INHERITANCE: PART 2

Topics for this weeks class:

Sex linkage
Autosomal linkage
Epistasis (AQA & OCR only)
Chi-squared

Playlist of videos to take notes on before the web class:

AQA VIDEOS	OCR VIDEOS	EDEXCEL VIDEOS
Autosomal Linkage	Autosomal Linkage	Autosomal Linkage
Sex Linkage	Sex Linkage	Sex Linkage
Non-Normal Phenotypic Ratios	Non-Normal Phenotypic Ratios	Chi-squared Test
Chi-squared Test	Chi-squared Test	
Epistasis	Epistasis	

INHERITANCE: PART 2

Q1.

(a) In fruit flies, the genes for body colour and wing length are linked. Explain what this means.

_____

_____

(1)

A scientist investigated linkage between the genes for body colour and wing length.
He carried out crosses between fruit flies with grey bodies and long wings and fruit flies with black bodies and short wings.

Figure 1 shows his crosses and the results.

G represents the dominant allele for grey body and **g** represents the recessive allele for black body.

N represents the dominant allele for long wings and **n** represents the recessive allele for short wings.

Figure 1

Phenotype of parents	grey body, long wings	×	black body, short wings
Genotype of parents	**GGNN**		**ggnn**
Genotype of offspring	**GgNn**		
Phenotype of offspring	all grey body, long wings		

These offspring were crossed with flies homozygous for black body and short wings.

The scientist's results are shown in **Figure 2**.

	GgNn	crossed with	**ggnn**	
	Grey body, long wings	**Black body, short wings**	**Grey body, short wings**	**Black body, long wings**
Number of offspring	975	963	186	194

(b) Use your knowledge of gene linkage to explain these results.

_____

_____

_____

_____

_____

(4)

(c) If these genes were **not** linked, what ratio of phenotypes would the scientist have expected to obtain in the offspring?

_____

_____

(1)

(d) Which statistical test could the scientist use to determine whether his observed results were significantly different from the expected results?

Give the reason for your choice of statistical test.

_____

_____

_____

_____

(2)

(Total 8 marks)

Q2.

Chickens have a structure called a comb on their heads. The drawings show two types of comb.

Pea comb

Single comb

The shape of the comb is controlled by two alleles of one gene. The allele for pea comb, **A**, is dominant to the allele for single comb, **a**.

The colour of chicken eggs is controlled by two alleles of a different gene. The allele for blue eggs, **B**, is dominant to the allele for white eggs, **b**.

The genes for comb shape and egg colour are situated on the same chromosome.

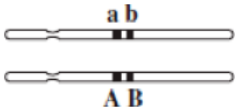
A farmer crossed a male chicken with the genotype **AaBb** with a female chicken that had a single comb and produced white eggs.

(a) What was the genotype of the female parent?

_____

(1)

The diagram shows how the alleles of the genes were arranged on the chromosomes of the male parent.



(b) Which **two** genotypes will be most frequent in the offspring?

_____

(1)

(c) The farmer could identify which of the female offspring from this cross would eventually produce blue eggs. Explain how.

_____

_____

_____

(2)

(d) Genes **A** and **B** are close together on the chromosome. This is important when trying to identify which of the female offspring would produce blue eggs. Explain why.

_____

_____

_____

(2)

(e) Suggest **two** environmental factors which are likely to affect egg production.

1. _____

2. _____

(2)

In chickens it is the males which are XX and the females which are XY.

(f) A gene on the X chromosome controls the rate of feather production. The allele for slow feather production, **F**, is dominant to the allele for rapid feather production, **f**.

A farmer made a cross between two chickens with known genotypes. He chose these chickens so that he could tell the sex of the offspring soon after they hatched by looking at their feathers.

Which of the crosses shown in the table did he make? Explain your answer.

Cross	Genotype of male parent	Genotype of female parent
A	$X^F X^F$	X^fY
B	$X^F X^f$	X^fY
C	$X^f X^f$	X^FY
D	$X^F X^f$	X^FY

Answer _____

Explanation _____

_____

_____

_____

_____

(3)

(g) Female chickens are more likely than male chickens to show recessive sex-linked characteristics. Explain why.

_____

_____

_____

_____

_____

(3)

(Total 14 marks)

INHERITANCE: PART 2

Q3.

The fruit fly is a useful organism for studying genetic crosses. Female fruit flies are approximately 2.5 mm long. Males are smaller and possess a distinct black patch on their bodies. Females lay up to 400 eggs which develop into adults in 7 to 14 days. Fruit flies will survive and breed in small flasks containing a simple nutrient medium consisting mainly of sugars.

(a) Use this information to explain **two** reasons why the fruit fly is a useful organism for studying genetic crosses.

1. _____

_____

2. _____

_____

(2)

(b) Male fruit flies have the sex chromosomes XY and the females have XX. In the fruit fly, a gene for eye colour is carried on the X chromosome. The allele for red eyes, **R**, is dominant to the allele for white eyes, **r**. The genetic diagram shows a cross between two fruit flies.

(i) Complete the genetic diagram for this cross.

Phenotypes of parents	red-eyed female		white-eyed male
Genotype of parents	_____	×	_____
Gametes	_____and_____		_____and_____
Phenotypes of offspring	red-eyed females	and	red-eyed males
Genotype of offspring	_____		_____

(3)

(ii) The number of red-eyed females and red-eyed males in the offspring was counted. The observed ratio of red-eyed females to red-eyed males was similar to, but not the same as, the expected ratio. Suggest **one** reason why observed ratios are often **not** the same as expected ratios.

_____

_____

_____

(1)

(c) Male fruit flies are more likely than female fruit flies to show a phenotype produced by a recessive allele carried on the X chromosome. Explain why.

_____

_____

_____

_____

(2)

(Total 8 marks)

Q4.

A sex-linked gene controls fur colour in cats. Ginger-coloured fur is controlled by the allele **G**, and black-coloured fur is controlled by the allele **g**. Some female cats have ginger and black patches of fur. They are described as tortoiseshell. Male cats cannot be tortoiseshell.

(a) What is meant by a *sex-linked* gene?

_____

_____

(1)

(b) A male cat with the genotype **X^g Y** mates with a tortoiseshell female.

(i) Give the phenotype of the male.

_____

(1)

(ii) Give the genotype of the tortoiseshell female.

_____

(1)

(iii) Complete the genetic diagram to show the genotypes and the ratio of phenotypes expected in the offspring of this cross.

Parents	Male	Tortoiseshell female
Parental genotypes	**X^g Y**	_____

Parental gametes

Offspring genotypes

Offspring phenotypes

Ratio

(3)

(c) The effect of the **G** and **g** alleles is modified by another gene. This gene is not sex-linked and it has two alleles. The allele **d** changes the ginger colour to cream and the black colour to grey. The dominant allele **D** does not modify the effect of **G** or **g**.

A cream-coloured male cat mated with a black female whose genotype was $\mathbf{X^gX^g\ Dd}$. Male kittens of two different colours were produced. Complete the genetic diagram.

Parental phenotypes	Cream-coloured male	Black female
Parental genotypes	_____	$\mathbf{X^gX^g\ Dd}$
Parental gametes		
Male kitten genotypes		
Male kitten colours		

(3)
(Total 9 marks)

INHERITANCE: PART 2

Q5.

The sweet pea plant has been used to study inheritance since the nineteenth century. The seeds of the sweet pea can vary in colour and shape.

The gene that controls colour has two alleles:

- **Y** is dominant and produces yellow seeds.
- **y** is recessive and produces green seeds.

The gene that controls shape has two alleles:

- **R** is dominant and produces round seeds.
- **r** is recessive and produces wrinkled seeds.

(a) In the nineteenth century, Gregor Mendel crossed a pea plant that was heterozygous for both seed colour and shape with a pea plant that had green and wrinkled seeds.

(i) List the gametes that would be produced by a sweet pea plant that was heterozygous for both seed colour and shape.

_____

(1)

(ii) List the genotypes of the offspring that were produced from Mendel's cross and state the corresponding phenotypes.

genotypes _____

phenotypes _____

(2)

Q5bi OCR & Edexcel ONLY

(b) When Mendel crossed two pea plants that were heterozygous for both seed colour and shape, the ratio of phenotypes in the offspring was:

9 yellow round 3 green round 3 yellow wrinkled 1 green wrinkled.

Some students tried to recreate this investigation using a modern variety of plant that showed the same phenotypic variation in seed colour and shape.

The students crossed two of the modern plants that were heterozygous for both seed colour and shape. The results of this cross were:

58 yellow and round 31 green and round 21 yellow and wrinkled 2 green and wrinkled

The students used the chi-squared test to compare their data to the expected 9:3:3:1 ratio.

(i) Use the chi-squared formula to calculate the chi-squared value for these data.

You may use the table below for working out.

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

AQA students do not need to be able to calculate the chi-squared test statistic

χ^2 = _____

(3)

Degrees of freedom	Probability (p)					
	0.95	**0.90**	**0.10**	**0.05**	**0.025**	**0.01**
1	0.00	0.02	2.71	3.84	5.02	6.64
2	0.10	0.21	4.61	5.99	7.38	9.21
3	0.35	0.58	6.25	7.82	9.35	11.34
4	0.71	1.06	7.78	9.49	11.14	13.28
5	1.15	1.61	9.24	11.07	12.83	15.09
6	1.64	2.20	10.64	12.59	14.45	16.81
7	2.17	2.83	12.02	14.07	16.01	18.48

(ii) After analysing the results, the students stated that the inheritance of the seed colour and shape in their investigation was different from that in Mendel's investigation.

Using the table, discuss whether the results of the investigation and the chi-squared test support the students' statement.

_____

_____

_____

_____

_____

_____

(3)

(iii) A ratio that is different from the expected 9:3:3:1, in a cross such as this, can be the result of epistasis.

Suggest and explain one reason, other than epistasis, why the phenotype ratio might not be 9:3:3:1.

Suggestion _____

Explanation _____

_____

_____

_____

(3)

(Total 12 marks)

Q6. AQA & OCR ONLY

The production of pigment in rabbit fur is controlled by two genes.

One gene controls whether any pigment is made. This gene has three alleles. Allele **A** codes for the production of one form of the enzyme tyrosinase, which converts tyrosine into a black pigment. Allele **A^h** codes for the production of a second form of the enzyme, which becomes inactive at temperatures close to a rabbit's core body temperature, so only the face, ears, legs and tail are pigmented. A third allele, **a**, fails to code for a functional tyrosinase.

The other gene controls the density of pigment in the fur. This gene has two alleles. Allele **B** is dominant and results in the production of large amounts of pigment, making the fur black.

Allele **b** results in less pigment, so the fur appears brown.

(a) How do multiple alleles of a gene arise?

_____

_____

_____

(2)

(b) The table shows some genotypes and phenotypes.

Genotype	Phenotype
A–B–	all fur black
aaB–	all fur white (albino)
A^habb	white body fur with brown face, ears, legs and tail (Himalayan)

(i) Give all the possible genotypes for a Himalayan rabbit with black face, ears, legs and tail.

_____

_____

(2)

(ii) Suggest an explanation for the pigment being present only in the tail, ears, face and legs of a Himalayan rabbit.

_____

_____

_____

(2)

(c) Using the information given, explain why the phenotypes of rabbits with **AABB** and **AA^hBB** genotypes are the same.

_____

_____

(2)

(Total 8 marks)

Q7. AQA & OCR ONLY

Coat colour in mice is controlled by two genes, each with two alleles. The genes are on different chromosomes.

One gene controls the pigment colour. The presence of allele **A** results in a yellow and black banding pattern on individual hairs, producing an overall grey appearance called agouti. Mice with the genotype aa do not make the yellow pigment and are, therefore, black.

The other gene determines whether any pigment is produced. The allele **D** is required for development of coat colour. Mice with the genotype **dd** produce no pigment and are called albino.

(a) What type of gene interaction is occurring between the two genes? Explain your answer.

_____

_____

_____

_____

(2)

(b) Give all the possible genotypes for a black mouse.

_____

(1)

(c) An agouti mouse of unknown genotype was crossed with an albino mouse of unknown genotype. Their offspring included albino, agouti and black mice.

(i) What was the genotype of the agouti parent?

_____

(1)

(ii) Give **two** possible genotypes for the albino parent.

_____

(1)

(iii) Suggest how the actual genotype of the albino parent could be determined.

_____

_____

_____

_____

(2)

(Total 7 marks)

INHERITANCE: PART 2

Q1.

(a) (Genes / loci) on same chromosome.

1

(b)
1. GN and gn linked
2. GgNn individual produces mainly GN and gn gametes
3. Crossing over produces some / few Gn and gN gametes
4. So few(er) Ggnn and ggNn individuals.

4

(c) (Grey long:grey short:black long:black short) =1:1:1:1

1

(d)
1. Chi squared test
2. Categorical data.

2

[8]

Q2.

(a) aabb

1

(b) AaBb and aabb

1

(c) Pea comb offspring will produce blue eggs
Alleles **A** and **B** are inherited together / are on the same chromosome

2

(d) Reference to crossing over
Reduce chance of genes being separated (by crossing over)
If crossing over occurred some gametes will contain alleles **A** and **b**

2 max

(e) Two suitable environmental factors

e.g.
Diet / named component of diet
Temperature
Light intensity / duration
Disease

2 max

(f) Cross C / $X^f X^f$ and $X^F Y$

1

(Only) cross where all males are one phenotype and all females are a different phenotype
Cross showing all males are slow feather production, all females fast feather production

2

(g) Two alleles for each gene present in male / chromosomes are homologous in male
Female has one allele for each gene
Recessive alleles always expressed in female
Males need two recessive alleles for allele to be expressed / in males recessive alleles can be masked by dominant allele

3 max

[14]

Q3.

(a) 1. Large number of eggs / offspring / flies (therefore) improves reliability / can use statistical tests / are representative / large sample (size) / reduces sampling error

Each mark point requires a feature linked in mark scheme (by therefore) to an explanation
Do not accept a large number of eggs produces a large number of flies unless the term sample is used
Ignore references to accuracy or precision

2. Small size / (breed) in small flasks / simple nutrient medium (therefore) reduces costs / easily kept / stored

Accept small size so can be kept in small flasks

3. Size / markings / phenotypes (therefore) males / females easy to identify

Answers must relate to size, markings or use the term phenotype

4. Short generation time / 7 - 14 days / develop quickly / reproduce quickly (therefore) results obtained quickly / saves times / many generations

2 max

(b) (i) 1. X^RX^R and X^rY

All marking points are completely independent. Allow crosses from the following parents for a possible three marks:
X^RX^R and X^r-
X^RX^R and X^rY
RR and rY / rY–
RR and r– or RR and r

2. X^R and X^R plus X^r and Y

3. X^RX^r and X^RY

OR - In my opinion the answer below is wrong (explanation in web class recording)

1. X^RX^r and X^rY

OR

X^RX^r and X^r–
X^RX^r and X^rY

2. X^R and X^r plus X^r and Y

Rr and rY / rY–
Rr and r– or Rr and r
Accept different symbols e.g. W and w
2. Accept gametes in a punnet square

3. X^RX^r and X^RY

3

(ii) Fertilisation is random / fusion of gametes is random / small / not large population / sample / selection advantage / disadvantage / lethal alleles

Mutation = neutral
Random mating = neutral
Accept fertilisation / fusion of gametes is due to chance

1

(c) 1. Males have one allele

Answers should be in context of alleles rather than chromosomes

2. Females need two recessive alleles / must be homozygous recessive / could have dominant and recessive alleles / could be heterozygous / carriers

2
[8]

Q4.

(a) gene located on X / Y / one sex chromosome (allow gene on X or Y chromosome, not X and Y)

1

(b) (i) black

1

(ii) **X^GX^g**

(lose this mark if the wrong genotype is given for the female in (iii))
(must show X chromosomes to gain the mark)

1

correct parent gametes
(**X^g** and **Y** from male, **X^G** and **X^g** from female)
correct offspring genotypes (**X^gX^g**, **X^GX^g**, **X^GY**, **X^gY**)
correct link of offspring genotypes with phenotypes
X^gX^g black female
X^GX^g tortoiseshell female
X^GY ginger male
X^gY black male

(correct gametes, offspring genotypes and link with phenotypes based on incorrect parent genotype = 3 marks)

3

(c) **X^GY dd**
correct male kitten genotypes (**X^gY Dd** and **X^gY dd**)
correct link of kitten genotypes with phenotypes

(ignore female kittens)

X^gY Dd black
X^gY dd grey

(correct kitten genotypes and phenotypes based on incorrect parent genotype = 2 marks)

3

[9]

Q5.

(a) (i) YR Yr yR yr (ALLOW ry Ry RY rY)

1

(ii) genotypes: YyRr Yyrr yyRr yyrr (ALLOW YRyr , Yryr, yRyr, yryr)

phenotypes: yellow round, yellow wrinkled, green round, green wrinkled

(phenotypes must correspond to correct genotype DO NOT CREDIT if no or incorrect genotypes are given)

2

(b) (i) 8.73 or 8.8

O	E	$(O-E)^2 / E$	
58	63	0.40	25/63
31	21	4.76	100/21
21	21	0	0
2	7	3.57	25/7

3

(ii) supports because...

critical / table , value = 7.82

difference is significant as (X2) , higher than , 7.82 / critical value

less than 5% / 1 in 20 , probability / chance , that difference is due to chance

X2 / calculated value is , smaller than , 9.35 / value at p=0.025

greater than , 2.5% / 1 in 40 , probability that difference is due to chance

3

(iii) (autosomal) linkage

(both) genes / alleles , occur on same , chromosome / autosome / chromatid

no independent assortment

so alleles , inherited together / end up in same gamete

unless crossing over occurs / chiasma forms between gene loci

3

[12]

Q6. AQA & OCR ONLY

(a) mutations
which are different / at different positions in the gene

2

(b (i) A^hA^h BB, A^haBB, A^hA^h Bb, A^haBb
(allow 1 mark for 2 or 3 correct answers)

2

(ii) temperature lower at extremities
enzyme active / not denatured

2

(c) if allele A is present (normal) tyrosinase / enzyme is produced, so it does not matter what other allele is present / explanation of why heterozygote is same phenotype as double dominant in terms of enzyme produced
phenotype / rabbit is black as both have alleles A and B

2
[8]

Q7. AQA & OCR ONLY

(a) epistasis
one gene influences the expression of another / description using example in question

2

(b) aaDD, aa Dd (or DDaa, Ddaa)

1

(c) (i) AaDd (or DdAa)

1

(ii) aadd, Aadd (or ddaa, ddAa)

1

(iii) cross with black individual / genotype aaDd or aaDD
genotype is Aadd if agouti offspring / genotype is aadd if no agouti offspring
Accept
repeat cross using original parents many times
ratio is 4 albino : 3 agouti : 1 black if Aa, or 2 albino : 1 agouti : 1 black if aa

2
[7]