CHAPTER 4: GENETIC INHERITANCE
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4.1 MENDELIAN GENETICS: MONOHYBRID & DIHYBRID

PSPM I 2006/2007

1. In peas, the allele for round seeds \((A)\) is dominant to that for wrinkled seeds \((a)\), the allele for yellow seeds \((B)\) is dominant to that for green seeds \((b)\). These loci are unlinked. The cross below is between two homozygous plants.

\[
\text{P generation : Round, green} \quad \times \quad \text{Wrinkled, yellow}
\]

\[
\begin{array}{c}
\text{F}_1 \\
\text{F}_2
\end{array}
\]

**FIGURE 2**

(a) What are the genotypes of the P generation? \([2 \text{ marks}]\)

(b) Define the law of independent assortment. \([2 \text{ marks}]\)

(c) What are the expected genotypes and phenotypes of the \(F_1\) hybrids produced by the above cross? \([2 \text{ marks}]\)

(d) What are the gametes that can be produced by \(F_1\)? \([2 \text{ marks}]\)
(e) State the expected proportion of F2 phenotypes given below. [2 marks]

(i) Round, yellow seeds : ______________________________

(ii) Wrinkled, yellow seeds : ______________________________

UPS I 2007/2008

2. In rats, short fur is controlled by dominant allele \( A \) while long fur is controlled by recessive allele \( a \). Black fur is controlled by allele \( B \) and brown fur by allele \( b \). The two genes concerned are located on different chromosomes. A cross is made between a female rat and male rat.

(a) The possible gametes produced by the female rat above are \( aB \) and \( ab \).

(i) State its genotype: ______________________________ [1 mark]

(ii) State its phenotype: ______________________________ [1 mark]

(b) The possible gametes produced by the male rat above are \( AB \), \( Ab \), \( aB \) and \( ab \).

State its genotype: _______________ [1 mark]

(i) What is the percentage of the progenies from the cross above have brown fur? Use genetic diagram to explain your answer. [4 marks]

(ii) On the genetic diagram, CIRCLE the genotype of progeny showing long and brown fur. [1 mark]
(iii) What is the percentage of the progenies with short and black fur?  [1 mark]

(iv) How do you determine the genotype of one of the progenies with short and black fur?  [1 mark]

PSPM I 2008/2009

3. (a) In a particular plant, leaf colour is controlled by gene $D$ where allele $D$ controlled green leaves and allele $d$ controlled yellow leaves. A true-breeding green-leaved plant is crossed with a yellow-leaved, and the $F_1$ progenies are allowed to self-pollinate. The predicted outcome of these cross are shown in the Punnet square below (FIGURE 4). M, N, O and P represent the genotypes corresponding to each box within the square.

![Punnett square](image)

**FIGURE 4**

Which of the labeled boxes M, N, O and P correspond to:  [3 marks]

(i) Plant with green leaves : _______________________

(ii) Plant with heterozygous genotype : _______________________

(iii) Plant which are true-breeding : _______________________
(b) In one experiment, a purple flower and long pollen grain plant was crossed with a homozygous red flower and round pollen grain plant. The number of progeny of F1 generation is shown in TABLE 2.

<table>
<thead>
<tr>
<th>PHENOTYPE</th>
<th>NUMBER OF PLANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purple flower, long pollen</td>
<td>46</td>
</tr>
<tr>
<td>Red flower, long pollen</td>
<td>39</td>
</tr>
<tr>
<td>Purple flower, round pollen</td>
<td>38</td>
</tr>
<tr>
<td>Red flower, round pollen</td>
<td>43</td>
</tr>
</tbody>
</table>

TABLE 2

Using P to represent allele for purple flower colour and L to represent allele for long pollen grain, determine the genotype of the following individuals.

(i) Purple flower and long pollen grain. [1 mark]

(ii) Homozygous for red flower and round pollen grain. [1 mark]

(iii) Are the genes for flower colour and pollen grain shape sex-linked? Why? [2 marks]

(iv) Name the type of cross that will give the above ratio. [1 mark]

(c) What is the phenotypic ratio of crosses involving two individuals who are heterozygous for a recessive lethal gene? Why? [2 marks]
In *Drosophila*, dominant *G* allele produces wild *Drosophila* which is grey body. The recessive *g* allele produces yellow body.

(a) If the gene for body colour is not sex-linked, consider a cross between a homozygous grey bodied male with a yellow bodied female.

(i) Determine the genotype for male and female *Drosophila*. [2 marks]

(ii) Draw a genetic diagram for the above crossing. [3 marks]

(b) If the gene for body colour is sex-linked, consider a cross between a grey bodied male with a yellow bodied female.

(i) Draw the genetic diagram for the above crossing. [3 marks]
(ii) What percentage of the F₁ progeny is expected to be homozygous? [1 mark]

(iii) Among the male progenies, what percentage is expected to be yellow bodied? [1 mark]

UPS I 2010/2011

5. (a) A man who is heterozygous for brown eyes marries a woman who is homozygous for blue eyes and they have four children (F₁). Half of the children are brown eyed and another half are blue eyed.

(i) Identify the genotype of the parent. [2 marks]

(ii) If a brown eyed man in F₁ marries a woman and produces F₂ offspring with the phenotype ratio 3:1, identify the genotype of the woman. [1 mark]

(iii) Draw a genetic diagram to show this marriage until F₂ generation. [3 marks]
In fruit fly (*Drosophila melanogaster*), the gene for grey body (G) and short bristles (B) are dominant over the genes for black body and long bristles. Pure breeding strains of the dominant and recessive were crossed and produced F\textsubscript{1} generation. A test cross of the F\textsubscript{1} generation produced the following results:

<table>
<thead>
<tr>
<th>NO. OF INDIVIDUAL</th>
<th>PHENOTYPES</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>Grey body, short bristles</td>
</tr>
<tr>
<td>58</td>
<td>Grey body, long bristles</td>
</tr>
<tr>
<td>60</td>
<td>Black body, short bristles</td>
</tr>
<tr>
<td>58</td>
<td>Black body, long bristles</td>
</tr>
</tbody>
</table>

**TABLE 2**

(a) Does the above result follow the Mendelian ratio? Explain. [3 marks]

(b) Draw the test cross of F\textsubscript{1} generation and state the phenotypes of offspring produced. [4 marks]
In pea, the gene for red colour flower (R) and smooth seed (Q) are dominant over the genes for white colour flower (r) and wrinkled seed (q). Homozygous of dominant and recessive were crossed and produced the results in TABLE 1.

<table>
<thead>
<tr>
<th>PHENOTYPE</th>
<th>TOTAL NUMBER OF PLANT PRODUCED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red flower, smooth seeds</td>
<td>55</td>
</tr>
<tr>
<td>Red flower, wrinkled seeds</td>
<td>122</td>
</tr>
<tr>
<td>White flower, wrinkled seeds</td>
<td>62</td>
</tr>
<tr>
<td>White flower, smooth seeds</td>
<td>15</td>
</tr>
</tbody>
</table>

TABLE 1

(a) Name the phenomenon that controls the recombination of genes in TABLE 1. [1 mark]

(b) By using a genetic diagram, show how the F1 generation is produced. [3 marks]

(c) (i) Draw a diagram of a test cross for the F1 generation. [3 marks]

(ii) What is the phenotypic ratio for (c)(i)? [1 mark]

(d) Calculate the distance between the genes for flower colour and seed texture for the test cross in TABLE 1. [2 marks]
PSPM1 2014/2015

8. In *Pisum sativum*, the genes for purple colour flower (R) and round seeds (Q) are dominant over the genes for white colour flower (r) and wrinkled seed (q). Heterozygous were test crossed and the result are shown in TABLE 1.

<table>
<thead>
<tr>
<th>PHENOTYPE</th>
<th>TOTAL NUMBER OF PLANT PRODUCED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purple flower, round seeds</td>
<td>56</td>
</tr>
<tr>
<td>Purple flower, wrinkled seeds</td>
<td>11</td>
</tr>
<tr>
<td>White flower, wrinkled seeds</td>
<td>63</td>
</tr>
<tr>
<td>White flower, round seeds</td>
<td>14</td>
</tr>
</tbody>
</table>

TABLE 1

(i) Draw the test cross. [3 marks]

(ii) Calculate the distance between flower colour and seed shape genes. [2 marks]
In a particular plant, dark green leaf colour is controlled by allele D, and light green colour is controlled by allele d. A cross between true breeding dark green and light green plant was conducted. The F₁ progeny was then self-fertilized to produce F₂ progeny.

(a) Based on the above crossing, complete the Punnet square for F₂ progeny. [3 marks]

(b) State the genotype for the dark and light green leaves in F₂. [3 marks]

(c) Give the phenotypic ratio of F₂. [1 mark]

(d) Define the Law of Segregation. [3 marks]
10. (a) Allele for red flower (R) is dominant over allele for white flower (r). A true breed flower plant is crossed with a true breed white flowered plant. The F₁ generation is self- crossed. Construct genetic diagrams of the crosses. [8 marks]

(b) A test cross was carried out on Drosophila sp. with grey body and normal wing produces the following progenies:

<table>
<thead>
<tr>
<th>PHENOTYPE</th>
<th>Number of progeny</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey body, normal wing</td>
<td>869</td>
</tr>
<tr>
<td>Black body, vestigial wing</td>
<td>877</td>
</tr>
<tr>
<td>Grey body, vestigial wing</td>
<td>111</td>
</tr>
<tr>
<td>Black body, normal wing</td>
<td>109</td>
</tr>
</tbody>
</table>

(i) Determine the genotypes of both parents in the above cross. (Assume that allele G codes for grey body and allele W codes for normal wing). [1 mark]

(ii) Calculate the genetic distance between the body colour and wing size genes. [3 mark]
### UPS I 2005/2006

1. The shapes and colours in carrots are determined by two pairs of different alleles. Both pairs of alleles did not show dominance. Each genotype produces different phenotypes. Colours of carrots are red (C\textsuperscript{R}C\textsuperscript{R}), purple (C\textsuperscript{R}C\textsuperscript{W}) or white (C\textsuperscript{W}C\textsuperscript{W}). The shapes are long (S\textsuperscript{L}S\textsuperscript{L}), oval (S\textsuperscript{L}S\textsuperscript{N}) or round (S\textsuperscript{N}S\textsuperscript{N}).

(a) What type of inheritance is shown by the shape and colours of carrot? [1 mark]

(b) The long, red carrot is crossed with the round, white carrot. With a genetic diagram, show the parent genotypes, gametes and F\textsubscript{1} generation. [3 marks]

(c) If the F\textsubscript{1} generation is self-crossed, what are the frequencies for the following phenotypes? [4 marks]

<table>
<thead>
<tr>
<th>Phenotypes</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red, oval</td>
<td></td>
</tr>
<tr>
<td>Purple, long</td>
<td></td>
</tr>
<tr>
<td>White, long</td>
<td></td>
</tr>
<tr>
<td>White, round</td>
<td></td>
</tr>
</tbody>
</table>

(d) If the purple, oval carrot has the highest demand in the market, give TWO possible crosses that can be done to meet the demand. [2 marks]
PSPM I 2005/2006

2. **FIGURE 1** shows a family tree for the inheritance of ABO blood groups involving multiple alleles. Blood groups for some individuals are labeled.

![Family Tree Diagram]

**FIGURE 1**

(a) What is meant by multiple alleles? [2 marks]

(b) List all possible combinations of alleles for the ABO blood groups. [2 marks]

(c) List all genotypes of individuals with B blood group. [1 mark]

(d) What is the blood group of individual I-2? [1 mark]

(e) Give the genotype of individual II-5? [1 mark]

(f) Using a Punnet square, give the probability of the offspring of individuals II-4 and II-5 having blood group O. [3 marks]
3. A fruit fly with wild phenotype but unknown genotype was crossed with a fruit fly with vestigial wings and grey body, which were homozygous recessive for both characteristics. The results were as follow:

- Normal wings (N), black body (E) 45
- Normal wings (N), grey body (e) 48
- Vestigial wings (n), black body (E) 43
- Vestigial wings (n), grey body (e) 51

(a) State the Mendel’s Law above. [1 mark]

(b) Give the definition of the Mendel’s Law in (a). [1 mark]

(c) Suggest the genotypes of parental that produce the result as above. Use the given symbols. [2 marks]

(d) Draw a genetic diagram to show the cross until F₁ generation. [4 marks]

(e) State the genotypes together with their ratio for F₁ generation. [2 marks]
FIGURE 3 shows pedigrees A and B with specific disorder.

(a) (i) Which pedigree shows the disorder most likely inherited by and X-linked recessive allele? [1 mark]

(ii) Give **ONE** reason for your answer. [1 mark]

(b) Assuming that the disorder is due to allele \( r \), draw the genetic cross between parents 1 and 2 of your chosen pedigree. [2 marks]

(c) Using the symbol \( D \) as a dominant allele and \( d \) as a recessive allele, state the genotype of parents 1 and 2, and the affected daughter in pedigree B. [3 marks]

(d) What is the ratio of heterozygous genotype in \( F_1 \) generation of pedigree B? [1 mark]
(e) Give **ONE** example of the disorder for pedigree A and B.  

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**UPS I 2008/2009**

5. Fruit fly (*Drosophila* sp.) may have various body color and wing shape. Grey (*G*) and normal (*N*) are dominant over black (*g*) and vestigial (*n*) respectively. A cross was done between a homozygous grey, Normal trait and a homozygous black, vestigial trait. The F₁ generation produced was then crossed with a homozygous black, vestigial trait. **TABLE 1** show the progenies produced in F₂ generation.

<table>
<thead>
<tr>
<th>PHENOTYPES</th>
<th>NUMBER OF PROGENIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey, normal</td>
<td>38</td>
</tr>
<tr>
<td>Black, vestigial</td>
<td>34</td>
</tr>
<tr>
<td>Grey, vestigial</td>
<td>5</td>
</tr>
<tr>
<td>Black, normal</td>
<td>3</td>
</tr>
</tbody>
</table>

**TABLE 1**

(a) What type of inheritance shown in **TABLE 1**?  

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(b) State the expected phenotypic ratio of the F₂ generation according to the Mendelian Law.  

---

(c) Give **TWO** reasons why the observed ratio shown in **TABLE 1** does not fit the expected ratio.  

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(d) Draw a genetic diagram to show the result obtained in **TABLE 1**.  

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(e) Calculate the distance between the genes controlling the body color and wing shape. [2 marks]

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**UPS I 2010/2011**

6. (b) A woman with group A blood marries man with group B blood. Their child has group O blood.

(i) What is meant by multiple alleles? [1 mark]

(ii) State the genotypes for woman, man and child. [3 marks]

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**PSPM I 2011/2012**

7. In maize, the gene for coloured seed (C), and smooth seed (F), are dominant over the genes for colourless seed and wrinkled seed. Pure breeding strains of the dominant and recessive varieties were crossed. A test cross of the F_1 generation produced the following results:

<table>
<thead>
<tr>
<th>Type</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coloured, smooth seed</td>
<td>380</td>
</tr>
<tr>
<td>Coloured, wrinkled seed</td>
<td>14</td>
</tr>
<tr>
<td>Colourless, smooth seed</td>
<td>10</td>
</tr>
<tr>
<td>Colourless, wrinkled seed</td>
<td>396</td>
</tr>
</tbody>
</table>

(a) (i) Does the above cross follow the Mendelian ratio? [1 mark]

(ii) Explain how the situation in (a)(i) occurs. [2 marks]
(b) Draw the genetic diagram for the test cross of F1 generation. [4 marks]

(c) Calculate the distance between the two genes. Show your calculation. [3 marks]

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FIGURE 3 shows a testcross.

(a) What is the purpose of a testcross? [1 mark]

(b) State the Mendel’s second law. [1 mark]
(c) Give the genotypes of:

(i) The two parents of P.                        [2 marks]

(ii) Use Punnett square to show the progenies of the above testcross.  [3 marks]

(d) How do recombinant genotypes formed?         [1 mark]

(e) Assume that a total of 300 progenies are produced, and the map distance between A and D is 18 cM, calculate the most ideal number of each recombinant progeny.  [2 marks]
ESSAY QUESTIONS

4.1 MENDELIAN GENETICS: MONOHYBRID & DIHYBRID

PSPM DB015 2016/2017

1. In a pea plant, purple flower is the dominant trait while white flower is the recessive trait. Explain how to determine the genotype of the purple flowered pea plant. [8 marks]

PSPM I 2016/2017

2. Ismail has brown hair and blue eyes. He is married to a woman with black hair and brown eyes, heterozygous for both genes. Explain how their children would have black hair and blue eyes. (The trait of brown eyes and black hair is dominant over blue eyes and brown hair). [10 marks]

4.2 DEVIATIONS FROM THE MENDELIAN INHERITANCE

4.3 GENETIC MAPPING

PSPM I 2012/2013

1. (a) Explain polygenic inheritance. [8 marks]

(b) With the aid of genetic diagram, explain incomplete dominance and its inheritance in snapdragon (Antirrhinum sp.) [12 marks]
PSPM1 DB015 2013/2014

2. (a) Explain codominant inheritance. [4 marks]

(b) The coat colour in guinea pigs maybe yellow (C\textsuperscript{Y}C\textsuperscript{Y}), cream (C\textsuperscript{Y}C\textsuperscript{W}) or white (C\textsuperscript{W}C\textsuperscript{W}). Using a genetic diagram, determine the F\textsubscript{2} phenotypic ratio if yellow guinea pigs are crossed to white guinea pigs and then the F\textsubscript{1} are self-crossed. [8 marks]

PSPM DB015 2015/2016

3. (a) Explain multiple allele using human blood group as an example. [8 marks]

(b) Daniel has brown hair and blue eyes. He is married to Azizah who has black hair and brown eyes. With the aid of a labelled genetic diagram, explain how their children will inherit black hair and blue eyes. The trait of black hair (H) and brown eyes (B) are dominant over brown hair and blue eyes. [12 marks]

PSPM DB015 2016/2017

4. Colour-blind is a sex linked disease determined by recessive gene \( b \). In a family, the father is a normal while the mother is colour blind. Explain the probability of the offspring inheriting the disease. [12 marks]

PSPM 1 2016/2017

5. A man with AB blood group marries a woman with B blood group. The couple has three boys and one girl with different types of blood group. With the aid of a genetic diagram, describe the crossing. [10 marks]