

- c** The nitrogen-fixing bacteria provide nitrates needed for growth. This is an environmental effect on growth, rather than a genetic one. Therefore the environment plays a big part in the growth of these plants.
- 8 ▶ a** Meiosis, because sperm are gametes that are haploid / contain half the number of chromosomes of body cells.
- b** Mitosis, because body cells are dividing to produce more body cells with the normal chromosome number.
- c** Mitosis, because body cells are dividing to produce more body cells with the normal chromosome number.
- d** Meiosis, because pollen grains are gametes that are haploid / contain half the number of chromosomes of the plant's body cells.
- e** Mitosis, because the zygote must divide to produce more body cells with the normal chromosome number.
- 9 ▶ a** Genetic – eye colour is inherited and not affected by the environment.
- b** Genetic – it depends on inheriting XX or XY chromosomes.
- c** Environmental – the pH of soil is a feature of the plant's environment.
- d** Both – genes determine whether a plant falls into the tall or dwarf categories, but environmental factors affect how well each plant grows.
- e** Both – genes affect the risk level, but environmental factors such as diet, smoking, etc. also have an effect.
- 10 ▶ a** Chromosomes align themselves along the equator of the cell, attached to the spindle fibres.
- b** Spindle fibres shorten and pull chromatids towards opposite poles of the cell.
- c** Chromosomes reach the opposite poles of the cell. Nucleus starts to re-form.

## CHAPTER 18

**1 ▶ D**      **2 ▶ A**      **3 ▶ D**      **4 ▶ C**

- 5 ▶ a** All tall.  
**b** All tall.  
**c** All tall.  
**d** 3 tall : 1 short.  
**e** 1 tall : 1 short (or 2 : 2).  
**f** All short.

- 6 ▶ a i** Homozygous.  
**ii** Dominant gene hides the expression of the recessive gene when heterozygous; recessive gene expressed only in homozygous form.

**b i** B and b; **ii** all Bb.

**c i** Heterozygous.

**ii**

	B	b
B	BB	Bb
b	Bb	bb

Phenotypes = 3 black : 1 red.

- 7 ▶ a** Gametes of parents = R and r  
 Genotypes of F1 = Rr  
 Genotypes of F1 parents = Rr and Rr  
 Gametes of F1 parents R, R and r, r  
 Genotypes of F2 =

	R	r
R	RR	Rr
r	Rr	rr

**b** A, B and C are red, D is yellow.

- 8 ▶ a** Individual 8 has cystic fibrosis, but neither of his parents does, so they must be heterozygous and the allele must be recessive. If the allele was dominant, he would have to have inherited at least one dominant allele from one parent, so that parent would have cystic fibrosis too.

**b** 3 and 4 must be heterozygous for the gene, as they do not have the disease, but their son does. 11 must be homozygous for the gene, since she has the disease.

- c i** Probability that the next child is male is 1 in 2, or 0.5:

	X	Y
X	XX	XY
X	XX	XY

- ii** Let A = the normal allele of the gene and a = cystic fibrosis gene.

Individual 11's genotype = aa. Individual 10's genotype could be AA or Aa.

So there are two possible outcomes:

AA × aa

	A	A
a	Aa	Aa
a	Aa	Aa

Aa × aa

	A	a
a	Aa	aa
a	Aa	aa

Depending on whether 10 is AA or Aa, there could be no chance, or a 1 in 2 chance (0.5 probability) of their next child having cystic fibrosis. It could also be argued that if the genotype of 10 is unknown, the probability of the child having cystic fibrosis is 1 in 4, or 0.25.

- 9 ▶ a** They must both be heterozygous. Let S = allele for short hair and s = allele for long hair.

	S	s
S	SS	Ss
s	Ss	ss

There is a 1 in 4 chance of producing a longhaired guinea pig (ss).

- b** Breed the shorthaired guinea pig with a homozygous longhaired guinea pig (ss). If it is heterozygous (Ss), both longhaired and shorthaired offspring will be produced (in a 1:1 ratio):

	S	s
s	Ss	ss
s	Ss	ss

If it is homozygous (SS), all offspring will have short hair:

	S	S
s	Ss	Ss
s	Ss	Ss

- 10 ▶ a** A gene is a length of DNA, coding for the production of a protein. Alleles are different forms of a gene. The phenotype is the appearance of an organism, or the features that are produced by a gene. (The way that a gene is 'expressed'.)
- b** Let allele for red coat = R and allele for white coat = W (note that different letters are used, since this is a case of codominance).

**i**

	R	R
W	RW	RW
W	RW	RW

**ii**

	R	R
R	RR	RR
W	RW	RW

**iii**

	R	W
R	RR	RW
W	RW	WW

- c** Ratios in (b) are:

- i** all roan;  
**ii** 1 red: 1 roan;  
**iii** 1 red : 2 roan : 1 white.

- b** It would decrease as it would not give an advantage; rats that don't have the gene will breed equally well. (In fact rats with the warfarin gene have a selective disadvantage when warfarin is not being used, although students will not know this.)

- 8 ▶ a** They have a heavy beak, which is adapted to crush seeds.  
**b** They have a long, narrow beak, which can be used to probe under the bark of trees for insects.  
**c** Ancestors showed slight variations in their beaks. Where the variation enabled a bird to catch insects, or eat leaves and other food better than birds with other types of beak, the birds survived better and reproduced (survival of the fittest), passing on their genes for the adaptation. Eventually groups of birds became so different from members of other groups that they couldn't interbreed, and formed new species.
- 9 ▶ a** As a result of (random) mutations.

- b** Selection pressure: a factor in the environment that affects the fitness of an organism. In this case the presence of toxic metals means that the non-tolerant plants will be killed and not reproduce to pass on their genes.

Selective advantage: varieties that survive in the presence of a selection pressure are said to have a selective advantage. In this example the plants that are tolerant to toxic metals have a selective advantage when compared with the non-tolerant plants.

Natural selection: the overall process that, when metals are present, results in fewer non-tolerant plants and an increase in the number of tolerant plants. If it continues, natural selection results in evolution.

- c** When there are no toxic metals, the metal-tolerant plants must have some sort of selective disadvantage over the non-tolerant ones. For example, they may need to use metabolic energy (ATP) to protect their cells against metals or get rid of metal ions. If there are no metal ions in the soil, this is a waste of resources.

## CHAPTER 19

- 1 ▶ D**      **2 ▶ B**      **3 ▶ A**      **4 ▶ D**
- 5 ▶ a** It means that the organisms that are best adapted to their environment are more likely to survive and reproduce.  
**b** Darwin and Wallace.
- 6 ▶ a** An organism that causes disease.  
**b** Fungi and bacteria.  
**c** Random mutations produce some bacteria that are resistant to an antibiotic. If the antibiotic continues to be used, the resistant bacteria will survive and the non-resistant ones will be killed. The resistant bacteria have a selective advantage over the non-resistant bacteria; they quickly reproduce and cause disease.
- 7 ▶ a** Rats with the resistant gene survived and reproduced, so now many more rats carry the gene. Rats without the gene did not survive to reproduce.

## CHAPTER 20

- 1 ▶ D**      **2 ▶ C**      **3 ▶ B**      **4 ▶ A**
- 5 ▶ a** Both involve selection of which animals or plants survive to breed.  
**b** In selective breeding the farmer / breeder does the selection. In natural selection it is the survival of the fittest in a habitat that leads to selection.
- 6 ▶ a** 1) Plants have resistance to disease, so they are not killed by fungi, bacteria, etc.  
 2) Plants are better suited to climate, so can grow well in a particular location.  
 3) Plants have a better balance of nutrients; produce more nutritious food, or have a high vitamin content etc.  
 (Or any other correct reason.)
- b** Two from: quicker to produce large numbers of plants because only a few cells needed; plants can be produced at any time of year since grown inside; large numbers of plants can be stored easily until needed.