Science lessons for Grade 12

Lessons in this section

Using these lesson plans

These sample lessons for Grade 12 are suitable for use with a whole class. The lessons are single examples to illustrate different teaching and learning activities. They are not intended to be taught as a sequence. They are drawn from different topics and points in the teaching year to show spread rather than sequence.

The objectives for the lessons are drawn mainly from the advanced standards for Grade 12. The relevant standards are shown in the lesson plans.

The lesson plans indicate any safety issues relevant to the lessons. They also provide equipment lists and any short- and long-term preparation required by the lessons. Some of the plans include notes that provide additional information relevant to the teaching of the lesson that may not be readily accessible elsewhere.

Most of the lessons are organised in three parts: an introduction to the lesson, a main activity, and a final phase to help students to reflect on the lesson and consolidate their learning. As part of the introduction, you should outline the purpose of the lesson, drawing out for students what they will learn and how this builds on previous work. In the final part of the lesson, you will need to establish the key learning points, what students need to remember and what they will go on to learn next. There is no expectation that students should copy out the key learning points in their exercise books.

Most of the lesson plans do not include homework tasks because the lessons are single examples taken out of sequence. You will need to provide this, since homework is an important part of a lesson.

The lesson plans have enough material to support a minimum of about 60 minutes of teaching. You may need to supplement the activities with simpler or more challenging tasks if the students in your class have a range of attainment. You could choose from activities in textbooks or from your own resources. If you wish, different tasks can be given to different groups of students, according to their needs.

For some classes there may be too much material in the lesson plan for 60 minutes. In this case, you could designate one of the activities in the lesson as homework, or carry it forward to the next lesson. Be selective about which activity to cut – it does not have to be the last one merely because it comes at the end.

12.1 A dihybrid cross

Objectives

- (Advanced) Calculate the ratios of the genotypes and phenotypes in the progeny of dihybrid crosses.
- (Foundation and Grade 11 Advanced) Use genetic diagrams to solve genetic problems involving monohybrid crosses.
- Make predictions directly related to a research question.

This lesson is suitable for both foundation and advanced students.

Preparation

You will need sets of four colours of beads or blocks that fit together. If these are not available, then any sets coloured beads, balls, blocks, painted stones or coloured paper can be used. As this lesson has been designed as a series of activities for small groups of students (three or four per group), you should try to have about ten of each of the four colours of beads for each group.

Introduction

Vocabulary
allele
dihybrid
dominant
gene
genotype
heterozygous
homozygous
phenotype
recessive

Checking understanding

Start this lesson by checking on students' understanding of the work covered in earlier lessons on genetics. Ask questions such as:

Q What is the difference between a genotype and a phenotype?

Q What is an allele?

Q What is the difference between an allele and a gene?

Q How does a dominant allele influence a recessive allele?

Q What do you know about the genotype of an organism if alleles are homozygous?

Q What do you know about the genotype of an organism if alleles are heterozygous?

Q How many genes are studied in a monohybrid cross?

Q How many genes are studied in a dihybrid cross?

Depending on the answers you receive you may need to revise some basic terminology. Students should be able to work out that if a monohybrid cross involves the alleles of one genetic characteristic (e.g. a height gene with tall and short alleles), then a dihybrid cross involves the alleles of two genes (e.g. a height gene with tall and short alleles and a colour gene with green and yellow alleles).

Explain that the class will simulate what happens to the alleles of the genes in a dihybrid cross but that first they will go through a monohybrid cross.

Main activity

Resources (per group)
Containers of coloured beads

Genetic crosses

Students should work in groups of about four in all the activities in this lesson so that they can discuss the outcomes and their explanations.

Activity 1 A simple cross

Give each group two containers holding a similar number of beads, all of the same colour. Tell students that the beads represent the alleles for a particular characteristic carried on a chromosome. Get students to mark the containers as male and female to represent a pair of breeding organisms (plants or animals).

Now ask students to pick out one bead from each container to represent the sex cells and to place these together to form the genotype of one of the progeny. Repeat this several times. Because the genotypes of all of the progeny are the same as the parents, all the progeny will resemble the parents for the characteristic determined by the gene. Now ask students to predict what will happen if one allele is dominant over the other:

Q What genotypes and phenotypes will be represented in the progeny if one allele is dominant over the other?

Activity 2 A heterozygous cross

Give each group two containers of beads holding a similar number of two colours of bead. Remind students that the beads represent the alleles for a particular characteristic carried on a chromosome. Get students to mark the containers as male and female to represent a pair of breeding organisms (plants or animals). Tell them that one of the alleles is dominant over the other and state the colour of the bead used to represent this.

Ask students to repeat the procedure used in activity 1 and create the genotypes of a number of progeny. Get them to record the results in a table like the one below, in which R represents the dominant allele and r the recessive allele.

Genotype	Phenotype	Number of progeny
RR		
Rr		
rr		

Once this has been done, collect the data from the different groups, complete a table on the board and determine the overall ratios of genotypes and phenotypes (1:2:1 and 3:1). This should answer the question posed at the end of activity 1.

Activity 3 A backcross

Give each group two containers of beads. Again, remind students that the beads represent the alleles for a particular characteristic carried on a chromosome. Tell them that one of the alleles is dominant over the other and state the colour of the bead used to represent this. One container should have equal numbers of beads of two colours and the other only beads of the colour representing the recessive allele. Get students to mark the containers as male and female to represent a pair of breeding organisms (plants or animals).

Ask students to repeat the procedure used in activities 1 and 2 and create the genotypes of a number of progeny. Get them to record the results in a table like the one below, in which R represents the dominant allele and r the recessive allele.

Genotype	Phenotype	Number of progeny
Rr		
rr		

Once this has been done, collect the data from the different groups, complete a table on the board and determine the overall ratios of genotypes and phenotypes (1:1).

Activity 4 Calculating genotypes and phenotypes

From their concrete experiences of working with beads, students should be able to move on to calculating the ratios of genotypes and phenotypes in genetic crosses. You should go over the following procedure, explaining the steps as you write them on the board.

Let the symbol for the dominant allele be R.

Let the symbol for the recessive allele be r.

Let the genotype of the Parents be Rr and Rr.

Possible alleles in the sex cell are:

Male = R or r Female = R or r.

Possible combination of alleles in the progeny are:

	R	**r**
R	Rr	Rr
r	Rr	rr

Ratio of genotypes is RR : Rr : rr = 1:2:1.

Ratio of genotypes is dominant : recessive = 3:1.

Activity 5 Calculating a backcross

Now ask students to calculate the ratios of genotypes and phenotypes in a backcross using the method you have demonstrated. Their table should be:

	R	**r**
r	Rr	rr
r	Rr	rr

Ratio of genotypes is Rr : rr = 1:1.

Ratio of genotypes is dominant : recessive = 1:1.

Activity 6 Calculating a dihybrid cross

Students should now be able to calculate the possible genotypes and phenotypes in a dihybrid cross. Ask them to do this for hybrid plants that have green (dominant) or yellow (recessive) and round (dominant) or wrinkled (recessive) seeds. You may have to start by telling students to use the symbols G and g for green and yellow and R and r for round and wrinkled so that the symbols for the two parents become RrGg. You may also have to explain that, because of independent segregation, the sex cells can contain the alleles RG, Rg, rG and rg. Students should establish a theoretical 9:3:3:1 ratio of different phenotypes (green-and-round : green-and-wrinkled : yellow-and-round : yellow-and-wrinkled).

If necessary, complete the following table on the board with the class.

	RG	**Rg**	**rG**	**rg**
RG				
Rg				
rG				
rg				

Activity 7 Testing the theory

For this final group activity give each group two pairs of containers of beads. This time students should be told that the beads represent the alleles for two particular characteristics carried on chromosomes. Tell them that one of the alleles for each characteristic is dominant over the other and state the colour of the bead used to represent this. One container of each pair should have equal numbers of beads of two colours representing one characteristic; the other should have equal numbers of the beads representing the other characteristic. As before, one pair of containers represents the male parent and one the female parent.

Ask students to repeat the procedure used in activities 1, 2 and 3 but this time to draw beads from the four containers to create the genotypes of a number of progeny. Get them to record the results in a table like the one below, in which R, r G and g represent the dominant and recessive alleles as in the theoretical example.

Genotype	Phenotype	Number of progeny
RRGG		
RRGg		
RRgg		
RrGG		
RrGg		
Rrgg		
rrGG		
rrGg		
rrgg		

Round off this section of the lesson with some questioning:

Q How similar were the experimental and calculated results?

Q Can you account for any differences?

Q Would you expect to find the exact theoretical ratio of phenotypes in experiment?

Try to involve several students in this discussion and ask students to comment on the responses of others.

Consolidation

Resources

Vocabulary cards

To help consolidate the learning in this lesson you could write the ratios of progeny of various genetic crosses on the board and ask the class to determine the genotypes of the parents.

For another activity, prepare some vocabulary cards with words such as ‘gene’, ‘homozygous’, ‘recessive’ and place them face down on the desk. Select a student to come out and pick a card and explain the term on the card. If successful, the student then selects another student to come out and pick a card, and so on.

Other tasks

Students could be asked to work out some genetic crosses as a homework activity.

Summary for students

- The theoretical phenotype ratio in the progeny of a monohybrid cross is 3:1.
- The theoretical phenotype ratio in the progeny of a backcross is 1:1.
- The theoretical phenotype ratio in the progeny of a dihybrid cross is 9:3:3:1.
- Natural variation in biological processes means that theoretical outcomes are not always observed.

Notes

This lesson may take longer than a normal class period; if this is planned, then the learning in the first lesson should be consolidated with an appropriate activity and reinforced at the start of the second lesson. It may also be desirable to prepare a worksheet for the students.

12.2 Anodising aluminium

Objectives

- Know that an important property of aluminium is the suppression of the natural reactivity of the metal by a coating of oxide and that this coat can be coloured by anodising.

This lesson is for suitable for advanced students.

Preparation

All solutions must be prepared in advance in sufficient quantities. The aluminium (which could be cut from a drink can) must be specially cleaned just before the lesson. This involves the following procedure:

1 clean with the finest sandpaper;

2 wash for a few seconds in hot 2 M sodium hydroxide;

3 rinse in distilled water;

4 dip in 3 M nitric acid at room temperature;

5 rinse in distilled water.

After this it should be kept under distilled water and should not be touched.

This is not an easy process to conduct effectively. It important that you practise it beforehand so that you are familiar with all the difficulties and potential safety issues. **Resource 12.1** gives an outline suggestion for the laboratory manual for this practical but you must modify these instructions to suit the laboratory conditions in your school.

Safety

Safety spectacles and a laboratory coat *must* be worn. There is a danger of a fine acid spray during the process.

Main activity

Resources (per student)

- $250\ cm^3$ plastic beakers
- Glass rod
- Power pack and leads with crocodile clips
- Cathode (clean lead or aluminium)
- Aluminium anode prepared from a drink can (see 'Preparation')
- Paper towels
- Wash bottle containing distilled water
- Access to 1.5 M sulfuric acid

This is a Grade 12 advanced chemistry practical. The theoretical introduction should have been done in the previous lesson, and students will also have been taken through the process then. They should be familiar with the conduct of laboratory sessions.

You will issue instructions and provide technical assistance. The instructions will indicate places in the procedure when students need you to check that everything is set up safely before proceeding.

Students will work to the instructions in the laboratory manual for the experiment.

Consolidation

There is no consolidation in this lesson. Students will discuss the exercise and compare products during the next lesson.

Summary for students

- The oxide layer on aluminium can absorb coloured dyes. This can be exploited to make aluminium attractively coloured using an electrolytic process called anodising that generates the layer in the presence of the dye.

Notes

There are several methods for simple anodising of aluminium that can be found in books or on the Internet. A cathode is required, for which clean lead or aluminium is suitable. Care in preparing the aluminium to be anodised is important and, once cleaned, the aluminium must not be touched or allowed to become dry.

During anodising, a fine spray of sulfuric acid is often produced, so it is important to keep the beaker lightly covered. The anodising voltage should not be too high or a poor finish will result. Many different dyes can be tried; soluble pen ink can be used as well as commercial fabric dyes and some experimentation is needed to find out which are the most effective. A gold colour can be obtained by making an aqueous solution of ammonium ethanedioate and iron(III) chloride in equal proportions (note that ammonium ethandioate is poisonous).

12.3 Resonance

Objectives

- Describe practical examples of forced oscillations and resonance.
- Show how the amplitude of a forced oscillation changes with frequency near to the natural frequency of the system.
- Describe circumstances in which resonance is desirable and others when it should be avoided.

This lesson is for suitable for advanced students.

Preparation

Search the Internet to find film of the Tacoma Narrows bridge collapse in 1941 and information about how a 16 mm film movie camera works.

Introduction

Students will be familiar with oscillations and damped oscillations. This lesson introduces the concept of resonant frequency applied to mechanical oscillations and also returns to the subject of damped oscillations.

Give **Resource 12.2** to students in the previous lesson so that they can do the pre-lesson preparation work indicated.

Discuss the concept of the natural frequency of an object. Think of everyday objects, such as a child's swing or a pendulum, that could be demonstrated. Ask questions that lead to the realisation that there is only one natural frequency for the swing, irrespective of the mass of the child on it:

Q What happens to the time period of the swing if you push it faster?

Q Can you make the swing/pendulum swing faster or slower?

The pendulum will resist any attempts to make it vibrate either faster or slower.

Show the film clip of the Tacoma Narrows bridge collapse shortly after it was built across the entrance to Puget Sound in Washington State, USA. Puget Sound and the replacement bridge can be located on a map. Ask why it collapsed to see if anyone can relate the collapse to the resonant frequency of the structure, but do not pursue this in depth at this stage.

Main activity

Resources (per pair)

String
Paper
Sticky tape
Curtain rings
100 g mass
Stopwatch
Resource 12.2

Barton's pendulums

Students should work in pairs. Time: about 40 minutes.

Ask each pair to make a set of Barton's pendulums from paper cones and curtain rings, as described on **Resource 12.2**. Check each pair to ensure that all the paper pendulum bobs are identical and the make sure that the length of the heavy pendulum is *identical* to the length of just *one* of the paper ones.

Ask the pairs to work through sections 1 and 2 of Resource 12.2. They will measure the frequency of the heavy pendulum (the driver) and the amplitudes of each of the paper ones. They will then repeat the experiment without the curtain ring masses. This will increase the damping of the pendulums by making air resistance more significant, and they will note that the vibrations have lower amplitudes.

Students should observe that:

- the largest amplitude occurs in the pendulum that has the same natural frequency as the driver – the one that is the same length;
- the other pendulums are forced to oscillate at an unnatural frequency.

See the notes below for a further discussion of this pendulum system.

While students are working, assist them with any problems they have setting up the equipment and taking measurements and ensure that the length of the driver is exactly the same as the length of one of the middle pendulums. Give advice on how to measure the frequencies exactly. Draw the attention of faster groups to other observations, such as the phase differences between the pendulums.

Consolidation

Bring the class together and draw three main conclusions from them:

- the biggest oscillation was observed in the pendulum that had the same natural frequency, and was the same length, as the driver;
- the other pendulums were not oscillating at their natural frequencies;
- the amplitude of the resonant oscillation can be reduced by damping.

More advanced students may observe the phase differences between the driver and the pendulums. The resonating pendulum is always one-quarter of an oscillation behind the driver so that the position of maximum kinetic energy of the driver corresponds to the position of maximum potential energy of the driven resonating pendulum.

Other tasks

Determine the resonant frequency of the Tacoma Narrows bridge

This will require access to computers. If there is only one computer in the laboratory it can be demonstrated, though it may be better to set the task for homework so that students are able to work with the computer individually. Ask students to determine the resonant frequency of the bridge as in section 3 of Resource 12.2.

Further discussion

There may not be time for this section in the lesson. If not, start the next lesson with it. Discuss practical applications of resonant frequency in engineering. Ask the class if they can think of examples, like the Tacoma Narrows bridge, where the resonant frequency is a problem, such as:

- the resonant frequency of a bridge should not be close to vibrations that can be produced by natural causes or by traffic;
- the resonant frequency of a building in an earthquake area should not be near the likely earthquake frequency;
- the resonant frequency of a car suspension system is often the same as the vibration that is set up when the car has an unbalanced wheel moving at a particular speed, so it is important that wheels are balanced.

The importance of damping can be re-emphasised here; buildings and vehicles can have devices built into them that absorb the energy of the oscillation.

Introduce some practical examples that make use of resonant frequencies, such as:

- the resonant frequency of a quartz crystal in a watch;

- the resonant frequency of the soundboard of a guitar or violin or a pipe in an organ.

As these examples are raised, summarise them on the board in two columns: examples where resonance is useful and examples where resonance is a problem. Ask students to read the appropriate section of their textbook for homework.

Summary for students

- All objects have a natural resonant frequency.
- Objects can be forced to oscillate at other frequencies, but they will oscillate with a much greater amplitude, for the same energy input, at their resonant frequency.
- Engineers must be aware of the natural resonant frequencies of the objects they are constructing so that they do not become damaged during normal use.
- Damping can be used to reduce the impact of resonance in engineering systems.
- Resonant frequencies can be useful in some systems.

Notes

Barton's pendulum system

This system will demonstrate resonant frequency. The frequency of a pendulum depends only on its length. In the system, energy is transferred from the heavy driver to the other pendulums through movement of the string from which they are hanging. The other pendulums will store up this energy and release it through movement at the same frequency. The position of maximum kinetic energy of the driver will therefore correspond to the position of maximum potential energy for the driven pendulums, which will be about 90 degrees out of phase with the driver. The driven pendulum that oscillates with the greatest amplitude will be the one that has the same natural resonant frequency as the driver.

Removing the curtain rings from the pendulums makes them lighter and their movement will be damped more by air resistance. Their oscillations will therefore be smaller.

Use of ICT in this lesson

The famous film of the Tacoma Narrows bridge can be found on several engineering sites on the Internet and downloaded. It will require video playing software to play it. Ensure that the software allows you to page frame by frame through it.

The film was shot using a 16 mm (or possibly 8 mm) film using a camera that operated at the standard 24 pictures per second. This speed can be checked by looking up how movie cameras work on the website www.howstuffworks.com. Encourage students to find this out for themselves before the lesson.

12.4 The fate of stars

Objectives

- Know how stars are created, that they are made mainly from the element hydrogen and that their ultimate fate depends on their size and can lead to supernovae, white dwarfs, neutron stars (pulsars) or black holes.
- Identify, and make critical use of, secondary information.
- Recognise that the development of scientific ideas often proceeds in periods of major changes followed by periods of slow elaboration.
- Use an appropriate range of methods to communicate scientific information.
- Work in an ethical manner with regard to acknowledging data sources and authenticity of results.

This lesson is for suitable for advanced students.

Preparation

This lesson requires an Internet connection and assumes that students can use it and know how to use search engines. You need to identify some appropriate sites before the lesson. You will also need to conduct a short planning session in a lesson about a week earlier.

Introduction

Resources

Resource 12.3

This is an example of a very useful kind of lesson for a small group of advanced students. The main objective for the students is to identify and filter secondary information and then present it in a form that is relevant to the needs of their peers.

Planning session

Hand out **Resource 12.3** and go through the instructions briefly, answering any questions that arise. Tell students to work individually but to help each other by sharing and discussing information that they find. They must each produce an output, which can involve any kind of method for sharing information with their peers. Electronic methods, such as the use of display software, should be encouraged and visuals should be an essential component of the presentation.

Share out the three tasks fairly but encourage all students to cover all three questions in Resource 12.3, focusing principally on their designated one.

Tell them that in a specific lesson (give the date), six of them (two per topic) will be chosen at random to make a five-minute presentation to the others.

Provide the class with a small list of suitable websites and other resources to help them start their research.

Main activity

Resources

Computer
Data projector
OHP

Presentation on the fate of stars

Time: about 90 minutes.

Choose six presenters, two on each of the three topics, by a random method. Tell them that they will be given just 5 minutes to present to the group what they have found out and that they will be notified when they have only 1 minute left. (You may wish to appoint a chairperson from among the group, but do this only if the group has experience of this process and the role and responsibilities of the chair are clearly understood.)

After the two presentations on each topic, encourage discussion for about 10 minutes. The discussion should generate clear information on the essential features of star decay, such as issues related to energy production, the densities of the products of star decay, the nature of pulsars, the consequences of the differing gravitational force in each example and the part played by a relativistic interpretation of gravity (as opposed to a Newtonian interpretation) in explaining the essential properties of a black hole.

This last point could accommodate a brief discussion on the nature of the advance of scientific understanding, which often proceeds through a slow elaboration of a prevailing paradigm followed by a major shift to a new paradigm when the older one fails to explain important new observations.

Consolidation

After the presentations and discussions, invite students to participate in the generation, initially on the chalkboard, of a summary display that encapsulates the essential processes of star decay.

This display can be further developed individually by each student for homework. Encourage students to use display software for this.

Summary for students

- The ultimate fate of a main sequence star depends on its mass and can lead to a white dwarf, a neutron star or a black hole.
- There is primary and secondary evidence for the existence of all three types of object.
- The explanation of the fate of stars requires a concept of gravity that goes beyond Newtonian mechanics.