The Determination of Sex

As figure 16.9 on page 185 of the textbook shows, human cells have 46 chromosomes: 23 homologous pairs. The last pair is responsible for determining the sex of the person, so these are called the **sex chromosomes.**

In a female, these chromosomes are a true pair. Each is given the symbol X, so her genotype is XX. But in a male, most of one of the pair is missing, forming a smaller Y chromosome. So his genotype is XY.

Genotype	Phenotype
XY	male
XX	female

The X and Y chromosomes are a pair, however, because they join up at meiosis like the other pairs.

Figure 18.12 on page 205 gives a genetic diagram explaining why approximately 50% of babies born are males and 50% females. In fact slightly more males are born, because the male sperms are stronger swimmers!

Interpreting Offspring Ratios

We have now met three different offspring ratios. It will be very helpful to remember when they occur:

- 3:1 ratio – F2 generation of a monohybrid cross
- 1:1 ratio – offspring of a test cross if the unknown organism was heterozygous
- 1:2:1 ratio – F2 generation if incomplete dominance is at work

Now is the time to read through chapter 18, pages 197–206 of *Edexcel IGCSE Biology*. It covers the same topics as this lesson, so will add to your understanding of the material.

Keywords

Diploid
Haploid
Allele
Homozygous
Heterozygous
Genotype
Phenotype
Dominant
Recessive
Genetic diagram
Monohybrid cross
Y chromosome
Family pedigree
X chromosome
Sex chromosomes

Summary

Lesson Eighteen: Genes and Inheritance

MONOHYBRID CROSS ------ dominance
------ phenotype ratios
----- test cross
------ family pedigrees

SEX DETERMINATION

What you need to know

- The meanings of the terms in **bold** in this lesson
- How sex is determined in human beings
- The phenotype ratios associated with the F2 of the monohybrid cross, the test cross

What you might be asked to do

- Draw genetic diagrams to illustrate the inheritance of dominant or recessive traits, and of gender.

- Interpret family pedigrees to determine the genotypes of the members and the nature of the trait involved.

Suggested Answers to Activities

Activity 2

Phenotype of parents yellow green

Genotype of parents YY yy

Gametes Y y

Genotype of F1 Yy

Phenotype of F1 all yellow

Gametes from F1 male gametes Y or y female gametes Y or y

Genotypes of F2

		female gametes Y	female gametes y
male gametes	Y	YY	Yy
male gametes	y	Yy	yy

Ratio of genotypes 1YY : 2Yy : 1yy

Ratio of phenotypes3 yellow : 1 green

Activity 3

(a) 3 and 4, neither of whom have the disease, have produced a diseased child.

(b) 3: She must be heterozygous, Cc, because she does not suffer from the disease but has passed it on to one of her children.

4: He is also heterozygous, for the same reason.

11: She must be homozygous recessive cc, because she has the disease, which is caused by a recessive allele.

Tutor-Marked Assignment G

Question 1

This question concerns cell division. For each of the following statements, say whether it is true for mitosis only, meiosis only, both, or neither (1 mark per statement):

(a) The DNA is replicated before cell division starts.

(b) The homologous chromosomes pair up during division.

(c) The cell divides only once during the process.

(d) The daughter cells contain precisely the same genetic material as each other.

(e) The number of chromosomes in each cell increases during the process.

(f) Recombination of the DNA occurs.

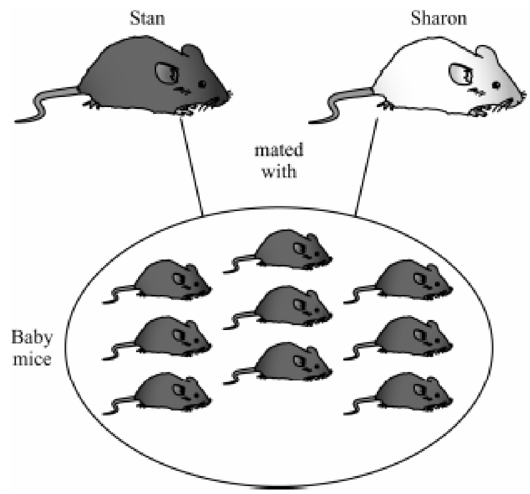
(g) The daughter cells form gametes

Question 2

A student's hobby was breeding pet mice. Three of the pet mice were called Stan, Tom and Sharon. Stan and Tom had black fur. Sharon had white fur. The colour of the fur is controlled by a single gene which has two alleles, **B** and **b**.

(a) The student first crossed Stan with Sharon.

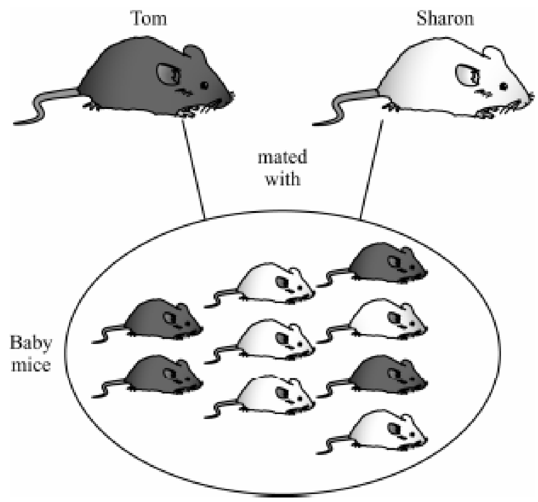
The results are shown on the diagram.



Give the alleles present in the body cells of Stan and Sharon.

(2 marks)

(b) The student then crossed Tom with Sharon. The results are shown on the diagram.



Use a genetic diagram to explain why some of the baby mice had white fur.

(3 marks)

Question 3

Cystic fibrosis is an inherited condition which affects the lungs. It is caused by a recessive allele.

N = the unaffected allele

n = the allele for cystic fibrosis

A person could have the following genotypes:

NN Nn nn

a) Give two genotypes of an unaffected person. 1 mark)

b) Give the genotype of someone who has cystic fibrosis. (1 mark)

c) A man and his wife are both unaffected but their first child suffers from cystic fibrosis. Complete the gaps below and the Punnet square to show the genotypes of the man and wife and their potential children.

Genotype of man ....

Genotype of woman .... (2 marks)

d) **Punnet square**

Gametes ....

......		
......		

(3 marks)

e) What is the probability that this couple's next child will have cystic fibrosis?

(1 mark)

Question 4

For question 4, please answer question 3 found on page 226 of *Edexcel IGCSE Biology*. The mark allocations are given in the textbook, except that part (a) is increased to 3 marks.

(Total: 13 marks)

Question 5

For question 5, please answer parts (b), (c) and (d) only of question 4 found on page 226 of *Edexcel IGCSE Biology*. The mark allocations are given in the textbook. (5 marks)

Question 6

For question 6, please answer Question 3 from page 149 of *Edexcel IGCSE Biology*. The marks allocated are as follows:

(a) 2 marks

(b) 2 marks

(c) 2 marks

(d) 4 marks (Total: 10 marks)

Total marks for TMA = 48

Lesson Nineteen

Natural and Artificial Selection

Aims

By the end of this lesson you should be able to:

- describe the process of evolution by means of natural selection
- understand how resistance to antibiotics can increase in bacterial populations, and appreciate how such an increase can lead to infections being difficult to control
- understand that plants and animals with desired characteristics can be developed by selective breeding

Context

This lesson covers elements 3.30 and 3.32 of Section 3 'Reproduction and inheritance' and elements 5.10–5.11 of section 5 'Use of biological resources' of the Edexcel specification.

Edexcel IGCSE Biology Chapter 19 pages 208–217 and Chapter 20 pages 218–221.

Oxford Open Learning

Introduction

For human beings in the developed world, it is normal for any child that is born to survive to adulthood and have children itself. Indeed we feel it is a tragedy when this does not happen. But this situation is very unusual. For most species (and for our own species in many places and for most of its history) the chances of surviving to reproduce are small. Usually, only those organisms best **adapted** (suited) to their **environment** (surroundings) survive long enough to reproduce.

How well an organism is adapted to its environment is largely determined by its **genes**, or better, by the particular **alleles** of genes it possesses. And because of the above point about survival, only those alleles which make their organism well-adapted will get passed on to the next generation during reproduction. It follows that, over the course of generations, the percentage of these alleles in a population will increase, other alleles will decrease, and the population will become better adapted to its environment.

This process is called **natural selection** and it was used by Charles Darwin to explain **evolution**: the change in species over time. In this lesson we shall examine Darwin's ideas carefully, and then look at a practical extension of them used in farming – the **artificial selection** of plants and animals.

Log on to Twig and look at the film titled: **Natural Selection**

www.ool.co.uk/1140vx

Darwin's theory of Natural Selection reveals an intense struggle for existence: a constant fight between individuals, species, and their physical environment, where only the fittest survive.

Evolution

Evolution is the change, or development, of species over the course of time.

The **fossil record** shows us that evolution has occurred over the millions of years for which there has been life on our planet. Fossils preserve a record of plants and animals which were alive in the distant past. Many of those (most famously the dinosaurs) are now extinct, while others, including our own group the mammals, have appeared relatively recently. So clearly life has changed over time: it has **evolved**.

Evolution has also been observed happening over the course of a few years. For example pages 210–212 of *Edexcel IGCSE Biology* describe changes observed in a species called the Peppered Moth as a result of the industrial revolution. These moths were originally all speckled. After the industrial revolution blackened tree trunks with soot, the moths evolved (changed) to having black wings (see figure 19.4 on page 210.) But after the passing of the Clean Air Act in 1956, there was a gradual regrowth of lichens on tree trunks, and the moths changed back to the speckled form.

Activity 1	Study carefully a classic example of natural selection in action: the story of the peppered moth (*Edexcel IGCSE Biology* pages 210–210). Account for the distribution of the speckled and black varieties of the moth in the 1950s as shown in the map on page 211.

Lamarck and Darwin

The naturalist, **Charles Darwin** (1809-1882), did not invent the idea of evolution. By the time he began his research in the 1830s most biologists already realized that evolution was happening. Darwin's genius was to hit upon natural selection as *the mechanism whereby evolution occurs.*

When Darwin entered the fray with his book *The Origin of Species* in 1859, most biologists accepted the mechanism for evolution proposed by the French naturalist, **Jean-Baptiste Lamarck** (1744-1829). Lamarck believed that improvements to an organism developed during its life were passed on to its offspring. So, for example, if a person trains very hard as an athlete during their teens and twenties, their improved athleticism will be passed on to their children, who will be naturally better athletes.

Darwin denied this. He claimed that *only the genes* get passed on, not the effect of the training. In the above example: he believed that children would only be naturally better athletes if they inherited a good set of athletic genes from their parents. How hard their parents had trained is irrelevant.

Many investigations have since proved Darwin right and Lamarck wrong.

Log on to Twig and look at the film titled: **Darwin's Dilemma**

www.ool.co.uk/1144fy

The creation, controversy and competition surrounding the publication of Darwin's most iconic work: The Origin of Species.

Darwin’s Theory of Evolution

Darwin’s successful theory is best called “evolution by natural selection”. He put it like this:

- Organisms always produce far more offspring than are needed just to replace the previous generation. This leads to fierce competition between the offspring for scarce resources: a **struggle for existence**.

- As a result of *random* changes (which we now trace to mutation of the genes to produce new alleles) these offspring differ from each other: they show **variation**.

- Only the best-adapted offspring survive long enough to reproduce: the **survival of the fittest**. We say they have a **selective advantage**.

- So only the best-adapted features are passed on to the next generation, who on average will be better-adapted to the environment than the preceding one.

This theory can be used to explain three puzzling things about species:

1. A species will *automatically* become well-adapted to the environment in which it finds itself, and will remain so.
2. If the environment changes, producing a change in **selection pressure**, the species will *automatically* evolve (change) to suit the new conditions.
3. If a species gets split into two sections where the environment is different, the two sections will evolve differently and eventually become two separate species. This process is called **speciation**.

Log on to Twig and look at the film titled: **Origin of Species**

www.ool.co.uk/1143sq

How are new species created? An insight into the key evolutionary processes, played out over many generations, which lead to speciation.

Biologists think that these three mechanisms have between them been responsible for the evolution and diversification of life from the first primitive organism to the rich variety of life we have on earth today.

Activity 2

(a) Study carefully figure 19.9 on page 215 of *Edexcel IGCSE Biology* which illustrates "speciation": the dividing of a single species into two separate species.

(b) Read 'The Course of evolution', pages 215–216, and examine figure 19.10 on page 216. This gives a thumbnail sketch of the main stages in the evolution of life since its beginning about 3500 million years ago.

Antibiotic Resistance in Bacteria

When **antibiotics** like penicillin were introduced in the 1940s, they revolutionised the treatment of diseases caused by bacteria which had previously caused large numbers of deaths. However a problem has emerged: **resistance**. Over time many bacteria need bigger and bigger doses of a particular antibiotic to kill them, and the eventually the antibiotic becomes useless.

Antibiotic resistance emerges as a result of natural selection. Consider a patient being treated using antibiotic X to kill the bacteria that are making them ill. If one of them, by chance, mutates to produce an allele which makes it resistant to the antibiotic, this bacterium will survive while the other, non-resistant, bacteria will die. As only the resistant bacterium will have a chance to reproduce, and because its resistance allele will be passed on to its offspring, all of the bacteria in the next generation will be resistant to the antibiotic. These resistant bacteria can then spread to other people and before long the antibiotic has become useless.

This process of the emergence and spread of antibiotic resistance is occuring all the time and it can make the control of serious infections very difficult. The only way to avoid it happening is not to use a particular antibiotic: but that defeats the purpose of having the antibiotic in the first place! This is why your GP will be reluctant to give you antibiotics for minor infections. He or she wants to reserve their use for serious cases, to reduce the chance of resistance against it spreading.

These days biochemists are in a continual race to develop new antibiotics to replace the old ones as resistance emerges.

Get it right! The use of antibiotics does not cause the production of resistance. That happens by chance. The use of antibiotics simply causes the resistance to spread once it has emerged by chance.

Artificial Selection

In natural selection, the natural *environment* chooses which organisms are allowed to reproduce and pass their genes on to the next generation. But for thousands of years *human beings* have being doing something rather similar on purpose. They have been choosing which of their crop plants and livestock are allowed to pass on their genes, and changing their crops and livestock as a result. This process is called **artificial selection** or **selective breeding**.

Log on to Twig and look at the fact-pack titled: **Selective Breeding**

www.ool.co.uk/1205xr

The artificial process behind some of our most common vegetables, and why we don't have purple carrots.

Crop Plants

The key step in selective breeding is to survey all of your growing crop plants, and **select** those which show in the most pronounced fashion the feature you want to develop. For example, if you want to increase the yield of wheat plants, you select the few wheat plants that are producing the most grain. You then collect the seeds from these plants and use *only them* to grow next year's crop. If you repeat this over several years, the crop will gradually become better-yielding.

An adaptation of this approach is shown in figure 20.2 on page 219 of the textbook. Over time original wild brassica plants have been selectively bred in several different directions as shown. By repeatedly selecting those with the biggest terminal (end of the stalk) buds, cabbages were developed; by repeatedly selecting those with the biggest flowers plus flower stalks, broccoli was developed. And so on.

Using the same approach, other less obvious traits can be developed as well, like resistance to pests or diseases, or better nutrient content.

Figure 20.1 on page 218 shows another twist of the method that was used to develop our modern wheat plants from wild grasses growing in the Middle East about 11,000 years ago. As well as selection as outlined above, different species of grass were cross-bred to enhance desirable features further. This relies on an interesting and useful characteristic of plants: unlike with animals, it is often possible to breed different species of plant together to produce new hybrid species.

Livestock

Similar techniques have also been used over the centuries to breed cows producing more milk or better meat, hens laying more eggs, sheep producing better-quality wool, dogs with particular character-traits, and so on.

With animals, of course, you need to select both a male and a female to produce the new offspring. Since the 1950s, this has been made easier by a technique called **artificial insemination**. The semen from a single bull with desirable characteristics is collected and frozen for storage. It is then transported to many different farms and used to fertilize the eggs of thousands of cows.

Now is the time to read through chapter 19 pages 208–217 and chapter 20 pages 218–221 of *Edexcel IGCSE Biology*. They cover the same topics as this lesson, so will add to your understanding of the material.

Keywords

Adapted

Natural selection

Variation

Resistance

Selective breeding

Speciation

Struggle for existence

Survival of the fittest

Environment

Evolution

Selective advantage

Artificial selection

Artificial insemination

Selection pressure