Government of **Western Australia**
School Curriculum and Standards Authority

Science: Biological sciences

Teaching, learning and assessment exemplar

Year 10

DNA, genes and inheritance

Acknowledgement of Country

Kaya. The School Curriculum and Standards Authority (the Authority) acknowledges that our offices are on Whadjuk Noongar boodjar and that we deliver our services on the country of many traditional custodians and language groups throughout Western Australia. The Authority acknowledges the traditional custodians throughout Western Australia and their continuing connection to land, waters and community. We offer our respect to Elders past and present.

Background

This teaching, learning and assessment exemplar (the exemplar) has been developed by the School Curriculum and Standards Authority (the Authority) as part of the *School Education Act Employees (Teachers and Administrators) General Agreement 2017* (Clause 61.1–61.3).

Disclaimer

Any resources, such as texts and websites, that may be referred to in this document are provided as examples of resources that teachers can use to support their learning programs. Their inclusion does not imply that they are mandated or that they are the only resources relevant to the course. Teachers must exercise their professional judgement as to the appropriateness of any resources they may wish to use.

This resource utilises electronic web-based resources, such as videos and image galleries. Teachers should be present while an electronic resource is in use and close links immediately after a resource, such as a video has played to prevent default 'auto play' of additional videos. Where resources are referred for home study, they should be uploaded through Connect, or an equivalent system, that filters advertising content.

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Contents

The Western Australian Curriculum

The *Western Australian Curriculum and Assessment Outline* (the *Outline* – https://k10outline.scsa.wa.edu.au) sets out the mandated curriculum, guiding principles for teaching, learning and assessment and support for teachers in their assessment and reporting of student achievement. The *Outline* recognises that all students in Australian schools, or international schools implementing the Western Australian Curriculum, are entitled to be given access to the eight learning areas described in the *Alice Springs* (*Mparntwe*) *Education Declaration*, December 2019.

The Science curriculum

The mandated curriculum is presented in the year level syllabus documents.

The Science curriculum delivers a sequential and age-appropriate progression of learning with the following key elements:

- a year level description that provides an overview of the context for teaching and learning in the year
- a series of content descriptions, populated through strands and sub-strands, that sets out the knowledge, understanding and skills that teachers are expected to teach and students are expected to learn
- an achievement standard that describes an expected level that the majority of students are achieving by the end of a given year of schooling. An achievement standard describes the quality of learning (e.g. the depth of conceptual understanding and the sophistication of skills) that would indicate the student is well placed to commence the learning required in the next year.

This exemplar

This Science exemplar articulates the content in the *Outline* and approaches to teaching, learning and assessment reflective of the Principles of Teaching, Learning and Assessment. This exemplar demonstrates a sequence of teaching and learning, including suggested assessment points, for 15 lessons.

Catering for diversity

This exemplar provides a suggested approach for the delivery of the curriculum and reflects the rationale, aims and content structure of the learning area. When planning the learning experiences, consideration has been given to ensuring that they are inclusive and can be used in, or adapted for, individual circumstances. It is the classroom teacher who is best placed to consider and respond to (accommodate) the diversity of their students. Reflecting on the learning experiences offered in this exemplar will enable teachers to make appropriate adjustments (where applicable) to better cater for students' gender, personal interests, achievement levels, socio-economic, cultural and language backgrounds, experiences and local area contexts.

Safety

Science learning experiences may involve the use of potentially hazardous substances and/or hazardous equipment. It is the responsibility of the school to ensure that duty of care is exercised in relation to the health and safety of all students and that school practices meet the requirements of the *Work Health and Safety Act 2011*, in addition to relevant State health and safety guidelines.

Using this exemplar

This teaching, learning and assessment exemplar provides suggestions to support the delivery of the mandated curriculum content. The exemplar provides:

- a teaching and learning sequence
- the mandated curriculum content to be taught at each point of the teaching and learning sequence, suggested resources, a sample assessment task and marking key
- the number of lessons to deliver the teaching and learning experiences
- learning intentions and support notes that may provide focus questions and additional information and/or examples to assist with the interpretation of curriculum content
- support notes to assist teachers to unpack the content and support teaching and learning experiences
- teaching and learning experiences that outline the structure of the lesson. These explicitly state each activity that the lesson will progress through and the key focus area for that activity.

Links to electronic resources

This sequence of lessons may utilise electronic web-based resources, such as videos and image galleries. Teachers should be present while an electronic resource is in use and close links immediately after a resource, such as a video, has played to prevent default 'auto play' of additional videos. Where resources are referred for home study, they should be uploaded through Connect, or an equivalent system, that filters advertising content.

Best practice

Teaching and learning

The teaching and learning opportunities offered in this exemplar are not exhaustive. Thus, teachers are encouraged to make professional decisions about which learning experiences, and the sequence in which they are delivered, are best suited to their classroom context, taking into account the availability of resources and student ability.

This sample may prove a useful starting point for amplifying creativity in the classroom, while presenting the embedded expectations of the Western Australian Curriculum: Science.

Teachers may find opportunities to incorporate the General Capabilities and the Cross-curriculum Priorities into the teaching and learning program.

Ways of teaching – teachers can locate additional information on the Ways of teaching from the School Curriculum and Standards Authority (the Authority) website https://k10outline.scsa.wa.edu.au/home/wa-curriculum/learning-areas/science/overview/science-ways-of-teaching.

Assessing

Assessment, both formative and summative, is an integral part of teaching and learning. Assessment should arise naturally out of the learning experiences provided to students. In addition, assessment should provide regular opportunities for teachers to reflect on student achievement and progress. As part of the support it provides for teachers, this exemplar includes suggested assessment points. It is the teacher's role to consider the contexts of their classroom and students, the range of assessments required, and the sampling of content descriptions selected to allow their students the opportunity to demonstrate achievement in relation to the year level achievement standard. Teachers are best placed to make decisions about whether the suggested assessment/s are used as formative or summative assessment and/or for moderation purposes.

Ways of assessing – a range of assessment strategies that can enable teachers to understand where students are in their learning is available on the Authority website https://k10outline.scsa.wa.edu.au/home/teaching/curriculum-browser/science-v8/overview/ways-of-assessing.

Reflecting

Reflective practice involves a cyclic process during which teachers continually review the effects of their teaching and make appropriate adjustments to their planning. The cycle involves planning, teaching, observing, reflecting and replanning.

This exemplar supports reflective practice and provides flexibility for teachers in their planning. The exemplar shows how content can be combined and revisited throughout the year. Teachers will choose to expand or contract the amount of time spent on developing the required understandings and skills according to their reflective processes and professional judgements about their students' evolving learning needs.

DNA, genes and inheritance

The teaching and learning sequence will develop students' understanding of DNA, genes and chromosomes, and the transmission of heritable characteristics from one generation to the next. It will provide opportunity to predict potential outcomes of interactions between autosomal and sex-linked alleles. In addition to explicit teaching, students will apply their science understanding and construct representations to predict outcomes of heritable characteristics. This allows students to build on their prior learning, before applying their understanding to a different context.

The teaching and learning sequence equips students with the foundational knowledge and experience to apply their understanding of inheritance to predict potential outcomes of interactions from allele combinations. This prepares them to confidently apply their understanding in the summative assessment.

Year level description

In the middle adolescence phase of schooling, teaching and learning programs encourage students to develop an open and questioning view of themselves as active participants in their society and the world.

Science provides opportunities for students to build on their understanding of important concepts and continue to develop scientific ideas and models to explain phenomena and events.

In Year 10, students investigate processes that underpin heredity and natural selection to understand the continuity of life. They develop a more sophisticated understanding of atomic theory and explore patterns and relationships within the periodic table to explain ionic and covalent bonding. They predict the effect of changing reactant and reaction conditions, use patterns of reactions to predict reaction products and represent reactions using chemical equations. They explore the key events in the formation of stars, galaxies and planetary systems and how space exploration has contributed to knowledge of the formation and evolution of the universe and improved life on Earth. They understand that motion and forces are related by applying physical laws and mathematical models. They apply the law of conservation of energy to analyse system efficiency.

Students propose questions and hypotheses to test relationships and develop models. They develop and follow risk assessments when planning and conducting reproducible investigations with appropriate sample sizes and replicable data. They select and construct appropriate representations to organise, process and summarise data. They analyse data to describe patterns, relationships and anomalies and use a variety of evidence to support conclusions. They describe the validity and reliability of methods and suggest ways to improve the quality of the data. They use content, language and text features to achieve their purpose when communicating their ideas, findings and arguments to specific audiences. They explore how advances in science, technologies and engineering are interconnected and examine how scientific responses impact society.

Achievement standard

By the end of the year:

Students describe the process of inheritance in terms of genes and predict the outcome of autosomal dominant/recessive crosses. They describe the processes involved in the theory of evolution by natural selection. They describe how the periodic table organises elements and use it to make predictions about types of bonding. They predict the effect of changing reactant and reaction conditions and use patterns of reactions to predict reaction products. They sequence key events in the formation of stars, galaxies and planetary systems and describe the benefits of space exploration. They recall Newton's laws of motion and use them to predict motion of objects in a system. They describe the concept of energy conservation and represent energy transfer and transformation within systems.

Students plan and conduct valid and reproducible investigations to test or identify relationships and models. They follow risk assessments when conducting investigations. They select equipment and use it to generate and record appropriate sample sizes and replicable data. They select and construct appropriate representations to organise, process and summarise data and information. They analyse data and information to identify and describe patterns, relationships and anomalies. They describe the validity and reliability of methods and suggest ways to improve the quality of the data. They use evidence to draw conclusions that identify patterns or relationships evident in their data. They construct arguments based on analysis of a variety of evidence to support conclusions and evaluate claims. They use content, language and text features effectively to achieve their purpose when communicating their ideas, findings and arguments to specific audiences. They describe how advances in science, technologies and engineering are interconnected and analyse scientific responses and how these responses impact society.

Lessons 1–15

DNA, genes and inheritance

Lesson 1: Structure and role of DNA

The Western Australian Curriculum content addressed in this lesson is below.

Science understanding

Biological sciences

- Cell division processes of meiosis and mitosis produce new cells with chromosome numbers specific to their role; chromosomes contain genes that are composed of DNA (deoxyribonucleic acid)

Science inquiry

Collaborating and applying

- Illustrate how proposed scientific responses to contemporary issues may impact on society

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Resources

- ITV News – How can DNA test companies use your data? | ITV News
  https://www.youtube.com/watch?v=iGGKbvnHLCM
- TED-ED – What can DNA tests really tell us about our ancestry? – Prosanta Chakrabarty
  https://www.youtube.com/watch?v=YiydsMxOdM8
- Your Genome: Introduction to genomics
  https://www.yourgenome.org/explore-genomics/introduction-to-genomics/#
- Learn Genetics: Genetic Science Learning Centre – How to extract DNA from anything living
  https://learn.genetics.utah.edu/content/labs/extraction/howto/
- Your Genome – Extracting DNA from fruit
  https://www.youtube.com/watch?v=ojGRBQ2FjP8
- Teach Engineering – Hands on activity DNA Build
  https://www.teachengineering.org/activities/view/cub_biomed_lesson09_activity2

Teacher information

- Genetics is the study of genes, heredity and variation of inherited characteristics.
- DNA (deoxyribonucleic acid) stores the information that controls cell activity.
- The structure of DNA
  - Nucleotides are molecules that make up DNA and consist of three parts: phosphate group, deoxyribose sugar, and one of four nitrogenous bases (the bases).
  - The four bases are: adenine (A), thymine (T), guanine (G) and cytosine (C).
  - The nucleotides are arranged as a double helix (similar to a twisted ladder). The ‘sides of the ladder’ are made up of alternating phosphate and sugar groups. The ‘steps of the ladder’ are made up of complementary base pairs.
  - The bases undergo complementary base pairing due to each having different chemical structures and so can only pair up in one way. For example, adenine with thymine (A–T) and guanine with cytosine (G–C). Therefore, the steps of the ladder are either A–T or G–C pairs.

Lesson outline

Learning intentions
Students will: • explore the use of DNA testing in current society • define genetics • describe the role and location of DNA • identify and describe the structure of DNA

Introduction

- Introduce the use of DNA testing by companies for a range of applications by showing students an appropriate video.
- Lead a whole-class discussion around the use, advantages and disadvantages of DNA testing.
- Ask the questions: 'What effect could this have in the future?', 'Would you do a DNA test? Why or why not?' and 'Would you have your pet DNA tested?'

Lesson activities

Activity 1

- Explicitly teach the following:
  - definition of genetics
  - role of DNA
  - location of DNA in cells
  - structure of nucleotide and DNA molecule including complementary base pairing rule.
- Instruct students to take notes and draw diagrams on the information presented.

Activity 2

- Demonstrate and explain a practical activity on DNA extraction.
- Instruct students to form groups and conduct a practical activity on DNA extraction from strawberries or other appropriate sources.
- Monitor students while conducting the practical activity to ensure the correct operation of the apparatus, and that the students are working safely and cooperatively.

Concluding activity

- To check understanding, provide students with a diagram of a nucleotide and DNA structure to colour and label the parts.
- Provide students with a glossary sheet, or have students start their own glossary to record definitions they encounter throughout the unit.

Optional activities

- Create a model of the structure of DNA.
- Investigate the use of DNA testing in medical research, conservation, forensics, etc.
- Explore the social and ethical issues associated with genetic and genomic science.
- Research how the work of Rosalind Frankland, James Watson, Francis Crick and Maurice Wilkins contributed to the development of the double helix structure of DNA.

Lesson 2: DNA, chromosomes and genes

The Western Australian Curriculum content addressed in this lesson is below.

Science understanding

Biological sciences

- Cell division processes of meiosis and mitosis produce new cells with chromosome numbers specific to their role; chromosomes contain genes that are composed of DNA (deoxyribonucleic acid)

Science inquiry

Processing, modelling and analysing

- Select and construct appropriate representations, including tables, graphs, descriptive statistics, models and mathematical relationships, to organise and process data and information

Communicating

- Communicate scientific ideas and information for specific purposes and audiences, including constructing evidence-based arguments and selection of appropriate content, language and text features, using digital tools as appropriate

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Resources

- National Geographic – Genetics 101 | National Geographic
  https://www.youtube.com/watch?v=v8tJGlicgp8
- Cognito – GCSE Biology - DNA Part 1 | Chromosomes & Genome
  https://www.youtube.com/watch?v=fy2F8yFxqOI
- Your Genome: Introduction to genomics
  https://www.yourgenome.org/explore-genomics/introduction-to-genomics/#
- Exploratorium – The DNA Files Workshop Series
  https://annex.exploratorium.edu/dnafiles/series.html

Teacher information

- Chromosomes are structures within cells that contain genes.
- Genes are segments of DNA that code for a particular protein.
- DNA is the molecule that is the hereditary material in living things, the blueprint for controlling characteristics of an organism.
- Traits and characteristics are passed on from parents through genes. Genes are located at a specific position on a chromosome. They are a made up of a sequence of letters that code for a specific protein, which are responsible for the structure and function of each cell in the body; therefore, responsible for all the characteristics inherited.

Lesson outline

Learning intentions
Students will: • define DNA, chromosomes and genes • recognise the structure of genes and chromosomes • use models and diagrams to represent the relationship between DNA, genes and chromosomes

Introduction

- Use a *Think, pair, share* strategy to answer the following question: 'Where is your genetic information stored and what does it look like?'

Lesson activities

Activity 1

- Explicitly teach the following:
  - the difference between DNA, a gene and a chromosome
  - the relationship between DNA, genes and chromosomes.
- Draw or provide a diagram of a chromosome, showing both where a gene is located and how DNA makes up that gene and chromosome.
- Instruct students to take notes and draw diagrams on the presented information.

Activity 2

- Instruct students to create a representation to show the location of DNA in a cell and explain the relationship between DNA, genes and chromosomes. This could be done by one of the following methods:
  - use of modelling clay and various other materials to create the model.
  - creating a digital animation, movie, infographic or any suitable method of presentation. The model/representation should include an explanation of the role of genes in the process of inheritance.
- This activity may be used as a formative assessment task for the teacher to provide feedback, or students may peer assess and provide feedback to each other based on a checklist/infographic created by the teacher.

Concluding activity

- Students complete a gallery walk around the classroom with the teacher to view other students' models, animations, videos, infographics and other presentations.

Optional activities

- Investigate the number of chromosomes and genes in different organisms.
- Research the Human Genome Project.

Lesson 3: DNA replication

The Western Australian Curriculum content addressed in this lesson is below.

Science understanding

Biological sciences

- Cell division processes of meiosis and mitosis produce new cells with chromosome numbers specific to their role; chromosomes contain genes that are composed of DNA (deoxyribonucleic acid)

Science inquiry

Processing, modelling and analysing

- Select and construct appropriate representations, including tables, graphs, descriptive statistics, models and mathematical relationships, to organise and process data and information

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Resources

- Your Genome – Introduction to genomics https://www.yourgenome.org/explore-genomics/introduction-to-genomics/
- Amoeba sisters – DNA Replication (Updated) https://www.youtube.com/watch?v=Qqe4thU-os8
- Crash Course – DNA Structure & Replication: Our Instruction Manual for Existing: Crash Course Biology #33 https://www.youtube.com/watch?v=4YNDB_zSzfE
- Your Genome – DNA replication – 3D https://www.youtube.com/watch?v=TNKWgcFPHqw
- ABC Education – Science games for secondary students https://www.abc.net.au/education/science-games-for-secondary-students-and-classrooms/14031616 (Scroll down to 18. Genes)

Teacher information

- Nucleotides are molecules that make up DNA and consist of three parts: phosphate group, deoxyribose sugar, and one of four nitrogenous bases (the bases).
- The four bases are: adenine (A), thymine (T), guanine (G) and cytosine (C).
- The nucleotides are arranged as a double helix (similar to a twisted ladder). The ‘sides of the ladder’ are made up of alternating phosphate and sugar groups. The ‘steps of the ladder’ are made up of complementary base pairs.
- The bases undergo complementary base pairing due to each having different chemical structures and so can only pair up in one way. For example, adenine with thymine (A–T) and guanine with cytosine (G–C). Therefore, the steps of the ladder are either A–T or G–C pairs.
- DNA replication
  - During interphase, the DNA is undergoing DNA replication, to produce exact copies of each strand. DNA Helicase ‘unzips’ the two original DNA strands, by breaking them apart at the hydrogen bond between the base pairs on the ladder. Primase is used to attach to the section of the original strand to be copied, so the DNA polymerase knows where to attach itself and begin ‘building’ the complementary bases onto the new strands. The process results in two identical DNA strands, ready to undergo cell division.

Lesson outline

Learning intentions
Students will: • explain the purpose of DNA replication • describe the basic steps of DNA replication • use models and diagrams to represent DNA replication

Introduction

- Review students' understanding of structure and role of DNA, chromosomes and genes using either an online or paper quiz.

Lesson activities

Activity 1

- Explicitly teach the following:
  - the purpose of DNA replication
  - that DNA replication occurs during interphase in the cell cycle
  - the basic steps of DNA replication.
- Students take notes and draw diagrams on the presented information.

Activity 2

- Prepare and provide students with:
  - a diagram of a DNA strand (about 10–20 nucleotides in length), different strands could be used for a different group
  - multiple diagrams of individual bases to match DNA strand
  - a diagram of a primer
  - a pair of scissors labelled as helicase
  - sticky tape labelled as DNA polymerase.
- Instruct students to work in small groups to model the process of DNA replication by:
  - colouring the nucleotides in the DNA strand and individual bases
  - using the helicase to separate the DNA strand
  - attaching the primer to DNA
  - using DNA polymerase to join bases using the base-pair rule to produce two new DNA strands.

Concluding activity

- Instruct students to exchange DNA strands with other groups to check for errors and provide feedback on the replication process.

Optional activities

- Add to the glossary from Lesson 1 important terms, including DNA, genes, allele, chromosomes.
- Conduct research on scientists who contributed to the knowledge of how DNA replicates, including Okazaki, Meselson and Stahl.

Lesson 4: Inheritance

The Western Australian Curriculum content addressed in this lesson is below.

Science understanding

Biological sciences

- Cell division processes of meiosis and mitosis produce new cells with chromosome numbers specific to their role; chromosomes contain genes that are composed of DNA (deoxyribonucleic acid)

Science inquiry

Communicating

- Communicate scientific ideas and information for specific purposes and audiences, including constructing evidence-based arguments and selection of appropriate content, language and text features, using digital tools as appropriate

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Resources

- Your Genome – Introduction to genomics
  https://www.yourgenome.org/explore-genomics/introduction-to-genomics/
- Learn.Genetics – Observable Human Characteristics
  https://learn.genetics.utah.edu/content/basics/observable/
- Teach.Genetics – Heritable or Acquired?
  https://teach.genetics.utah.edu/content/change/heritable-acquired/
- Teach.Genetics – Trait Shuffle
  https://teach.genetics.utah.edu/content/change/trait-shuffle/
- Teach.Genetics – Mutt Mixer Modelling
  https://teach.genetics.utah.edu/content/change/mutt-mixer-modeling/

Teacher information

- The genotype of an individual generally refers to the set of alleles a person has inherited for a particular gene, represented as letters, e.g. Tt or tt. The phenotype of an individual is the result of how the genotype is expressed as an observable characteristics/trait, e.g. tall or short. The phenotype is a result of how the genotype interacts with environmental factors
- Allele is an alternative form of a gene, e.g. T (tall), t (short)
- Individuals receive two versions of a gene (allele), one from each parent. If the alleles inherited are different, only one allele will be expressed, the dominant allele (Tt). The recessive allele will be masked. For the recessive allele to be expressed, the same recessive allele must be inherited from both parents (tt) (Dominant/recessive inheritance).

Lesson outline

Learning intentions
Students will: • explain the role of genes in the process of inheritance • define genotype, phenotype, allele, dominant, recessive, homozygous and heterozygous • explain how heredity and the environment can affect phenotypes • understand genes are responsible for all inherited characteristics

Introduction

- Students complete a brainstorm in their notepads on common observable traits of humans and what factors cause changes in our observable traits.
- Teacher collate responses from the class to generate discussion about factors that cause changes in observable traits and those that may be inherited, and clarify any misconceptions identified.

Lesson activities

Activity 1

- Explicitly teach the following:
  - the role of genes in the process of inheritance
  - the definitions and difference between genotype and phenotype
  - the factors that can affect phenotypes
  - the terms genotype, phenotype, allele, dominant, recessive, homozygous and heterozygous
  - the phenotype in some cases can be the result of the genotype interacting with the environment.
- Instruct students to take notes and draw diagrams on the presented information.

Activity 2

- Provide students with a list of observable human traits that are dominant/recessive in nature, such as tongue rolling, earlobe attachment, dimples, handedness.
- Instruct students to form groups and conduct an audit of each other's traits.
- Collate the class results and create a column graph to illustrate the most and least common traits.
- Lead a class discussion on whether dominant or recessive traits are more common.

Activity 3

- Students explore traits in animals and plants using appropriate online resources such as those provided. Preparation is required for most activities.
  - Instruct students to form groups and conduct online activities as directed by the teacher on heritable or acquired phenotypes.
  - Monitor student activities and question the groups, who explain their ideas and conclusions.

Concluding activity

- Each group reports back to class on one of the online activities they completed and the traits that are inherited or affected by environmental factors.

Lesson 5: Mitosis and the cell cycle

The Western Australian Curriculum content addressed in this lesson is below.

Science understanding

Biological sciences

- Cell division processes of meiosis and mitosis produce new cells with chromosome numbers specific to their role; chromosomes contain genes that are composed of DNA (deoxyribonucleic acid)

Resources

- Khan academy – Phases of mitosis
  https://www.khanacademy.org/science/biology/cellular-molecular-biology/mitosis/a/phases-of-mitosis
- Britannica – Mitosis
  https://www.britannica.com/science/mitosis
- Cells Alive! – Home page
  https://www.cellsalive.fun/cellsalive_files/index.htm
- Nucleus Medical Media – Cell Division: Meiosis vs. Mitosis
  https://www.youtube.com/watch?v=GHIlA76-h3c
- CrashCourse – Mitosis & the Cell Cycle: How Cells Clone Themselves: Crash Course Biology #29
  https://www.youtube.com/watch?v=skPOXcVvS5c&t=68s

Teacher information

- The cell cycle is a series of processes that a cell goes through including interphase and mitosis.
- Mitosis produces identical body cells for growth and repair and each cell produced contains a full set of chromosomes – 23 pairs (46 chromosomes) in humans (diploid number).
- The phases of mitosis are:
  - Prophase – nuclear membrane (around nucleus) breaks down, chromosomes condense and become visible, centrioles move to opposite ends (poles) of the cell and spindle fibres form.
  - Metaphase – chromosomes line up at equator of cell to prepare for division; spindle fibres attach to chromosomes centre.
  - Anaphase – sister chromatids/chromosomes divide into two (identical copies of each other) and spindle fibres pull chromosome to opposite poles of cell.
  - Telophase – two new cells begin to form; nuclear membrane starts to form creating a nucleus for each of the two cells, spindle fibres disappear.

Lesson outline

Learning intentions
Students will: • understand mitosis is the process to produce cells for growth and repair • recognise mitosis as part of the cell cycle • describe the general process, products and site of mitosis in plants and animals • observe mitotic cells using a compound microscope

Introduction

- Provide students an animal and plant cell to label. Review the function of the organelles.
- Highlight the parts of the cell involved in cell division.

Lesson activities

Activity 1

- Explicitly teach the following:
  - the role of mitosis
  - the general processes in the cell cycle
  - the phases of mitosis (prophase, metaphase, anaphase and telophase)
  - a mnemonic to remember the order of the phases of mitosis, such as PMAT
  - where mitosis occurs in plant and animal cells.
- Instruct students to take notes on the presented information.
- Provide students a diagram to label and annotate the steps involved in the phases of mitosis.

Activity 2

- Review the use of a compound microscope to observe cells.
- Instruct students to view the prepared mitotic onion-root cells under a compound microscope.
  - Students identify each phase of mitosis and draw labelled diagrams.
  - Students scan one root hair and estimate the number of cells in each phase of mitosis and interphase.

Concluding activity

- Show students different images of cells, organelles and stages of mitosis. Students take turns identifying and describing functions or stages.

Optional activities

- Research and create a storybook about the cell cycle.
- Investigate what happens to the cell cycle in cancer cells.

Lesson 6: Meiosis

The Western Australian Curriculum content addressed in this lesson is below.

Science understanding

Biological sciences

- Cell division processes of meiosis and mitosis produce new cells with chromosome numbers specific to their role; chromosomes contain genes that are composed of DNA (deoxyribonucleic acid)

Science inquiry

Processing, modelling and analysing

- Select and construct appropriate representations, including tables, graphs, descriptive statistics, models and mathematical relationships, to organise and process data and information

Communicating

- Communicate scientific ideas and information for specific purposes and audiences, including constructing evidence-based arguments and selection of appropriate content, language and text features, using digital tools as appropriate

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Resources

- Your Genome – Introduction to genomics
  https://www.yourgenome.org/explore-genomics/introduction-to-genomics/
- Meiosis - Made super easy – animation
  https://www.youtube.com/watch?v=nMEyeKQClqI

Teacher information

- Meiosis produces four gametes (sex cells) that are non-identical and contain half the number of chromosomes as the body cells – 23 in humans (haploid number). It is during meiosis that genetic information is passed on to offspring.
- Two divisions occur in meiosis.
  - Meiosis I – reduces the chromosome number by half from diploid to haploid. Homologous chromosomes pair up along equator of cell to prepare for division, one of each homologous chromosome is pulled to opposite sides of cell. Two intermediate cells form containing half the number of chromosomes (haploid cells).
  - Meiosis II – chromosomes line along equator of cell to prepare for division, chromosomes divide into two and are pulled to opposite sides of cell. New cells begin to form producing four haploid daughter cells in total (four gametes).

Lesson outline

Learning intentions
Students will: • understand meiosis is the process to produce gametes (sex cells) • describe the general process, products and site of meiosis in plants and animals • identify homologous chromosomes, diploid and haploid numbers

Introduction

- Lead a class discussion to review mitosis and the cell cycle.

Lesson activities

Activity 1

- Explicitly teach the following:
  - the role of meiosis
  - the two divisions involved in meiosis and the formation of four haploid gametes
  - where meiosis occurs in plant and animal cells
- Instruct students to take notes on the presented information.
- Provide students with a diagram to label; annotate the steps involved in the phases of meiosis.

Activity 2

- Provide students with a marking rubric (with or without marks visible) to provide guidance on the specifics and depth of detail expected.
- Using modelling clay, and other available resources, such as straws, pipe cleaners, wool, etc. create a model of the processes involved in meiosis.
- Inform students that they can present their model in one of the following ways:
  - an annotated model explaining the processes on A3 paper
  - create a digital animation of the divisions.

Concluding activity

- Following the completion of the activity, students use the marking key provided at start of activity to peer assess and provide feedback to each other on the accuracy, depth of detail and presentation of their work. Alternatively, use this as a formative assessment task and provide feedback to students.

Optional activities

- Research aneuploidy in humans, such as Down syndrome.
- Compare the diploid and haploid numbers in different plants and animals.

Lesson 7: Comparing types of cell division and karyotypes

The Western Australian Curriculum content addressed in this lesson is below.

Science understanding

Biological sciences

- Cell division processes of meiosis and mitosis produce new cells with chromosome numbers specific to their role; chromosomes contain genes that are composed of DNA (deoxyribonucleic acid)

Resources

- Amoeba Sisters: Mitosis versus meiosis: Side by side comparison (video)
  https://youtu.be/zrKdz93WlVk
- Your Genome – Introduction to genomics
  https://www.yourgenome.org/explore-genomics/introduction-to-genomics/
- Learn Genetics – Karyotype
  https://learn.genetics.utah.edu/content/basics/karyotype/
  Make a karyotype.
- BioNinja – Karyotyping and karyograms
  https://ib.bioninja.com.au/karyograms/

Teacher information

- There are two types of cell division:
  - Mitosis produces identical body cells for growth and repair and each cell produced contains a full set of chromosomes – 23 pairs (46 chromosomes) in humans (diploid).
  - Meiosis produces gametes (sex cells) that are non-identical and contain half the number of chromosomes as the body cells – 23 in humans (haploid). It is during meiosis that genetic information is passed on to offspring.
- A karyotype is the number and appearance of an individual's set of chromosomes after DNA replication and visible in metaphase. A karyogram is an image in which the homologous pairs of chromosomes are ordered by shape and size.

Lesson outline

Learning intentions:
Students will: • recall and compare the processes involved in the two types of cell division, mitosis and meiosis • define the terms karyotype and karyogram • distinguish between autosomal and sex chromosomes • match and analyse the arrangement of chromosomes in a karyotype

Introduction

- In pairs or groups, students revise the processes of mitosis and meiosis. They focus on applying the correct terminology from previous lessons.

Lesson activities

Activity 1

- Provide students with a Venn diagram to compare mitosis and meiosis either on A3 paper for each group, or on the board as a class activity.
- Instruct students to write one similarity or one difference on a sticky note and place it in the relevant part of the Venn diagram under the appropriate heading.
- Formatively assess student understanding from questions and observations whilst students are completing the activity.

Activity 2

- Explicitly teach the following:
  - the definitions of a karyotype and a karyogram
  - the characteristics of how a karyotype is displayed.
- Provide students with a diagram of a karyotype to label and annotate.

Activity 3

- Demonstrate and explain a practical activity on creating and analysing a karyotype.
- In pairs, conduct a practical activity on creating and analysing a karyotype.

Concluding activity

- Discuss and compare results of karyotype activity with other pairs/or class.

Optional activity

- Investigate how a karyotype is prepared and describe its application in medical testing.

Lesson 8: Sexual and asexual reproduction

The Western Australian Curriculum content addressed in this lesson is below.

Science understanding

Biological sciences

- Cell division processes of meiosis and mitosis produce new cells with chromosome numbers specific to their role; chromosomes contain genes that are composed of DNA (deoxyribonucleic acid)

Resources

- Amoeba sisters – Asexual and sexual reproduction
  https://youtu.be/fcGDUcGjcyk
  Worksheet provided in the link
- BioNinja – Reproduction
  https://ib.bioninja.com.au/reproduction/
- BBC Bitesize – Inheritance: OCR Gateway
  https://www.bbc.co.uk/bitesize/guides/zshqcj6/revision/4

Teacher information

- Reproduction is important for the survival of species, maintaining balance in ecosystems and for the continuation of life.
- There are two type of reproduction, sexual and asexual. Sexual reproduction involves two parents (gametes) and produces offspring that have variation/aren't genetically identical. Asexual reproduction involves one parent and produces identical offspring.
- Genetic information is passed on to offspring from both parents during sexual reproduction by fertilisation and meiosis.
- Fertilisation occurs when the nucleus of the sperm fuses with the nucleus of the ovum (fusion of the gametes). As the sperm and ovum carry half the number of chromosomes (haploid – 23 chromosomes for humans) than the rest of the cells in the body (diploid – 23 pairs, 46 chromosomes), half of the genetic information is passed on from each parent. The chromosomes then rejoin their pairs during fertilisation to create a full set of chromosomes. Each gamete has a different combination of characteristics as they are formed from a type of cell division called meiosis.
- The gender (sex) of the individual is determined by one of the sets of chromosomes. All ovum carry an X chromosome. Half of the sperm produced carry an X chromosome with the other half carrying a Y chromosome. If two X chromosomes join during fertilisation (one from the ovum, one from the sperm carrying an X chromosome), a female is produced. If the X chromosome from the ovum and Y chromosome from the sperm join, a male is produced.

Lesson outline

Learning intentions
Students will: • describe the importance of reproduction • distinguish between sexual and asexual reproduction • describe how genetic information from both parents is passed on to offspring by fertilisation • describe the role of gametes in sexual reproduction • explain how sex/gender is determined in mammals

Introduction

- Complete a think-pair-share routine to demonstrate prior knowledge of fertilisation and reproduction.
- Lead a discussion with the class following the completion of the routine to identify students' level of understanding and any misconceptions and gaps in knowledge.

Lesson activities

Activity 1

- Explicitly teach the following:
  - importance of reproduction
  - difference between sexual and asexual reproduction
  - process of fertilisation in passing on genetic information
  - role of gametes in sexual reproduction and how sex is determined in mammals.
- Students take notes on presented information.

Activity 2

- Direct students to appropriate online resources to read and take notes on key information on types of reproduction, fertilisation and gametes.
- Provide students with a suitable worksheet or graphic organiser to summarise the key information on types of reproduction, fertilisation and gametes.

Concluding activity

- Review student understanding of the content covered in the lesson by using a paper or online quiz.

Optional activities

- Investigate how sex is determined in other animal groups, such as reptiles, birds and bees.
- Research the advantages and disadvantages of asexual and sexual reproduction.

Lessons 9–10: Punnett squares and autosomal inheritance

The Western Australian Curriculum content addressed in these lessons is below.

Science understanding

Biological sciences

- Patterns of monohybrid inheritance, including autosomal dominant/recessive and sex-linked recessive inheritance, can be predicted using pedigrees and Punnett square crosses

Science inquiry

Processing, modelling and analysing

- Select and construct appropriate representations, including tables, graphs, descriptive statistics, models and mathematical relationships, to organise and process data and information

Communicating

- Communicate scientific ideas and information for specific purposes and audiences, including constructing evidence-based arguments and selection of appropriate content, language and text features, using digital tools as appropriate

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Resources

- Teach Genetics – Practice with Punnett squares
  https://teach.genetics.utah.edu/content/change/practice-with-punnett-squares/
- Elemental Science – Peas, the ABC's, and the Punnett square
  https://elementalscience.com/blogs/science-activities/punnett-square?srsltid=AfmBOoq7y_m92qX5TNjt20D3Q679WYQyPxXYH7kp3B53FEZnNSPCwWKN
  (Punnett square worksheet available)
- National Agriculture in the Classroom – Rock, Paper, Scissors: Dominant and recessive traits
  https://agclassroom.org/matrix/lesson/406/
  (Some preparation is required for this activity)
- Health Centre of Genetics Education – Autosomal dominant inheritance
  https://www.genetics.edu.au/SitePages/Autosomal-dominant-inheritance.aspx
- National agriculture in the classroom – Coats and Genes: Genetic traits in cattle
  https://cdn.agclassroom.org/ok/lessons/beef/coatsgenes9-12.pdf

Teacher information

- Use the first lesson to introduce Mendel's work on pea plants and how to use a Punnet square. Show students worked examples. Time is allocated in the second lesson for students to practise solving autosomal dominate recessive crosses and receive feedback on work.
- A Punnett square is a square diagram used to predict the combinations of offspring, given the genotypes of the parents. It shows the ratio of different genotypes in the offspring from a genetic cross.
- Monohybrid inheritance is the inheritance of a trait controlled by a single gene.

- Autosomal inheritance of a gene is when the gene is located on one of the autosomes (any chromosome that is not a sex chromosome).
- Allele is an alternative form of a gene, e.g. T (tall), t (short).
- Individuals receive two versions of a gene (allele), one from each parent. If the alleles inherited are different, only one allele will be expressed, the dominant allele (Tt). The recessive allele will be masked. For the recessive allele to be expressed, the same recessive allele must be inherited from both parents (tt) (dominant/recessive inheritance).
- If the same recessive or dominant alleles for a particular gene are inherited from both parents, it is homozygous (tt, TT). If different forms of the allele are inherited, e.g. one recessive and one dominant, it is heterozygous (Tt).

Lesson outline

Learning intentions
Students will: • understand monohybrid inheritance is affected by dominant and recessive autosomal alleles • identify examples of dominant and recessive alleles • predict simple ratios (using Punnett squares) of offspring genotypes and phenotypes in crosses involving dominant and recessive gene pairs

Introduction

- Conduct a class discussion to review:
  - inheritance (Lesson 4)
  - the terms genotype, phenotype, allele, dominant, recessive, homozygous, heterozygous, autosomal and sex chromosomes.

Lesson activities

Activity 1

- Explicitly teach the following:
  - Gregor Mendel's pea-plant genetics and monohybrid inheritance
  - how Mendel's work on pea plants developed an understanding of how dominant and recessive autosomal traits are passed from parents to offspring
  - how to draw and use a Punnett square with correct allele notation
  - how to calculate ratios of offspring genotypes and phenotypes using Mendel's pea plants.
- Instruct students to take notes on the information presented.

Activity 2

- Provide students with worksheets and activities to determine ratios of offspring for autosomal dominant/recessive traits in humans. Some examples include baldness, dimples, freckles and the ability to tongue roll.
- Give students time to work through at their own pace. Monitor and provide feedback.

Activity 3

- Individually or in pairs, instruct students to research examples of dominant and recessive traits in a chosen animal such as a cat, dog, horse, guinea pig or rabbit.
- Instruct students to develop questions to determine the ratios of offspring for autosomal dominant/recessive traits for their chosen animal.
- Instruct students to share information and questions with the class.

Concluding activity

- Students demonstrate to a partner how to draw and work out ratios using a Punnett square example given by the teacher.

Optional activities

- Students investigate dominant and recessive traits using an activity, such as rock, paper, scissors.
- Students investigate other types of autosomal inheritance, such as co-dominance and incomplete dominance.

Lessons 11–12: Sex-linked inheritance

The Western Australian Curriculum content addressed in these lessons is below.

Science understanding

Biological sciences

- Patterns of monohybrid inheritance, including autosomal dominant/recessive and sex-linked recessive inheritance, can be predicted using pedigrees and Punnett square crosses

Science inquiry

Processing, modelling and analysing

- Select and construct appropriate representations, including tables, graphs, descriptive statistics, models and mathematical relationships, to organise and process data and information

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Resources

- Learn Genetics – Inheritance Patterns for Single Gene Disorders
  https://learn.genetics.utah.edu/content/disorders/inheritance/
- Bitesize (BBC) – Genetic inheritance – Sex-linked disorders
  https://www.bbc.co.uk/bitesize/guides/zy7vw6f/revision/3
- Amoeba sisters – Punnett squares and sex-linked traits
  https://youtu.be/h2xufrHWG3E.
  (Worksheet available)
- BioNinja – Sex linkage: Sex determination in humans and inheritance
  https://ib.bioninja.com.au/sex-linkage/
- Health Centre of Genetics Education – X-linked inheritance
  https://www.genetics.edu.au/SitePages/X-linked-inheritance.aspx

Teacher information

- Use the first lesson to introduce sex-linked alleles and annotation. Show students worked examples. Give time in the second lesson for students to practise solving sex-linked recessive crosses and receiving feedback on work.
- Sex-linked inheritance is when the genes responsible for a disorder are located on the sex chromosomes, often the X chromosome as this is larger and contains more chromosomes than the smaller Y chromosome. This often results in more males being affected because they have only one copy of the X chromosome that carries the mutation. Females may carry the mutation; however, this may be masked by the second X chromosome that is normal.
- Examples of sex-linked traits in humans include red-green colour blindness, haemophilia and Duchenne muscular dystrophy.
- When predicting outcomes for sex-linked traits using a Punnett square, XX and XY are used to illustrate where the mutated allele is, for example, X^HX^h and X^hY.

Lesson outline

Learning intentions
Students will: • understand that some traits are inherited as sex-linked • explain the process of sex-linked inheritance • predict simple ratios (using Punnett squares) of offspring genotypes and phenotype in crosses involving sex-linked recessive inheritance.

Introduction

- Review sex determination in mammals/humans (Lesson 8).
- Show, using a Punnet square, the probability of a male is 50% or female is 50%.

Lesson activities

Activity 1

- Explicitly teach the following:
  - the process of sex-linked inheritance
  - the annotations for sex-linked alleles
  - the reason males are more affected by recessive sex-linked inheritance
  - the use of Punnett squares to predict ratios of offspring for recessive sex-linked inheritance.
- Students take notes on the information presented.

Activity 2

- Prior to the lesson, download and print student copies of the available worksheet from the *Amoeba sisters* video link in the resources section (marking guide also available).
- Instruct students to complete the worksheet whilst watching the video.
- Instruct students to complete a graphic organiser on the main concepts relating to sex-linked inheritance.

Activity 3

- Provide students with worksheets and activities to determine ratios of offspring for X-linked recessive traits in humans. Some examples include red-green colour blindness, haemophilia, and Duchenne muscular dystrophy.
- Give students time to work through the activity at their own pace. Monitor and provide feedback.

Concluding activity

- Illustrate a sex-linked Punnett square problem on the whiteboard for students to solve in groups. Work through the answer as a whole class, with students demonstrating their working out.

Optional activity

- Students investigate other types of sex-linked inheritance, such as dominant and co-dominant.

Lessons 13–14: Pedigrees

The Western Australian Curriculum content addressed in these lessons is below.

Science understanding

Biological sciences

- Patterns of monohybrid inheritance, including autosomal dominant/recessive and sex-linked recessive inheritance, can be predicted using pedigrees and Punnett square crosses

Science inquiry

Processing, modelling and analysing

- Select and construct appropriate representations, including tables, graphs, descriptive statistics, models and mathematical relationships, to organise and process data and information

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Resources

- Amoeba Sisters – Pedigrees
  https://youtu.be/Gd09V2AkZv4
- BioNinja – Inheritance
  https://ib.bioninja.com.au/pedigree-charts/
  (Pedigree charts to deduce patterns of inheritance of genetic disorders)
- Khan Academy – Pedigrees (practice)
  https://www.khanacademy.org/science/generations-old-and-new/x74478e8d979438e2:principles-of-inheritance-and-variation/x74478e8d979438e2:mendelian-disorders-and-pedigree-analysis/e/hs-pedigrees

Teacher information

- Use the first lesson to introduce parts of pedigrees and terminology. Show students some worked examples. Give students time in the second lesson to practise solving pedigrees and receive feedback on work.
- Pedigree charts show the genetic history of a family from one generation to the next (occurrence and appearance of phenotypes of a particular gene), often over several generations.
- The chart illustrates males as a square and females as circles. If the square or circle is shaded, this means the individual is affected by a condition; if not, they are unaffected.

Lesson outline

Learning intentions
Students will: • analyse simple pedigrees to determine individual phenotypes and genotypes • represent patterns of inheritance of a simple dominant/recessive characteristic through generations of a family • predict simple ratios of offspring genotypes in crosses involving dominant and recessive gene pairs or in genes that are sex-linked

Introduction

- Conduct a class discussion. Ask the following questions:
  - What is a pedigree or family tree? Are they the same?
  - What does a pedigree or family tree tell you?

Lesson activities

Activity 1

- Explicitly teach the following:
  - the components of a pedigree chart
  - how to construct a pedigree chart of your family
  - how to read and analyse pedigree charts
  - how to identify recessive autosomal and sex-linked inheritance in a pedigree chart.
- Instruct students to take notes on the presented information.

Activity 2

- Instruct students to construct their own family tree of at least three generations.
- If possible, using one of the observable human traits that are dominant/recessive from Lesson 4, identify individuals who have a recessive trait.

Activity 3

- Download and print student copies of the available worksheet prior to the lesson from the Amoeba sisters video link in the resources section.
- Show students the video, stopping at various points as directed in the video for students to practise predicting genotypes.
- Students can either self-assess or peer assess their worksheets, or the teacher may collect the worksheets as a formative assessment to provide feedback on student understanding.

Activity 4

- Provide students with worksheets and activities on pedigree problems to identify autosomal and X-linked recessive traits and predict the outcomes of crosses.
- Give students time to work through the pedigree problems at their own pace. Students may need extra support with this concept. Monitor and provide feedback to students.

Concluding activity

- Provide students with revision activities, such as worksheets, questions and a graphic organiser to review Lessons 1–14 in preparation for the summative assessment.

Lesson 15: Summative assessment

The Western Australian Curriculum content addressed in this lesson is below.

Science understanding

Biological sciences

- Cell division processes of meiosis and mitosis produce new cells with chromosome numbers specific to their role; chromosomes contain genes that are composed of DNA (deoxyribonucleic acid)
- Patterns of monohybrid inheritance, including autosomal dominant/recessive and sex-linked recessive inheritance, can be predicted using pedigrees and Punnett square crosses

Science inquiry

Processing, modelling and analysing

- Select and construct appropriate representations, including tables, graphs, descriptive statistics, models and mathematical relationships, to organise and process data and information

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Resource

- Appendix A: Assessment task

Teacher information

Students work independently, under test conditions, for one 50-minute lesson.

Lesson outline

Learning intentions
Students will demonstrate their understanding of: • the structure of DNA • DNA, chromosomes and genes • mitosis and meiosis • inheritance of traits/characteristics • autosomal dominant/recessive and sex-linked recessive crosses • how to use Punnet squares and pedigrees

Introduction

- Follow the instructions provided in the assessment task in Appendix A.

Lesson activities

Activity

- Students complete the assessment task individually under test conditions.

Appendix A

Assessment task

DNA, genes and inheritance

Task details

Title	DNA, genes and inheritance test
Description	Students will demonstrate their understanding of: • the structure of DNA • DNA, chromosomes and genes • mitosis and meiosis • inheritance of traits/characteristics • autosomal dominant/recessive and sex-linked recessive crosses • how to use Punnet squares and pedigrees.
Ways of assessing	Completion of student assessment sheet
Evidence to be collected	Student assessment sheet
Suggested time	One 50-minute lesson
Differentiation	Teachers should differentiate their teaching and assessment to meet the specific learning needs of their students, based on their level of readiness to learn and their need to be challenged. Where appropriate, teachers may either scaffold or extend the scope of the assessment tasks.

Content descriptions

Science understanding

Biological sciences

- Cell division processes of meiosis and mitosis produce new cells with chromosome numbers specific to their role; chromosomes contain genes that are composed of DNA (deoxyribonucleic acid)
- Patterns of monohybrid inheritance, including autosomal dominant/recessive and sex-linked recessive inheritance, can be predicted using pedigrees and Punnett square crosses

Science inquiry

Processing, modelling and analysing

- Select and construct appropriate representations, including tables, graphs, descriptive statistics, models and mathematical relationships, to organise and process data and information

Key concepts

DNA; genes; chromosomes; mitosis; meiosis; Punnett squares used to predict outcomes of inheritance of autosomal and sex-linked alleles; pedigree charts

Information for teacher

This task follows the completion of the sequence of lessons, where students have had prior opportunities and practice to explain the structure and role of DNA, genes and chromosomes, the processes of mitosis and meiosis, the process of inheritance, and interpret and construct representations to predict the outcome of interactions between different allele combinations.

Students will be provided with a student assessment sheet. They will be required to apply their understanding of the relationship between DNA, genes and chromosomes, and how this relates to the process of inheritance. They will be required to interpret and construct representations to predict the outcome of interactions between autosomal and sex-linked alleles using Punnet squares and pedigrees.

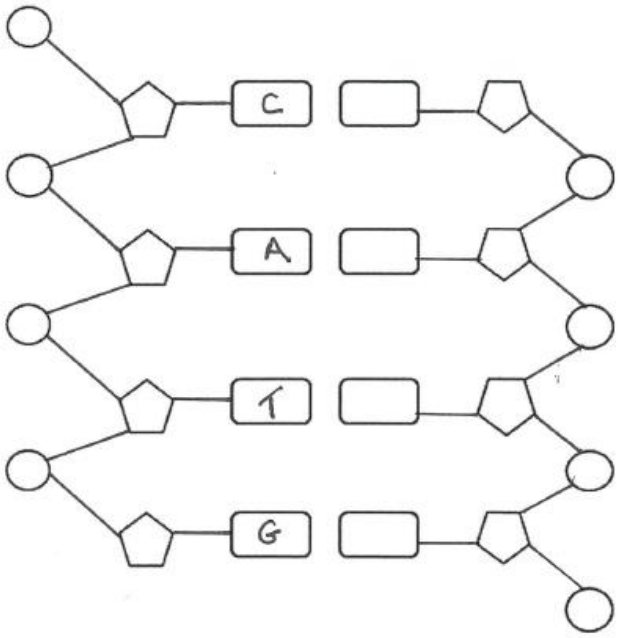
Students will work independently, under test conditions, in one 50-minute lesson.

Instructions to students

This assessment has five questions. Answer all questions in the space provided.

You have 50 minutes in class under test conditions.

1.



(a) On the DNA strand above, complete the complementary base pairing (one mark each). (4 marks)

(b) Label the following parts of the DNA strand above with:

- deoxyribose sugar (1 mark)
- phosphate group (1 mark)
- nitrogenous base (1 mark)
- sugar-phosphate backbone (1 mark)
- hydrogen bonds. (1 mark)

(c) DNA is made up of units called nucleotides. Circle a DNA nucleotide in the strand above. (1 mark)

2. Describe the relationship between DNA, genes and chromosomes. (3 marks)

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3. All cells undergo cell division at some stage. Compare the two types of cell division, using skin cells and sperm cells as your examples. (8 marks)

Description	Skin cells	Marks	Sperm cells	Marks
Type of cell division		(1 mark)		(1 mark)
Number of divisions		(1 mark)		(1 mark)
Number and type of cells produced		(1 mark)		(1 mark)
Amount of variation between cells		(1 mark)		(1 mark)

In this section, you will take on the role of a genetic counsellor. You will be given two different scenarios to apply your understanding of inheritance and demonstrate how you would predict the outcome of certain characteristics/diseases being passed on from one generation to the next.

4. **Scenario 1:** Your first appointment of the day is with a husband and wife.

   (a) The couple have advised they do not understand how inherited characteristics are passed on to offspring (their children). Explain inheritance and how characteristics are passed on to the next generation. (2 marks)

   _____

   _____

   _____

   _____

   (b) The mother believes that their children's sexes are determined by her. From a biological view, is the mother correct? Explain your answer. (3 marks)

   _____

   _____

   _____

   _____

(c) With the use of a Punnett square, demonstrate to the parents the percentage chance of them conceiving a boy. (3 marks)

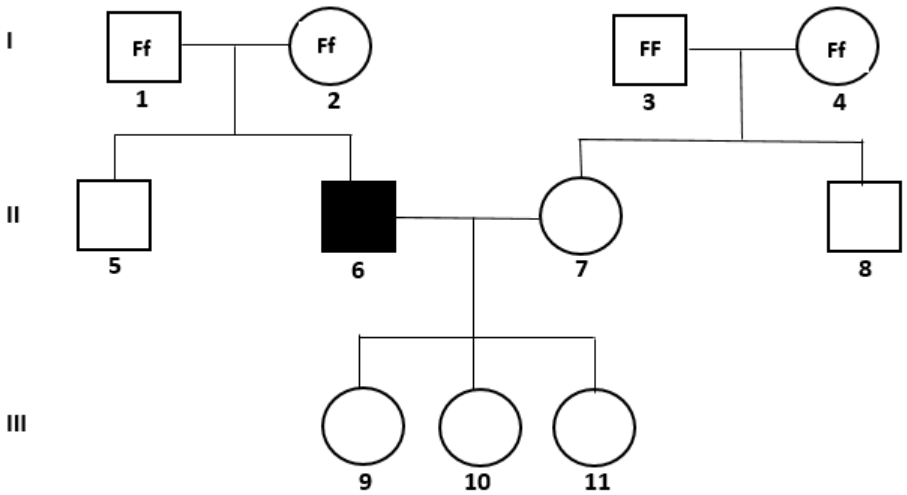
(d) With the couple already having three girls, they want to know if there is an increased chance of conceiving a boy if they have another child. Explain your answer. (2 marks)

_____

_____

(e) The father advised he has a genetic disease called cystic fibrosis, a condition that affects the lungs, limiting the ability to breathe over time, and also affects the digestive system and other organs of the body. Cystic fibrosis is an autosomal recessive disorder, which means the trait needs to be passed on by both parents for their offspring to be born with the disease. The mother is a carrier of the cystic fibrosis gene but none of their three children were born with cystic fibrosis. Determine the possible genotypes and phenotypes of their offspring. (4 marks)

The pedigree chart below shows the inheritance of cystic fibrosis for this family across three generations.



(f) Which generation represents the children of this husband and wife? (1 mark)

_____

(g) What is the potential genotype of Individual 5? (1 mark)

_____

(h) Identify one individual who could be homozygous dominant in the pedigree chart. Explain your answer. (2 marks)

_____

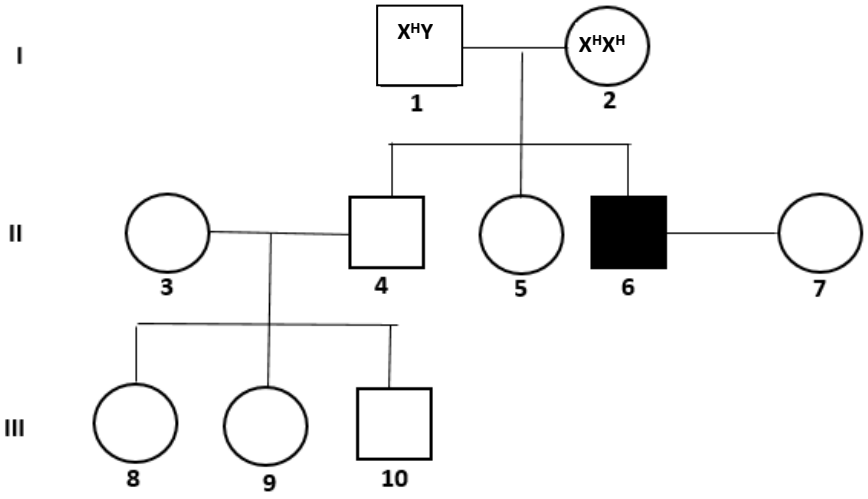
_____

(i) The father asked what the probability would be of one of his daughters having children with cystic fibrosis if she were to marry someone with a genotype the same as Individual 1? Use a Punnett square to determine the possible genotypes and phenotypes of their offspring. (4 marks)

5. **Scenario 2:** Your second appointment of the day is with a young couple who were thinking of starting a family.

   (a) The father has a sex-linked recessive condition called haemophilia, a bleeding disorder where the blood doesn't clot properly. As the couple are considering starting a family, they want to know whether their child will also be born with this condition. Following genetic testing, it was confirmed that the mother was a carrier of haemophilia. Determine the potential genotype and phenotype of their offspring. (5 marks)

Before the meeting started, you created a pedigree chart showing three generations of the man's family and the inheritance of haemophilia. The pedigree chart is shown below.



(b) If individuals 8 and 9 are both carriers of haemophilia, identify the genotypes for: (2 marks)

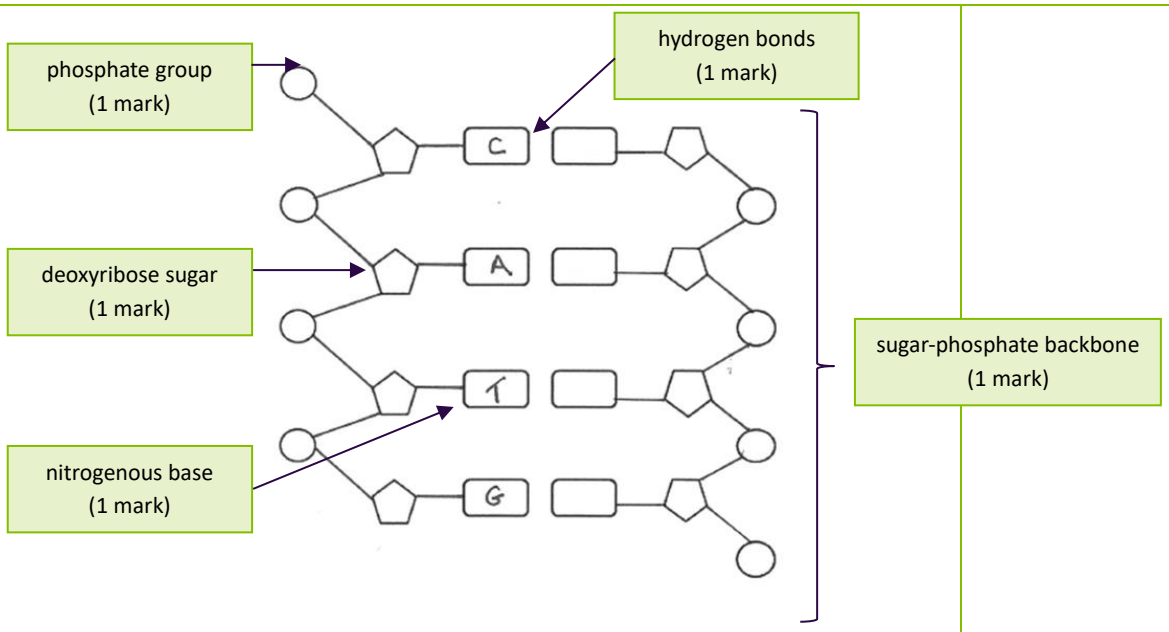
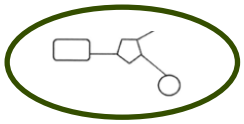
(i) Individual 3 _____

(ii) Individual 4 _____

(c) During the meeting, the man advised that his nephew is married, and they have a son who also has haemophilia. Add this information correctly to the pedigree chart to show all family members. (3 marks)

End of assessment

Marking key

Description	Marks
Question 1	
(a) On the DNA strand above, complete the complementary base pairing (one mark each).	
C – G	1
A – T	1
T – A	1
G – C	1
Subtotal	**/4**
(b) Label the following parts of the DNA strand above with deoxyribose sugar, phosphate group, nitrogenous base, sugar-phosphate backbone, hydrogen bonds.	
	
Subtotal	**/5**
(c) DNA is made up of units called nucleotides. Circle a DNA nucleotide in the strand above.	
	1
Subtotal	**/1**
Question 2	
Describe the relationship between DNA, genes and chromosomes.	
DNA is made up of nucleotides	1
a gene is a section of DNA (responsible for a particular trait/characteristic)	1
chromosomes are made up genes.	1
Subtotal	**/3**

Description	Marks
Question 3	
All cells undergo cell division at some stage. Compare the two types of cell division, using skin cells and sperm cells as your examples.	

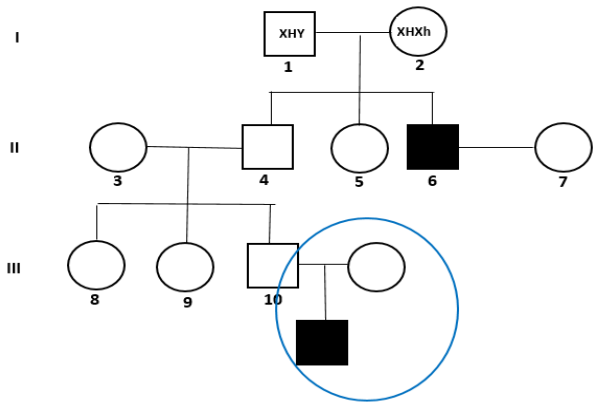
Description	Skin cells	Marks	Sperm cells	Marks	Subtotal
Type of cell division	Mitosis	1	Meiosis	1	2
Number of divisions	1	1	2	1	2
Number and type of cells produced	2 daughter cells	1	4 gametes	1	2
Amount of variation between cells	Identical to the parent cell	1	Different from the parent cell **or** only half the number of chromosomes	1	2
				Subtotal	**/8**

Question 4	
Scenario 1: Your first appointment of the day is with a husband and wife. (a) The couple have advised they do not really understand how inherited characteristics are passed on to offspring (their children). Explain inheritance and how characteristics are passed on to the next generation	
Through genes/alleles (for a particular trait/characteristic).	1
Which are inherited, one from each parent.	1
Subtotal	**/2**
(b) The mother believes that their children's sex is determined by her. From a biological view is the mother correct? Explain your answer.	
No	1
Sperm carries either X or Y chromosome.	1
So it is the father's sperm that determines the sex of the child.	1
Subtotal	**/3**
(c) With the use of a Punnett square, demonstrate to the parents the percentage chance of them conceiving a boy.	
Identifies the father as XY chromosomes and mother as XX chromosomes	1
Constructs a Punnett square showing the correct potential combinations. (Father identified at the side XY; mother identified at the top XX. These can be either way around.)	1
50% chance of conceiving a boy	1
Subtotal	**/3**

		mother	
		X	**X**
father	**X**	XX	XX
	Y	XY	XY

<table>
<tr><th>Description</th><th>Marks</th></tr>
<tr><td colspan="2">(d) With the couple already having three girls, they wanted to know if there was an increased chance in conceiving a boy if they have another child. Explain your answer.</td></tr>
<tr><td>No increased chance of conceiving a boy</td><td>1</td></tr>
<tr><td>Same chance each time (50%)/50% sperm are X and 50% are Y carrying chromosomes.</td><td>1</td></tr>
<tr><td>Subtotal</td><td>/2</td></tr>
<tr><td colspan="2">(e) The father advised he has a genetic disease called cystic fibrosis, a condition that affects the lungs, limiting the ability to breathe over time, and affects the digestive system and other organs of the body. Cystic fibrosis is an autosomal recessive disorder, which means the trait needs to be passed on by both parents for their offspring to be born with the disease. The mum is a carrier of the cystic fibrosis gene but none of their three children were born with cystic fibrosis. Determine the possible genotypes and phenotypes of their offspring.</td></tr>
<tr><td>Identifies the father’s and mother’s genotypes:
Father genotypes: ff (has CF)
Mother genotypes: Ff (carrier of CF)</td><td>1</td></tr>
<tr><td>Constructs a Punnett square showing the correct potential combinations. (Father identified at the side ff; mother identified at the top Ff. These can be either way around.)
<table><tr><td></td><td></td><td colspan="2">mother</td></tr><tr><td></td><td></td><td>F</td><td>f</td></tr><tr><td rowspan="2">father</td><td>f</td><td>FF</td><td>ff</td></tr><tr><td>f</td><td>Ff</td><td>ff</td></tr></table></td><td>1</td></tr>
<tr><td>Possible genotypes: 50% Ff; 50% ff</td><td>1</td></tr>
<tr><td>Possible phenotypes: 50% carrier of CF; 50% has CF</td><td>1</td></tr>
<tr><td>Subtotal</td><td>/4</td></tr>
<tr><td colspan="2">(f) The pedigree chart below shows the inheritance of cystic fibrosis for this family across three generations. Which generation represents the children of this husband and wife?</td></tr>
<tr><td>3 / III</td><td>1</td></tr>
<tr><td>Subtotal</td><td>/1</td></tr>
<tr><td colspan="2">(g) What is the potential genotype of Individual 5?</td></tr>
<tr><td>FF or Ff</td><td>1</td></tr>
<tr><td>Subtotal</td><td>/1</td></tr>
<tr><td colspan="2">(h) Identify one individual who could be homozygous dominant in the pedigree chart. Explain your answer.</td></tr>
<tr><td>Individual 5 or 8</td><td>1</td></tr>
<tr><td>Both parents are carriers of the dominant allele, so it can be inherited from both parents</td><td>1</td></tr>
<tr><td>Subtotal</td><td>/2</td></tr>
</table>

<table>
<tr><th>Description</th><th>Marks</th></tr>
<tr><td colspan="2">(i) The father asked what the probability would be of one of his daughters having children with cystic fibrosis if she were to marry someone with a genotype the same as Individual 1. Use a Punnett square to determine the possible genotypes and phenotypes of their offspring.</td></tr>
<tr><td>Identifies the genotypes of the father and mother:
Male genotypes: Ff
Daughter genotypes: Ff (carrier of CF)</td><td>1</td></tr>
<tr><td>Constructs a Punnett square showing the correct potential combinations. (Potential husband identified at the side with Ff; the daughter is identified at the top with Ff. These can be either way around)
<table><tr><td></td><td></td><td colspan="2">daughter</td></tr><tr><td></td><td></td><td>F</td><td>f</td></tr><tr><td rowspan="2">husband</td><td>F</td><td>FF</td><td>Ff</td></tr><tr><td>f</td><td>Ff</td><td>ff</td></tr></table></td><td>1</td></tr>
<tr><td>Possible genotypes: 25 % FF; 50 % Ff; 25 % ff</td><td>1</td></tr>
<tr><td>Possible phenotypes: 25 % No CF; 50 % carrier of CF; 25 % has CF</td><td>1</td></tr>
<tr><td>Subtotal</td><td>/4</td></tr>
<tr><td colspan="2">Question 5</td></tr>
<tr><td colspan="2">Scenario 2: Your second appointment of the day was with a young couple who are thinking of starting a family.
(a) The father has a sex-linked recessive condition called haemophilia, a bleeding disorder whereby the blood doesn’t clot properly. As the couple are considering starting a family, they want to know whether their child will also be born with this condition. Following genetic testing, it was confirmed that the mother was a carrier of haemophilia. Determine the potential genotype and phenotype of their offspring.</td></tr>
<tr><td>Father and mother genotypes identified:
Father genotypes: XhY (has haemophilia)
Mother genotypes: XHXh (carrier of haemophilia)</td><td>1</td></tr>
</table>

Description	Marks
Constructs a Punnett square showing the correct potential combinations. (The father is identified at the side with X^hY; the mother is identified at the top with X^HX^h. These can be either way around) **mother**: **X^H**, **X^h** **father**: **X^h** → $X^H X^h$, $X^h X^h$; **Y** → $X^H Y$, $X^h Y$	1
Possible genotypes: 25% X^HX^h; 25% X^hX^h; 25% X^HY; 25% X^hY	1
Possible phenotypes: Females: 50% carrier of CF; 50% has CF Males: 50% has CF; 50% does not have CF	1 1
Subtotal	**/5**
(b) If Individuals 8 and 9 are both carriers of haemophilia, identify the genotypes for: (i) Individual 3	
X^HX^h	1
(ii) Individual 4	
X^HY	1
Subtotal	**/2**
(c) During the meeting, the man advised that his nephew is married, and they have a son who also has haemophilia. Add this information correctly to the pedigree chart to show all family members	
Adds the wife as a circle, not shaded	1
Adds the child in the correct place	1
Shades the child to represent them having haemophilia (An example of correct representation is shown in the circle below)  	1
Subtotal	**/3**
Total	**/53**