosis produces sex cells that are genetically different.

24. Use the following information to answer questions (a) to (h).

The gene for long eyelashes is dominant to the gene for short eyelashes. A man who is heterozygous for eyelash length marries a woman who is also heterozygous for eyelash length. **L long: l short**

a) What is the woman's genotype? **Ll**

b) What is the probability that their child will have long eyelashes? Show working.

L = long **P1 Ll X Ll**

l = short

F1

	L	**l**
L	**LL**	**Ll**
l	**Ll**	**ll**

GENOTYPE: 25% LL : 50% Ll : 25% ll

PHENOTYPE: 75% long : 25 % short

c) The couple has two children with short eyelashes. What is the probability that their third child will also have short eyelashes?

25% always the same probability

d) Who determines the gender of a child? Explain with reasons.

The father, he has a "X" and a "Y" chromosome to contribute. Mother has only got "X" chromosome. If father gives "X" it is a girl and if he gives "Y" it will be a boy.

e) If a person has two identical genes for a particular trait, what are the genes referred to as?

homozygous

f) What is the main difference between autosomal and sex chromosomes?

Autosomal chromosomes code for similar characteristics in male and female and sex chromosomes determine sex of an individual.

g) Name the smallest piece of genetic material which has the instructions for one characteristic, like wide nostrils. **gene**

h) What causes differences between identical twins? **Environment e.g. diet**

25. What is a mutation?
Quick sudden change in the DNA code of an organism.

26. What is a mutagen **This is a substance that can cause a mutation.**
Give examples of mutagens : **UV light, radiation, chemicals**

27. Explain the difference between a mutation and epigenetics.

In a mutation the DNA code changes,

In epigenetics the DNA code does not change, but something in the environment can cause the code to be expressed differently e.g. diet

28. Define Evolution: **Evolution is the change of the allele frequency of the genepool of a population over a very long time.**

29. Gene: **It is a code for a specific characteristic**

Allele: **It is a different expression of a gene: Eg. for gene Blood type can have 3 alleles: A, B or O**

Chromosome **: Linear collection of genes**

Genepool: **The collection of all the alleles within an interbreeding population.**

30. Name and explain (five) mechanisms that can contribute towards process of evolution.
Mutations, natural selection, founder effect, genetic drift, immigration and emigration

a) Mutations: Quick sudden change in the genetic code of DNA, caused by mutagens e.g. UV light

b) Immigration and emigration: (gene flow) The loss or addition of individuals to a population will bring or take away alleles from a genepool.

c) Founder effect: Group of individuals that separate themselves deliberately form main breeding population and do not interbreed with them. They might not have all the alleles that the main population has and therefore alleles in genepool are restricted.

d) **Genetic drift: Caused by non- selective factor e.g. major disaster e.g. earthquake wipe out individuals of a population at random and with that certain alleles could be lost that would have enabled them to survive in the aftermath of the disaster. Hence, genetic drift, do not know which alleles will be expressed.**

e) **Natural selection: When a population is put under pressure (selective pressure) and something vital changes in their environment e.g. food shortage or predator (selective agent) moves into their community, some individuals will starve or get caught but there could be some that have favorable genes that can enable them to survive or outrun the predator. Therefore "survival of the fittest" and they can transfer favorable alleles to their offspring.**

31. Explain how the process of natural selection can contribute to a bacteria becoming resistant to antibiotics.

In a population of bacteria there is variation.
Most bacteria will die when exposed to an antibiotic, but a few will survive.
The antibiotic is called the "agent of selection" because those that die are selected against by the antibiotic.
Those that survive begin to reproduce passing their resistance genes on to offspring.
The population continues to reproduce until most members are resistant to the antibiotic.
The next time the population comes into contact with the antibiotic, most bacteria will survive and only a few will die.

32. Explain how the process of speciation creates two separate species from one. You may use diagrams.

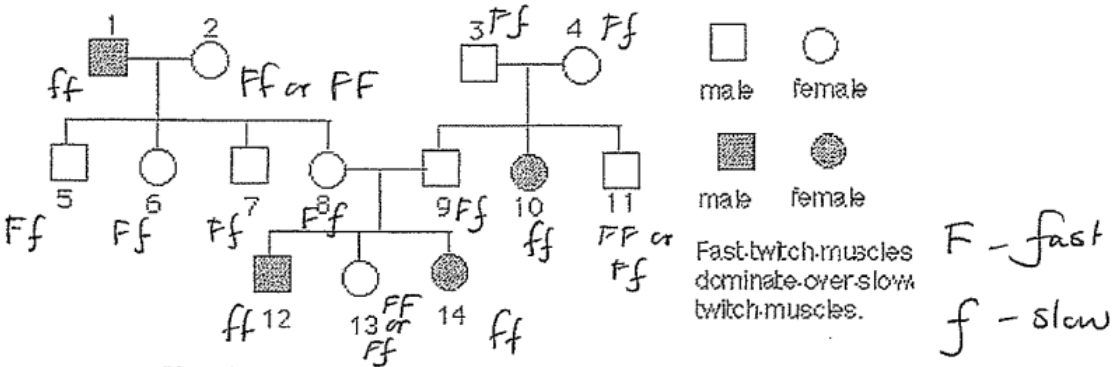
1. **Variation -** there is allele variation within a gene pool of a population due to
   i. *Favourable mutations and*
   ii. *Sexual reproduction (through genetically unique gametes)*.
2. **Geographic Isolation occurs e.g. Allopatric speciation** is caused by a Geographical barrier causing permanent separation of a group of individuals from the parent population. The population becomes reproductively isolated from parent population and reproduction is no longer possible – gene flow ceases between the two groups.
3. **Natural selection occurs independently in the groups that have become separated:** different selection pressures (e.g. unavailable food sources, predators) in each of the populations cause changes in the allele frequencies independently. Each population will be exposed to the different selection pressures independently. Creates a struggle for existence – survival of the fittest. This causes a change in the allele frequencies of certain alleles in the population.

   Two groups may undergo evolution independently (i.e. changes in allele frequencies of gene pools). Because the populations are now smaller, this may allow random genetic drift; certain alleles become more common for no apparent reason (i.e. **not** caused by natural selection)
4. **Reproduction** – There is an increase in the frequency of these newly favoured alleles in the population through reproduction as those that are now able to survive pass on their selectively advantageous alleles to the next generation.
5. **Speciation –** eventually the gene pools and the phenotypes of both populations become so different that, if the geographical barriers were removed, they would not be able to interbreed under natural circumstances to produce fertile offspring, and would therefore be considered two separate species.

.. Pedigree Charts:

In genetics, traits can be traced over several generations similar to a family tree. This family tree is called a Pedigree chart. Pedigree charts are useful in gathering background genetic information that can be used for medical reasons. Horse race enthusiasts also rely heavily on pedigree charts to predict a horse's success. sWhen interpreting pedigree charts remember square are male and circles are females

1. Use the below pedigree chart to answer the following three questions. Muscle type is not a sex linked characteristic. Assume slow twitch - shaded



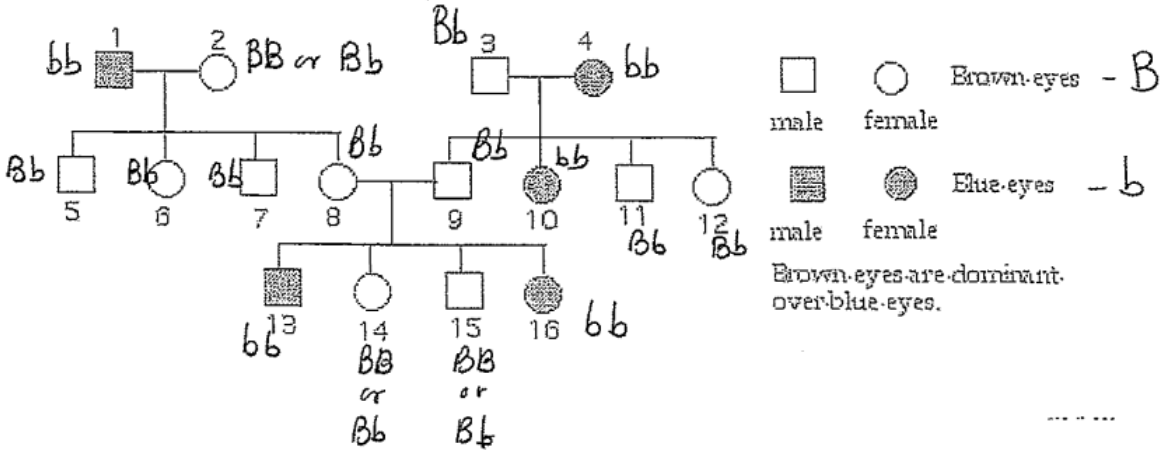
a. Place the genotypes of each individual below its symbol.

b. What is the genotype of individual #3 and 4?.

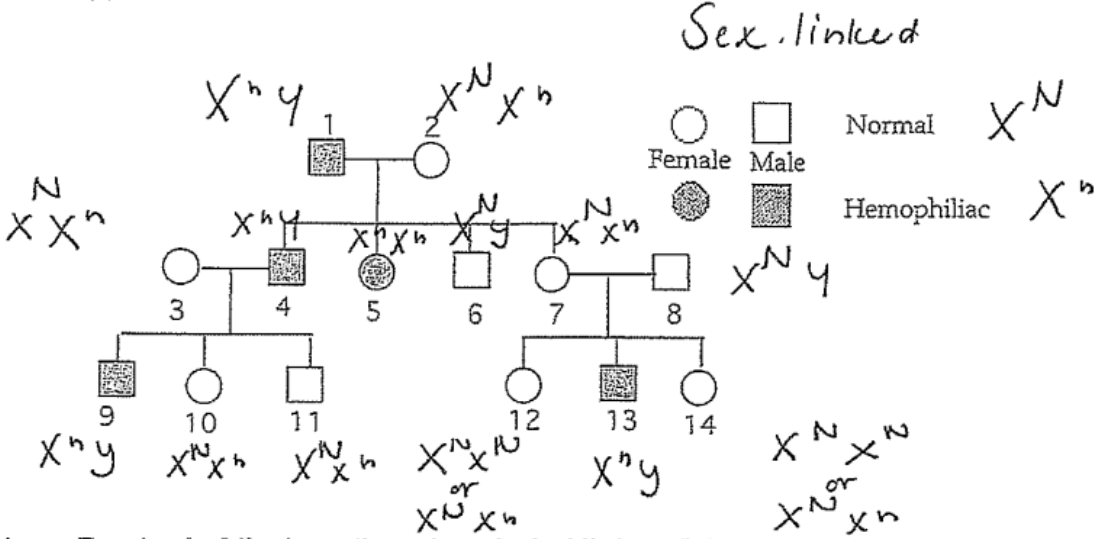
c. Can either individual #8 or 9 be homozygous?
No; produce offspring with recessive trait; must both be carriers.

d. Explain the family relationship that #12 has with #2. 2 is grandmother of 12

2. Label the genotype for each of the individuals below its symbol on the pedigree chart (note: eye color is not a sex-linked trait).



3. List the possible genotypes of the following hemophilia pedigree chart below. Remember hemophilia is a sex linked trait that is caused by a recessive allele, therefore you must denote the individuals sex chromosomes (X^nX^n and X^nY or Nn and nY) as well as the hemophilia allele (n).



4. Examine the following pedigree chart of color-blindness. In humans, color blindness is caused by a recessive sex-linked allele. On the diagram, label the genotypes of the individuals 1-16.