# Genes & Alleles Revision

A Level

## Part A Mutations

Sickle cell anaemia is caused by a mutation in the gene that codes for the $\beta$-globin polypeptide of haemoglobin.

The sequence of bases in a small section of the sense/coding strand of DNA for both the HbA (normal) and HbS (sickle cell) $\beta$-globin alleles are shown below. Both sequences are "in-frame" i.e. the first three bases correspond to a single codon.

HbA: $\mathrm{CTGACTCCTGAGGAGAAGTCT}$

HbS: $\mathrm{CTGACTCCTGTGGAGAAGTCT}$

How will the HbS mutation result in the production of an altered version of the $\beta$-globin polypeptide? Select all that apply.

- [ ] mRNA transcribed from the HbS allele will contain the codon $\mathrm{CAC}$ instead of the codon $\mathrm{CUC}$.
- [ ] mRNA transcribed from the HbS allele will contain the codon $\mathrm{GUG}$ instead of the codon $\mathrm{GAG}$.
- [ ] a tRNA molecule with the anticodon $\mathrm{CAC}$ will bind to the altered codon on mRNA
- [ ] a tRNA molecule with the anticodon $\mathrm{GUG}$ will bind to the altered codon on mRNA
- [ ] the amino acid coded for by the altered codon will differ from the corresponding region in the HbA protein
- [ ] all of the amino acids coded for after the mutation will differ from those in the HbA protein

## Part B Allele interactions

The table below describes different examples of allelic interactions.

| | |
|---|---|
| **A** | An Antirrhinum plant with red flowers is crossed with one that has white flowers. All the offspring have pink flowers. |
| **B** | A haemophiliac man has children with a woman who is not a haemophiliac. Their daughters all carry the allele for the disease, but their sons do not have the disease. |
| **C** | Two Salvia plants with purple flowers are crossed. The offspring are produced in the ratio $9$ purple-flowered : $3$ pink-flowered : $4$ white-flowered. |
| **D** | A short-haired black mouse crossed with a long-haired brown mouse produces all short-haired black offspring. Mating one of these offspring with the long-haired parent produces mice in the ratio of $1$ short-haired black : $1$ long-haired black : $1$ short-haired brown : $1$ long-haired brown. |
| **E** | Two snails with plain shells produce $34$ offspring with plain shells and $12$ with striped shells. |

Complete the table below by matching each of the examples above to the correct explanation.

| Explanation | Example |
|---|---|
| One gene with two alleles. The alleles show codominance. | |
| One gene with two alleles located on an autosome (gene not sex-linked). One allele is dominant and the other is recessive. | |
| Two genes for two different characteristics on two different chromosomes. | |
| A sex-linked gene with a dominant and a recessive allele. | |
| Epistasis, where two genes interact to affect one phenotypic character. | |

Items:

**A** **B** **C** **D** **E**

## Part C Gene regulation

How do transcription factors regulate gene expression? Select all that apply.

- [ ] Some transcription factors (activators) activate/increase gene expression by binding to the enhancer region of a gene.
- [ ] Transcription factors synthesise mRNA as they move along a gene.
- [ ] Binding of transcription factors to mRNA facilitates the binding of tRNA molecules
- [ ] Some transcription factors (repressors) stop/decrease gene expression by binding to the silencer region of a gene.
- [ ] Binding of transcription factors to regulatory regions either facilitates or inhibits the binding of RNA polymerase to the promoter region.
- [ ] Transcription factors synthesise a polypeptide chain as they move along an mRNA strand.

---

Created for isaacphysics.org by Lewis Thomson. Parts A and B adapted with permission from CIE A Level Biology, June 2015, Paper 1, Question 22 and OCR A Level Biology A, June 2014, Control, Genomes and Environment, Question 6a

# Chicken Feathers

A Level

C C C

Domestic chickens have been bred for many years to increase the number of eggs laid by the females. It is useful to be able to identify the young female chicks on the day after they hatch, as only the females need to be kept for laying eggs.

Unlike mammals, where the sex chromosomes are known as X and Y, in chickens the sex chromosomes are known as Z and W.

- Male chickens have two Z chromosomes (ZZ).
- Female chickens have one Z chromosome and one W chromosome (ZW).

## Part A Inheritance type

Some genes for feather colour and pattern in chickens are carried on the Z chromosome but not on the W chromosome. One such example is the gene for striped feathers (barring).

State the name given to this type of inheritance.

## Part B Genotype to phenotype

Inheritance of the barring pattern can be used to identify female chicks when they are one day old.

The phenotypes associated with the two alleles of the barring gene are shown in the table below.

| Allele | Adult phenotype | Day-old chick phenotype |
|---|---|---|
| dominant **B** | black feathers striped with white bars (barred) | black body with a white spot on head |
| recessive **b** | black feathers (non-barred) | black body and head |

Match the adult phenotype and sex to the genotype in the table below.

| Genotype | Adult phenotype | Sex |
|---|---|---|
| $Z^BZ^b$ | | |
| $Z^BW$ | | |
| $Z^bW$ | | |

Items:

**barred** **non-barred** **male** **female**

## Part C Genetic cross

A cross was carried out between a barred female and a non-barred male.

Which of the following genotypes could be observed in the F1 generation? Assume that no mutations occur. Select all that apply.

- [ ] $Z^bW$
- [ ] $Z^BW$
- [ ] $Z^bZ^b$
- [ ] $Z^BZ^b$
- [ ] $Z^BZ^B$

## Part D Epistasis

The autosomal gene **I** / **i** shows epistasis over **all** other genes affecting feather colour in chickens.

Individuals carrying the dominant allele **I** have white feathers.

Chickens that are not white have the genotype **ii**.

State the precise term used to describe the genotype **ii**.

A cross was carried out between a male homozygous barred chicken and a white female chicken with the genotype **II**.

Which of the following adult phenotypes could be observed in the F1 generation? Assume that no mutations occur. Select all that apply.

- [ ] black feathers striped with white bars (barred)
- [ ] white feathers
- [ ] black feathers (non-barred)

Adapted with permission from OCR A Level Biology A, June 2013, Control, Genomes and Environment, Question 1

Gameboard:

**STEM SMART Biology Week 46**

# Primate Mutation Rates

A Level

Differences between nucleotide base sequences can be used to estimate the length of time since two species diverged from one another.

The greater the number of differences, the greater the length of time that has elapsed since the two organisms were part of the same species.

The figure below shows the line of best fit for the differences in coding DNA between pairs of primate species plotted against the number of years since the two species diverged from a common ancestor.

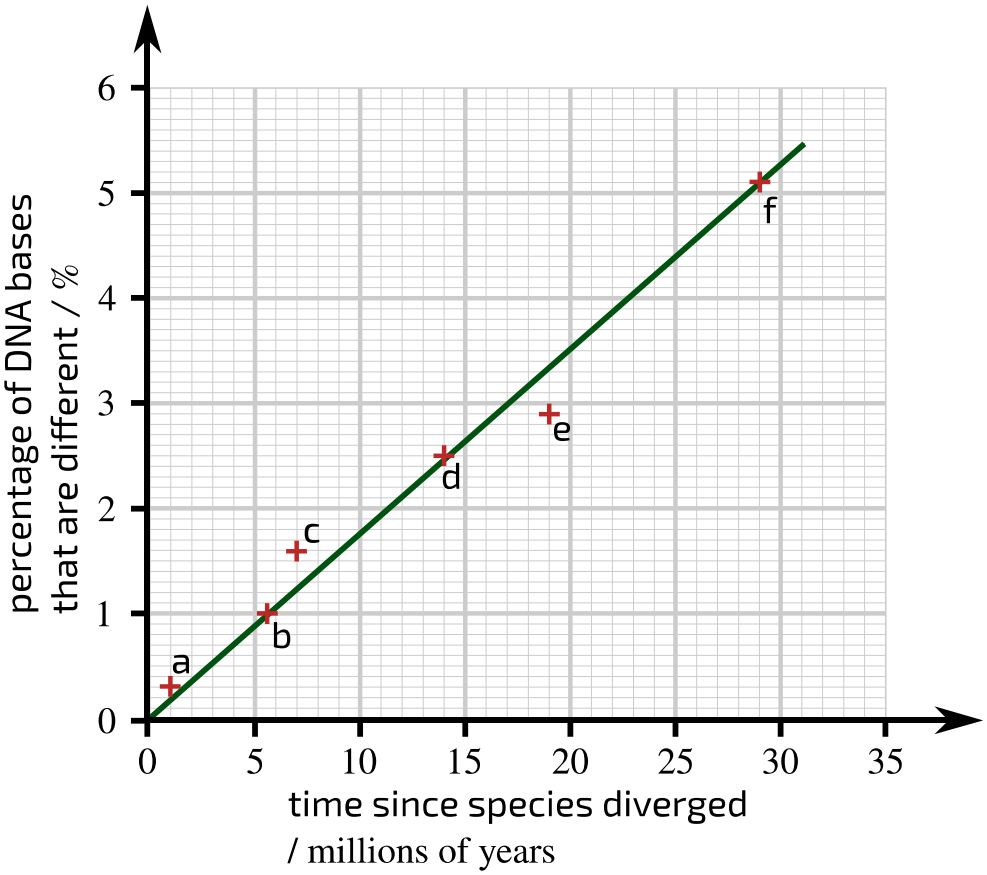


**Figure 1:** Percentage of coding DNA bases that are different between species pairs plotted over time since those two species diverged. Each point (a-f) represents a pair of primate species. "a" represents chimpanzees & bonobos. "b" represents chimpanzees & humans. "d" represents orangutans and humans.

## Part A Rate of change

Calculate the rate of DNA change using the data in **Figure 1**.

Give your answer to 2 significant figures.

## Part B Estimation accuracy

The mutation rate in mammals can vary by as much as $20\%$ between species.

Using **Figure 1** and your answer in part A, calculate the **shortest** possible time since the divergence of humans and chimpanzees.

Give your answer to 2 significant figures.

Using **Figure 1** and your answer in part A, calculate the **longest** possible time since the divergence of humans and chimpanzees.

Give your answer to 2 significant figures.

## Part C Point c

The figure below shows the phylogenetic tree of the great apes (Hominidae).

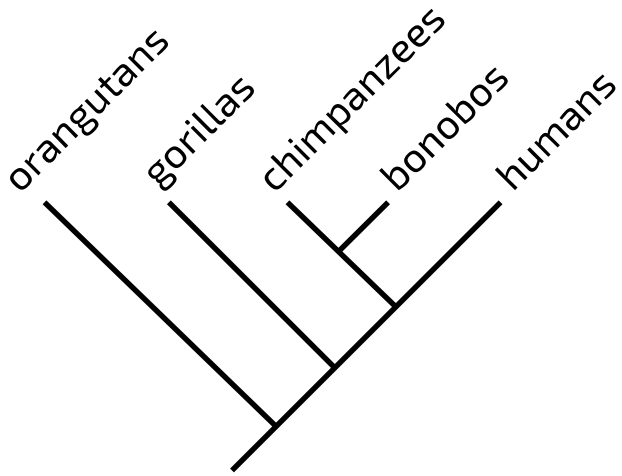


**Figure 2:** Diagram representing the phylogenetic tree of great apes (Hominidae).

Based on **Figure 2**, which primate pairs could be represented by point **c** in **Figure 1**? Select all that apply.

- [ ] humans & bonobos
- [ ] humans & gorillas
- [ ] bonobos & gorillas
- [ ] chimpanzees & gorillas
- [ ] gorillas & orangutans
- [ ] chimpanzees & orangutans
- [ ] bonobos & orangutans

Adapted with permission from OCR A Level Biology A, June 2017, Biological diversity, Question 19

Gameboard:
**STEM SMART Biology Week 46**

# Ash Woodland Biodiversity

A Level

On a biology field trip, a pair of students collected some data about plant species in an area of ash woodland. Their results are shown in the table below.

| Species | Number of individuals $(n)$ |
|---|---|
| Dog's mercury | 40 |
| Wild strawberry | 13 |
| Common avens | 43 |
| Wood sorrel | 4 |

## Part A Simpson's Index of Diversity

Use the information in the table above to work out the Simpson's Index of Diversity ($D$) for the area of woodland sampled using the formula:

$$D = 1 - \sum \left(\frac{n}{N}\right)^2$$

where

- $n =$ the number of individuals of each species
- $N =$ the total number of individuals of all species

Give your answer to 2 significant figures.

## Part B Species richness and species evenness

Simpson's Index of Diversity is a measure of biodiversity that takes into account both species **richness** and species **evenness**.

What is meant by species **richness**? Select one option.

- the number of individuals of one species in an area
- the total number of individuals across all species in an area
- the number of species in an area
- the similarity in relative abundances of all the species in an area

---

What is meant by species **evenness**? Select one option.

- the number of individuals of one species in an area
- the total number of individuals across all species in an area
- the number of species in an area
- the similarity in relative abundances of all the species in an area

---

## Part C Increasing diversity

Which of the following changes to the data above would give a **higher** value of Simpson's Index of Diversity? Select all that apply.

- [ ] if an additional species of population size $n = 25$ were added (while keeping the existing population sizes the same)
- [ ] if the population size of each species were 25
- [ ] if Common avens were removed (while keeping the existing population sizes the same)
- [ ] if Wood sorrel were removed (while keeping the existing population sizes the same)
- [ ] if the population size of Common avens were greater (while keeping the total number of individuals of all species ($N$) the same)
- [ ] if the population size of Wood sorrel were greater (while keeping the total number of individuals of all species ($N$) the same)

---

Adapted with permission from OCR AS Level Biology A, June 2013, Molecules, Biodiversity, Food and Health, Question 4

Gameboard:
**STEM SMART Biology Week 46**

# Respiration & Photosynthesis Revision

A Level

## Part A Respiration

Name the molecule that is produced during glycolysis and which is converted to acetyl CoA during the link reaction.

Name the molecule that reacts with acetyl CoA during the Krebs cycle to produce citric acid.

Name the part of the mitochondrion in which the Krebs cycle takes place.

## Part B Photosynthesis: light-dependent reaction

Photosynthesis involves two main stages:

- the light-dependent stage, which involves photosystems
- the light-independent stage, which involves the Calvin cycle.

Photosynthetic pigments are arranged in groups known as photosystems I and II.

Name the primary photosynthetic pigment in these photosystems.

---

Name an accessory pigment.

---

Name the compound that is synthesised in the light-dependent stage as a result of the generation of an electrical and pH gradient across the thylakoid membrane.

---

## Part C Photosynthesis: light-independent reaction

Name the part of the chloroplast in which the Calvin cycle takes place.

Name the enzyme that catalyses the fixation of carbon dioxide.

Name the first stable product of carbon dioxide fixation.

Name the compound that is regenerated in the Calvin cycle so that more carbon dioxide can be fixed.

Parts B and C adapted with permission from OCR A Level Biology A, June 2014, Communication, Homeostasis and Energy, Question 1.

Gameboard:
**STEM SMART Biology Week 46**

# Plant Physiology Revision

A Level

## Part A Xylem vs phloem

Fill in the table below to compare xylem and phloem.

| Xylem | Phloem |
| --- | --- |
| xylem transports water and [ ] | phloem transports [ ] |
| xylem vessel walls are reinforced with [ ] | sieve tube walls have no additional support |
| xylem vessel walls contain [ ] that allow water to pass into adjacent vessels | there are many gaps in the cell walls between companion cells and sieve tube elements called [ ] |

Items:

lignin | chitin | plasmodesmata | mineral ions e.g. nitrates and phosphates | assimilates e.g. sucrose and amino acids | pits

## Part B Phloem loading

A scientist isolated companion cells and conducted some experiments to investigate the mechanism involved in loading sucrose into the sieve tubes. The scientist recorded the following observations:

- Observation 1: isolated companion cells became slightly negatively charged compared with their surroundings.
- Observation 2: companion cells could decrease the pH of the surrounding solution from $7.0$ to $5.6$.
- Observation 3: the pH inside the companion cells rose from $7.0$ to $8.2$.
- Observation 4: treatment with cyanide (which stops aerobic respiration) prevents the change in pH occurring.

Which of the following conclusions can be drawn from the observations above? Select all that apply.

- [ ] hydrogen ions are moving from the companion cells to the surrounding solution
- [ ] hydrogen ions are moving from the surrounding solution into the companion cells
- [ ] hydrogen ions are moving by passive transport
- [ ] hydrogen ions are moving by active transport

## Part C Xerophytes

Xerophytes are plants that are adapted to living in dry conditions.

The table below describes four general features of leaves. In each section, one leaf belongs to a xerophyte.

| | |
|---|---|
| **Presence of hairs on leaves** | |
| Leaf **A** | no |
| Leaf **B** | yes |
| Leaf **C** | no |
| **Mean number of stomata** $(\mathrm{cm}^{-2})$ | |
| Leaf **D** | 30 000 |
| Leaf **E** | 23 000 |
| Leaf **F** | 13 000 |
| **Mean surface area of one leaf** $(\mathrm{cm}^{2})$ | |
| Leaf **G** | 0.2 |
| Leaf **H** | 10.0 |
| Leaf **I** | 23.0 |
| **Thickness of cuticle** $(\mu\mathrm{m})$ | |
| Leaf **J** | 4.25 |
| Leaf **K** | 8.50 |
| Leaf **L** | 2.00 |

Which four leaves belong to xerophytes? Choose one from each section.

- [ ] A
- [ ] B
- [ ] C
- [ ] D
- [ ] E
- [ ] F

- [ ] G
- [ ] H
- [ ] I
- [ ] J
- [ ] K
- [ ] L

---

Adapted with permission from OCR AS Level Biology A, June 2013, Cells, Exchange and Transport, Question 6 and OCR AS Level Biology A, June 2014, Cells, Exchange and Transport, Question 4