Grade 12 LS Biology notes

Genetic Risk

How to determine the risk of a fetus to be diseased?

Autosomal diseases

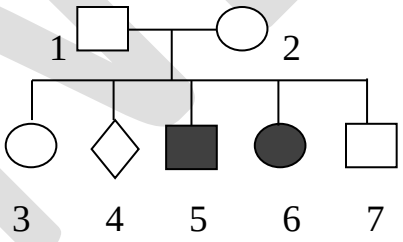
➢ Case A: If the real genotypes of the parents of the fetus are determined.

1st method: Determine (indicate + justify) the genotypes of the parents. Then make factorial analysis and a punnet square and find out the ratio for having diseased offsprings.

2nd method: Determine (indicate + justify) the genotypes of the parents of the fetus.
Chance of the fetus to receive diseased allele from the father =
Chance of the fetus to receive diseased allele from the mother =

Then the risk = ratio of the allele taken from paternal origin (paternal gamete) X ratio of the allele taken from maternal origin (maternal gamete)

Example 1: autosomal disease, N>d



1st method:

Both parents 1 and 2 are normal and they got diseased children 5 and 6 with genotype dd (recessive is always expressed as pure), these children should receive the diseased allele from both parents. Then parents have allele d in addition to allele N.

Phenotypes of parents : Normal x normal
Genotypes of parents: Nd x Nd
Gametes : ½ N ½ d x ½ N ½ d

	½ N	½ d
½ N	¼ NN	¼ Nd
½ d	¼ Nd	¼ dd

The genetic risk for the fetus to be diseased is ¼

2nd method:

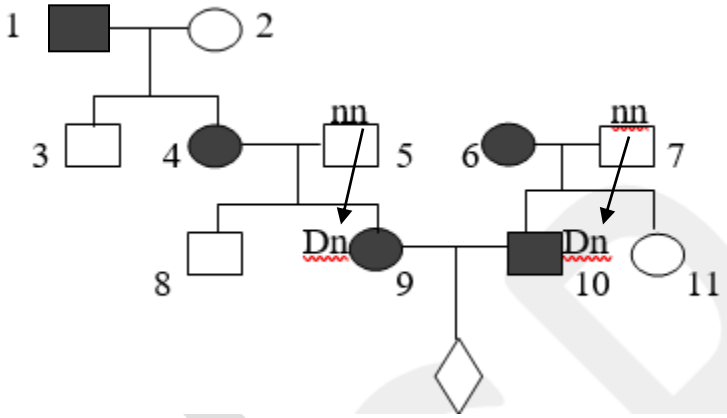
Parents 1 and 2 are normal and they got diseased children 5 and 6 with genotype dd (recessive is always expressed as pure) and these children receive the diseased allele from their parents. Then the parents have diseased allele in addition to normal allele. Therefore the genotype of the parents is Nd.

The chance for the fetus to get diseased allele d from the father is ½

The chance for the fetus to get diseased allele d from the mother is ½

The genetic risk of offspring to be affected = ½ x ½ = ¼

Example 2: Autosomal, D>n



Parent 9 has genotype Dn since she has a normal father 5 with genotype nn (recessive is always pure) then she receives the recessive allele n from her father and dominant allele D from her mother 4. Similarly for parent 10 that is hybrid Dn .
Therefore , both parents are hybrid

Phenotypes of parents : diseased x diseased

Genotypes of parents: Dn x Dn

Gametes : ½ D ½ n x ½ D ½ n

	½ D	½ n
½ D	¼ DD	¼ Dn
½ n	¼ Dn	¼ nn

Then risk of offspring to be affected ¾

➢ Case B: If the real genotypes of the parents of the fetus Can Not be determined (not sure).

I. If the parents have family history.

Find the chance for the parents to be carriers of the disease by making factorial analysis and punnet square for the grandparents with justification of the genotypes of grandparents.

Then risk=

(Probability of the father to be hybrid X ratio of diseased allele from father) X (Probability of the mother to be hybrid X ratio of diseased allele from mother)

II. If the parents don't have family history.

There should be given the frequency of hybrid (heterozygous) in a population

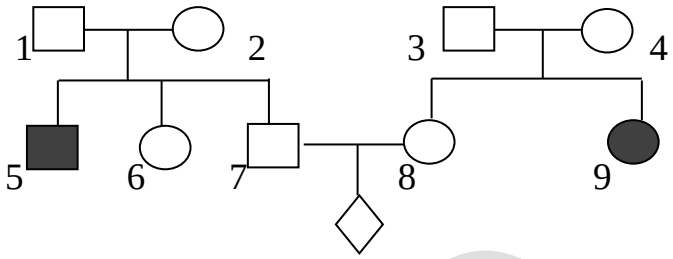
Since there is no family history, we consider the frequency of heterozygous in a population.

Then risk of offspring to be affected=

(Frequency of heterozygous in a population for the father X ratio of diseased allele from father) X (Frequency of heterozygous in a population for the mother X ratio of diseased allele from mother)

Example 1: autosomal, N>d

Both parents have family history



If one of the parents 7 or 8 is pure having genotype NN, then this parent will give allele N to the fetus and allele N is dominant and expressed. Then there will be no risk for the fetus to be diseased if one of the parents is pure NN. (zero risk).

If both parents 7 and 8 are hybrid;
The parents of individuals 7and 8 are hybrid since they got diseased children 5 and 9 respectively with genotypes dd (pure recessive). These children should receive diseased allele from their parents. Therefore the parents 1,2, 3, and 4 have genotype Nd.

	½ N	½ d
½ N	¼ NN	¼ Nd
½ d	¼ Nd	¼ dd

The chance for individuals 7 and 8 to be hybrid is 2/3

Note for you(there are 3 normal but only 2 are hybrid, we don't count the diseased since parents are normal)

The chance for the fetus to get diseased allele from the father is ½

The chance for the fetus to get diseased allele from the mother is ½

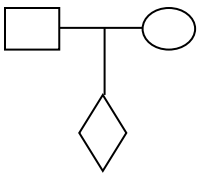
The chance for the mother to be hybrid is 2/3

The chance for the father to be hybrid is 2/3

The genetic risk = $(\frac{1}{2})\ (2/3)\ \text{x}\ (\frac{1}{2})\ (2/3) = 1/9$

Example 2: autosomal, N>d, the frequency of hybrid individuals in a population is 1/ 30

Both parents don't have family history



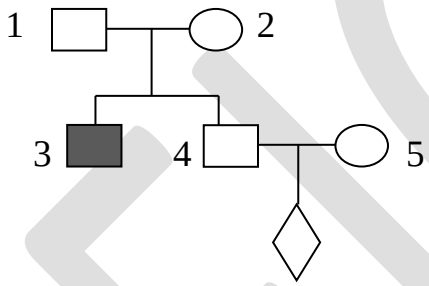
If one of the parents is pure having genotype NN, then this parent will give allele N to the fetus and allele N is dominant and expressed. Then there will be no risk for the fetus to be diseased if one of the parents is pure. (zero risk).
If both parents are hybrid and there is no family history then we have to consider the frequency of hybrid individuals in a population which is 1/30

The chance for the fetus to get diseased allele from the father is $\frac{1}{2}$

The chance for the fetus to get diseased allele from the mother is $\frac{1}{2}$
The chance for the mother to be hybrid is 1/30
The chance for the father to be hybrid is 1/30

The genetic risk= $\left(\frac{1}{2}\right)\left(1/30\right) \times \left(\frac{1}{2}\right)\left(1/30\right) = 1/3600$

Example 3: autosomal, N>d, the frequency of hybrid individuals in a population is 1/ 20
Only one of the parents have family history



If one of the parents is pure having genotype NN, then this parent will give allele N to the fetus and allele N is dominant and expressed. Then there will be no risk for the fetus to be diseased. (zero risk).
Parent 5 doesn't have family history, then we consider the frequency of hybrid individuals in a population which is 1/20

If father (4) is hybrid; The parents of individual 4 are hybrid having genotype Nd since they got diseased individual 3 with genotype dd (pure recessive)which should receive diseased allele form both parents.

Parents 1 and 2: Normal x Normal
Genotypes of 1 and 2: Nd x Nd

	½ N	½ d
½ N	¼ NN	¼ Nd
½ d	¼ Nd	¼ dd

The chance for the father 4 to be hybrid is 2/3

The chance for the fetus to get diseased allele from the father is ½

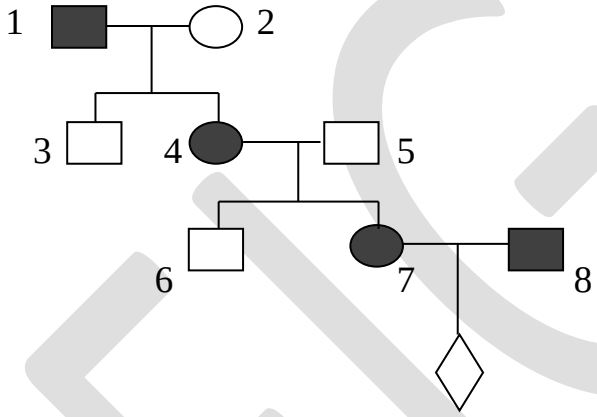
The chance for the fetus to get diseased allele from the mother is ½

The chance for the mother to be hybrid is 1/20

The chance for the father to be hybrid is 2/3

The genetic risk= (½) (2/3) x (½) (1/20) = 1/ 120

Example 4: autosomal, D>n



Parent 7 has genotype Dn since she has a normal father 5 with genotype nn (recessive is always pure) then she receives allele n from her father and allele D from her mother 4.
If parent 8 is pure then he gives allele D to his offspring and allele D is dominant and it will be expressed.
Therefore the risk for the fetus to be diseased is 100 % if parent 8 is pure.

Note: in this case we don't have neither family history nor frequency in a population that's why we solved by factorial analysis.

If parent 8 is hybrid,
Phenotypes of 7 and 8: Diseased x diseased
Genotypes of 7 and 8: Dn x Dn
Gametes of 7 and 8: ½ D ½ n x ½ D ½ n

	½ D	½ n
½ D	¼ DD	¼ Dn
½ n	¼ Dn	¼ nn

The risk for the fetus to be diseased is 3/4

Sex linked diseases

- **Case A: If the real genotypes of the parents of the fetus are determined.**

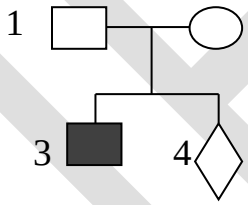
1st method: Determine (indicate + justify) the genotypes of the parents. Then make factorial analysis and a punnet square and find out the ratio for having diseased offsprings.

2nd method: Determine (indicate + justify) the genotypes of the parents of the fetus.
Chance of the fetus to receive diseased allele from the father =
Chance of the fetus to receive diseased allele from the mother =

Then the risk = ratio of the allele taken from paternal origin (paternal gamete) X ratio of the allele taken from maternal origin (maternal gamete)

Important note: if the gene is carried on sex chromosome, we solve same as the case when we have autosomal diseases but we have to find the risk of the disease if the fetus is a girl and if the fetus is a boy.

Example : gene is carried on non-homologous part of sex chromosome X, N>d



1st method:
The father 1 is normal then his genotype is X^NY. The mother is normal but she got a diseased boy 3 with genotype $X^d Y$ and this child should receive X^d from his mother. Therefore the mother has genotype X^NX^d.
Phenotypes of parents : Normal x normal
Genotypes of parents: $X^N Y$ x $X^N X^d$
Gametes : ½ X^N ½ Y x ½ X^N ½ X^d

	½ X^N	½ X^d
½ X^N	¼ $X^N X^N$	¼ $X^N X^d$
½ Y	¼ $X^N Y$	¼ $X^d Y$

The genetic risk is ¼ if the fetus is a boy
There is no risk if the fetus is a girl

2nd method:

The father 1 is normal then his genotype is X^NY. The mother is normal but she got a diseased boy 3 with genotype X^dY and this child should receive X^d from his mother. Therefore the mother has genotype X^NX^d.

If the fetus is a girl, she will take X^N from her normal father with genotype X^NY and normal is dominant and will be expressed. Then there is no risk if the fetus is a girl.

If the fetus is a boy :

The chance to receive Y from his father is ½

The chance to receive X^d from his mother is ½

The genetic risk= $(½)$paternal gamete x $(½)$maternal gamete = 1/ 4 of all children (½ of the boys)

- **Case B: If the real genotypes of the parents of the fetus Can Not be determined (not sure).**

I. If the parents have family history.

Find the chance for the parents to be carriers of the disease by making factorial analysis and punnet square for the grandparents.

Then risk=

(Probability of the father to be hybrid X ratio of diseased allele from father) X (Probability of the mother to be hybrid X ratio of diseased allele from mother)

Important note: if the gene is carried on sex chromosome, we solve same as autosomal diseases but we have to find the risk of the disease if the fetus is a girl and if the fetus is a boy.

II. If the parents don't have family history.

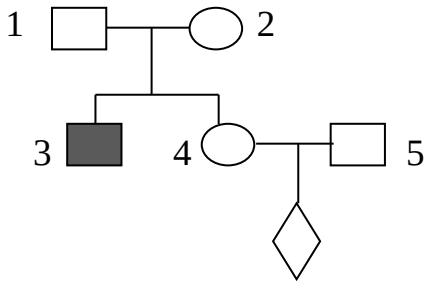
There should be given the frequency of hybrid (heterozygous) in a population ex. 1/30

Since there is no family history, we consider the frequency of heterozygous in a population.

Then risk of offspring to be affected=

(Frequency of heterozygous in a population for the father X ratio of diseased allele from father) X (Frequency of heterozygous in a population for the mother X ratio of diseased allele from mother)

Example 1: gene is carried on non-homologous part of sex chromosome X, N>d



The father has genotype X^NY. If the mother is pure with genotype $X^N X^N$ then she will give her offsprings X^N and normal is dominant and will be expressed. Therefore there will be no risk for the fetus to be diseased if the mother is pure.

If the mother is hybrid:

Parents 1 and 2: Normal x Normal

Genotype of parents 1 and 2: X^NX^d x X^NY

	½ X^N	½ X^d
½ X^N	¼ $X^N X^N$	¼ $X^N X^d$
½ Y	¼ X^N Y	¼ X^d Y

The chance for the mother to be hybrid is ½

Note for you: the female 4 is normal, there are only 2 possibilities for a female to be normal and only one possibility out of the two is hybrid. Then the ratio is 1/2

If the fetus is a girl, she will receive X^N from her father and normal is dominant and expressed. Then the will be no risk for the fetus to be diseased if she is a girl.

If the fetus is a boy;

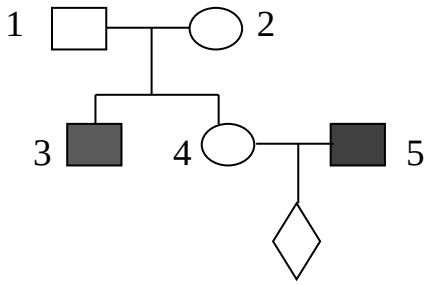
The chance to receive Y from his father is ½

The chance to receive X^d from his mother is ½

The chance for the mother to be hybrid is ½

The genetic risk= $(½)$ x $(½)$ $(½)$ = 1/ 8 of all children (1/4 of the boys)

Example 2: gene is carried on non-homologous part of sex chromosome X, N>d



The father has genotype X^dY. If the mother is pure with genotype $X^N X^N$ then she will give her offsprings X^N and normal is dominant and will be expressed. Therefore there will be no risk for the fetus to be diseased.

If the mother is hybrid,

Parents 1 and 2: Normal x Normal

Genotype of parents 1 and 2: X^NX^d x X^NY

	½ X^N	½ X^d
½ X^N	¼ $X^N X^N$	¼ $X^N X^d$
½ Y	¼ $X^N Y$	¼ $X^d Y$

The chance of the mother to be hybrid is ½

If the fetus is a girl:

The chance for the fetus to get X^d diseased allele from the father is ½

The chance for the fetus to get X^d diseased allele from the mother is ½

The chance for the mother to be hybrid is ½

The genetic risk= (½) x (½) (½) = 1/ 8 (1/4 of the girls)

If the fetus is a boy:

The chance for the fetus to get Y from the father is ½

The chance for the fetus to get X^d from the mother is ½

The chance for the mother to be hybrid is ½

The genetic risk= (½) x (½) (½) = 1/ 8 of all children (1/4 of the boys)