Getting to know you

Time check:
1 lesson

You will need:

- ✔ 100 AberElf seeds (lawn grass)
- ✔ 100 AberLinnet seeds (grazing grass)
- ✔ 100 AberHerald seeds (clover)
  (keep these seeds separate)
- ✔ plain drawing paper
- ✔ millimetre graph paper
- ✔ a sharp pencil

Part 1: Look closely at the seeds. Take a blank sheet of A4 paper and create a table using the picture below as a guide.
Draw seeds from each variety and note the **colour** of their seed coats.

This variety is:	**This variety is:**	**This variety is:** .....
Notes	Notes	Notes

Q *Do you think (predict) there will be any difference in germination between the seeds? Germination is the process by which a seed grows into a new plant. Seed germination is triggered by a combination of warmth, moisture and, in some cases, sunlight.*

- ☐ Yes, I predict there will be a difference.
- ☐ No, I predict there will not be a difference.

Touch the seeds from each species with your jumper or on any textured piece of material.

Q *What do you notice?*

Q *How do you think the seeds are scattered from the 'parent' plant?*

Getting to know you

Part 2: Count out 100 seeds of each type and then weigh and measure them using the millimetre graph paper. Create a table to show your results.

Q *Which seeds are the largest and which are the smallest?*

Q *Which seeds weighed the most and which weighed the least?*

Seed packing companies, garden centres and farmers all need to be able to split up large amounts of seed and work with smaller batches.

Q *How can you count out lots of groups of seeds quickly?*

Do you think the size, colour or the weight of the seed will affect the number of seeds that germinate; the time when the roots or shoots appear or the growth rate of the plant? Use the 'Germination Tests' which follow to explore these questions.

Germination tests

Time check:

Experiments 1 to 3, 5–7 days in total

You will need:

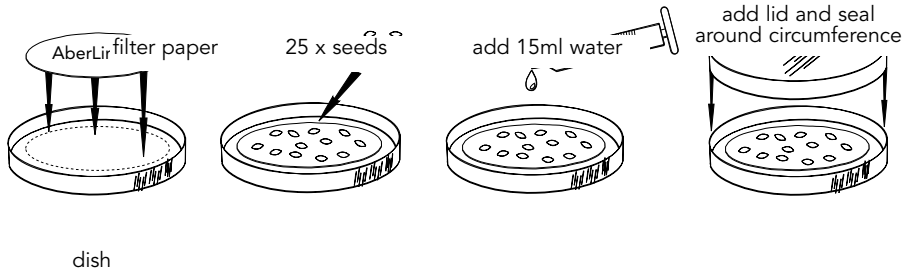
- ✔ Petri dishes (or any clear plastic/glass dish with a tight fitting lid)
- ✔ filter/blotting paper
- ✔ tea bag
- ✔ silver foil
- ✔ forceps

You can make these tests as simple or as complicated as you like by choosing as many experiments as you think you can handle (once the seed has been counted all the experiments are simple and straight forward). When you have completed the germination tests you can go on to further experiments using the seed you have germinated.

You can carry out the experiments on your own or as part of a small group but to complete them properly each experiment should be **replicated (copied) at least once**.

First Steps

- Take 25 seeds of each variety; AberLinnet, AberElf and AberHerald. Make a note of any differences you see between the different varieties (size, colour etc.).
- **In pencil,** write the name of the variety of seeds on the filter paper; place the paper flat in the dish and carefully scatter the seed on the surface making sure that the different varieties are kept **separate**.
- Add 15mls of water to each dish.

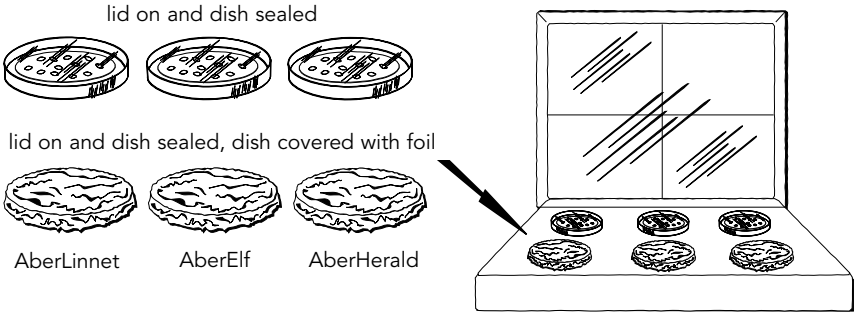


Tips

Only count a seed as germinated when a **shoot** (known as the plumule) can be seen. Make sure the lids of the Petri dishes are a good fit or the seeds will dry out. You can seal the dishes with tape or cling film.

Experiment 1: Light and Dark

- Cover half of the prepared dishes of each type of **grass** seed with silver foil to exclude all the light.
- Place **all** the dishes (with foil and without foil) on a windowsill.
- Record the number of seeds that have germinated as often as you can (daily if possible) until most or all have germinated successfully.



Germination tests

- In the space below, plot the germination rates of the grass seeds germinated **in the light** (a bar chart is best).

Q *Which grass variety showed the highest rate of successful germination?*

Q *Can you think of reasons why the two seed varieties might germinate differently?*

Q *Which seeds showed the highest rate of successful germination, those in the dark or those in the light? Why?*

Germination tests

Experiment 2: Hot and cold

- Prepare several dishes of each type of grass seed, as you did for experiment 1 (covering some of the dishes in foil and leaving an equal number uncovered).
- Place half of the **uncovered** dishes of each kind of grass seed in a **fridge.**
- Put the same number of **uncovered** dishes in an incubator or an oven at low temperature (30-50^{o}C). Alternatively, you can put them on a rediator, *if* they are sealed properly with clear tape so that they do not dry out.
- Leave the dishes for 2-3 days.

Q *Do the seeds germinate at extreme temperatures?*

- After 2-3 days, move all the dishes to a windowsill and record the numbers of seeds that germinate as often as you can, until all or most have germinated successfully.

- In the space below, plot the germination rates as a bar chart, **after** the seeds have been placed at normal (room) temperature.

Q *Try to explain your results.*

Germination tests

Experiment 3: Clover colouring

Tip

The seed coat of clover contains chemicals especially tannins which could have the effect of delaying germination if the concentration is high enough.

- **Step 1:** Separate the clover seed into light-coated seeds (yellow) and dark-coated seeds (brown).
- **Step 2:** Line some Petri dishes with blotting paper and label them - then put 50 'light' seeds in one dish and 50 'dark' seeds in another dish and add **15 ml of water** to each dish and germinate as in **First steps**.
- Repeat steps 1 and 2 only this time squeeze a little **cold tea** from a used tea bag onto the blotting paper in the dishes *instead* of the 15 ml of tap water.

Q *Do you think the colour of the clover seed's coat will affect its germination?*

- In the space below, record the numbers of seed that germinate until most or all have germinated successfully.

Look at the clover seeds which have been given water.

Q *What can you say about the area on the blotting paper around the seeds? How might this have happened?*

Germination tests

In the space below, plot the germination rates of the different coloured clover seeds exposed to **water** (a bar chart is best).

Look at your results.

Q *Are there are differerences in germination between the 'light' and 'dark' coated seeds? If so, what do you think might have caused these differences?*

Germination tests

Now plot germination against rates for the seeds exposed to **tea.**

Look at your results.

Q *What effect does the tea have on germination rates? What chemical might tea contain?*

Watching the grass grow

Time check:

10–15 days for each experiment

To complete all the experiments in this section you will need:

- ✔ filter or blotting paper
- ✔ empty 1.5 litre clear plastic pop bottles (you need at least 8 for each group) with the base cut off evenly (see diagram below)
- ✔ Petri dishes (or any clear plastic/glass dishes which will fit inside the pop bottle - 9cm in diameter)
- ✔ a ruler or strips of cm squared graph paper cut into strips for measuring
- ✔ silver foil to cover pop bottles (or a light-proof cardboard box)
- ✔ insulating tape or similar

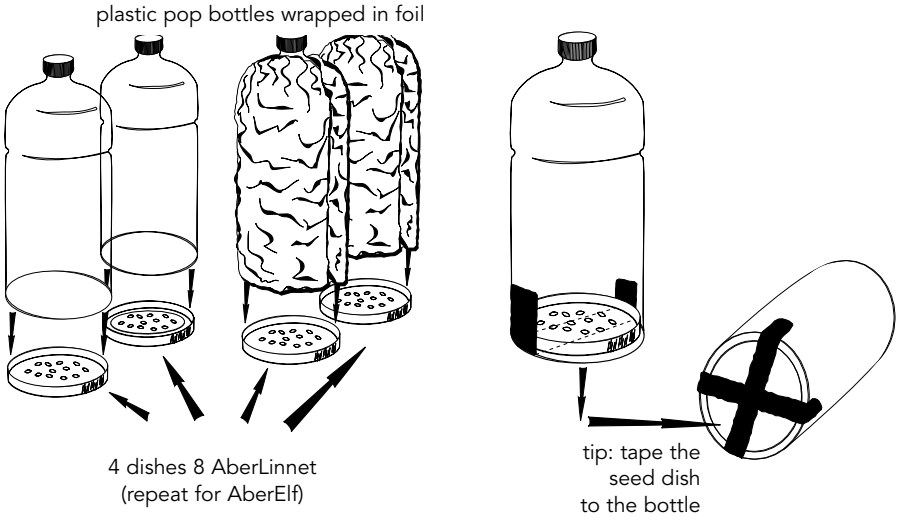
Experiment 4

How to Start

- Germinate at least 4 dishes of each of the types of **grass** seed following the instructions in the '**First steps**' section. To save time you might want to use germinated seeds from previous experiments (except those exposed to the tea!). If so, make sure you know what variety of grass they are.
- Divide your pop bottles into two equal groups. Wrap each of the pop bottles in one group in silver foil to exclude the light. Leave the pop bottles in the other group uncovered.
- Cover each dish of germinated grass seed with a pop bottle.

Tip

It is a good idea to fix the dish to the pop bottle or the dish contents may end up on the floor (insulating tape is best as it can be stuck and unstuck easily).



Measure the height of the tallest grass leaf from each dish (daily if possible) or as often as you can for 10 to 15 days. On a separate piece of paper, record your results in the form of a table and draw a bar chart to show your results. In the space below, draw a bar chart to show your results.

Watching the grass grow

Now plot a **line graph** showing the growth rates for the 2 varieties of grass seed (height x variety x time).

Q *What happened to the grass grown in the dark and why?*

Q *In your tests, which type of grass grown in the light grew the tallest?*

AberLinnet *is a hybrid ryegrass. This variety has larger leaves than AberElf. Many farmers in the UK choose AberLinnet to graze their livestock on.*
AberElf *is a perennial ryegrass grass, ideal for garden lawns and sports areas. This variety produces lots of small, short leaves and forms a carpet-like surface which will stand up to close mowing and lots of wear (for example regular trampling by footballers on a football pitch).*

Using the information in the box above, comment on your results.

Important: Don't throw your germinated seed away. You can use it for the next experiment.

Watching the grass grow

Experiment 5

Cut the grass from experiment 4 right back to the top of each dish, keeping the cut level. Now measure the re-growth for up to 10 days (as in experiment 4). Record your results as a table and then draw a bar chart in the space below.

Q *Is there any difference in the re-growth rates between the varieties?*

Q *Do you think this is helpful or unhelpful? Why?*

Starch test

Time check:

2 lessons

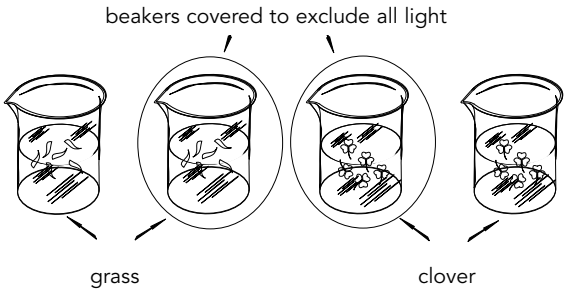
To complete all the experiments you will need:

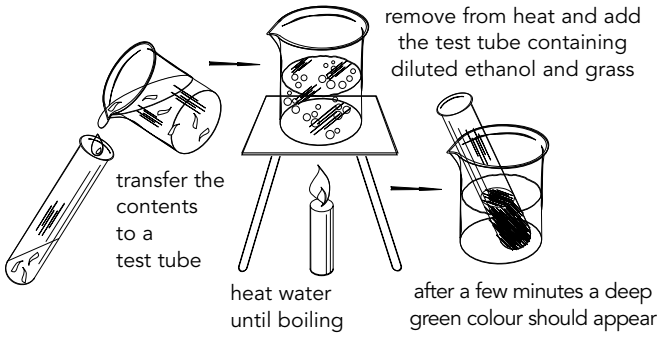
- ✔ freshly picked, healthy clover and grass leaves. Use the biggest leaves you can find
- ✔ small and large beakers.
- ✔ silver foil
- ✔ potassium iodide solution (KI).
- ✔ alcohol (ethanol)
- ✔ test tubes
- ✔ a drop pipette
- ✔ safety glasses
- ✔ protective clothing (a lab coat, apron or similar and safety glasses)

Experiment 6

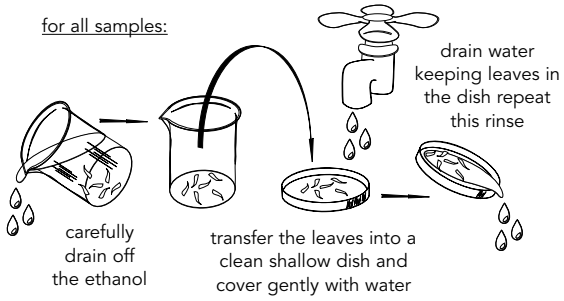
Part 1:

- Separate the leaves of grass from the leaves of clover and then divide each into two lots and put them into small beakers or tubes of water.
- Cover one breaker containing grass and one beaker containing clover with a box to block out **all the light.**
- **Leave for at least 24 hours**.





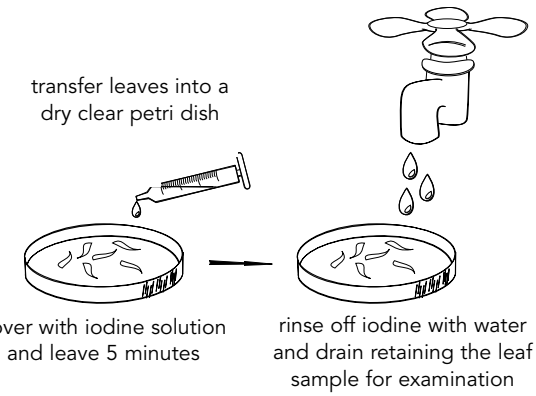
- Cut off some of the leaves from the clover and grass which have been in the **dark** and put them into a 100 ml beaker. Your teacher will provide you with a liquid which is 80% v/v ethanol/water (diluted alcohol made up of eight parts ethanol and two parts water). Wearing appropriate protective clothing including safety glasses, carefully cover the leaves in the beaker with a little of this diluted ethanol and transfer the mixture to a large test tube until the test tube is about one third full.
- The leaves covered with diluted ethanol must now be heated but care should be taken as ethanol is a flammable liquid. **Directions:** fill a heat proof beaker with water until it is just over half full. Place the beaker on a tripod and heat using a Bunsen Burner until the water is boiling. **Turn off the Bunsen Burner:** Quickly but carefully, place the test tube containing the diluted ethanol and leaves into the beaker of boiling water. After 5 – 10 minutes the liquid in the test tube should go a deep green colour.



- Now repeat steps 1- 3 using some of the grass and clover leaves which have been left in the **light**. Make sure you know which leaves are which (i.e. 'kept in the dark' or 'kept in the light').
- **Very carefully** drain away the ethanol from each beaker. Put the leaves in separate shallow dishes or beakers and gently cover them with water. Drain the water (be careful not to loose your leaves too) and then repeat this water rinse. The leaves should be a pale colour at this stage.

Starch test

Transfer each leaf sample to its own clean dish (a Petri dish is ideal) and cover with iodine solution using a pipette. Leave for 5-10 minutes. Gently rinse off the iodine with water. Again, make sure you hold onto your leaves!



Part 2: Take a few seeds of the grasses and clovers. Keeping the different varieties separate from each other, squash them (a pestle and mortar is best). Scrape each squashed sample into its own dish and add a few drops of iodine solution. Leave for 5 minutes.

Q *Did you see any differences between the leaves kept in the light and those kept in the dark after they had been stained with iodine solution?*

Q *What colour did the seeds go?*

Q *What do the results from this experiment show?*

Roots and shoots

Time check:

Experiment 7; part 1, 1 lesson; part 2, variable. Experiment 8, 7 to 10 days.

You will need:

- ✔ a piece of turf which contains grass and clover plants (about 20 cm wide x 20 cm long and at least 30 cm deep) ***Please make sure you have permission before removing the turf***
- ✔ white sticky paper cut into thin strips
- ✔ access to resource material

Experiment 7

Part 1:

- Remove as much loose soil as you can by hand and then gently wash away the remainder with water.
- Carefully separate the grass and the clover plants from each other.
- Examine the root systems of both grass and clover. Draw what you see in the box below. On your diagram note any differences between the grass and the clover.

Tip if there are several clover plants close to each other in the turf, try not to break the stolons (see glossary) which will probably join one to the other.

Q *Which plant roots have bumps?*

Q *Are there any differences in the bumps (size, colour, position on the root?)*

Roots and shoots

Sourcing Information

Q ***What do you think the bumps (root nodules) might be and how might they be caused?***
Key search words: **nodule;** ***Rhizobium*****.**

- In your group, find out as much information as you can, from as many different sources as possible.
- In the box below, write a summary of the information you have gathered and describe where you found this information (sources could include the library, CD Roms, non-school organisations, the Internet).
- Share your findings with the other group.

Summary:

Roots and shoots

Part 2: We now know that the nodules on clover plant roots are caused by *Rhizobium* bacteria. Where do the bacteria live? Do they only live in the nodules, or can they be found in other places e.g the soil?

Using clover seedlings, plan an experiment to find out where *Rhizobium* bacteria live.

Remember a good **experimental protocol** (description of the experiment) will include:

- a clear statement about what is being investigated;
- a prediction about the outcome and findings of the experiment;
- an account of how the prediction will be tested (what equipment and techniques will be used etc). Consider the safety precautions that need to be taken and why. Scientists call this a 'risk assessment'.

The experiment itself should be:

- planned so that enough information can be collected to give reliable evidence (deciding on the key factors to be investigated before you begin and repeating experiments will help).

During and after the experiment there will be:

- accurate recording of information and clear presentation of the results (drawings, graphs, bar charts and tables can all be used);
- a statement about the findings;
- any conclusions which can be made;
- suggestions for improving the experiments or using different experiments to find out more.

Experiment 8: Which parts of the plant's shoots actively grow?

- All plants have growth areas. To investigate where they are on clover and grass plants, keep some of the plants (roots and shoots) from experiment 7 and plant them in soil-filled pots. (Alternatively, in spring or summer, you can use plants growing outside in an undisturbed part of the grounds but the sticky paper must be waterproof.)
- When the plants have had at least a week to get over the shock of transplanting, add thinly cut strips of white sticky paper (water resistant) to the area of the plants **where you predict growth will occur** (for instance, the tip of a grass leaf). **Tip:** before you add them, label each strip with a number and when you have added your strips measure and record how far away each strip is from the tip of the leaf it is attached to.
- Observe these plants for 2-3 weeks. Measure how far the sticky paper is away from the tip. Record your results on a separate piece of paper.

Q *Did the distance between the paper and the leaf or stolon tip change or stay the same?*

Compare your results with your classmates.

Q *What do the findings tell you about growing areas?*

Classification

There are millions of different kinds of living things in the world. Each different kind of living thing is called a **species**. Species can be grouped together and classified according to certain characteristics.

Classification may be based on a number of things including; life-cycle characteristics, biochemistry and structure (with flowering plants the structure of the flower is very important).

With new technologies it is now possible to see how closely related living things are by how similar their **DNA** is. Although studying their unique DNA patterns has led to the need to re-classify some living things, in most cases, the original classifications made by people like the botanist Linnaeus, have been proved correct.

In 1735, **Carolus Linnaeus,** a Swedish botanist, developed a two word system for classifying all plants and animals. He used two Latin words which described the **Genus** and the **species** of the organism, in order to name it. Even his own name is a Latin version of his original name, Carl von Linne.

Classification terms

Kingdom. A taxonomic term in classification. Five biological kingdoms are commonly recognised;
Monera (bacteria),
Protista (multicellular algae, slime moulds, and unicellular or simple colonial protozoans),
Fungi – many different forms from microscopic to the toadstools and mushrooms we eat.
Plantae – multicellular, eukaryotic organisms (plants) that (usually) conduct photosynthesis.
Animalia – all the animals which generally must consume other organisms to obtain most of their nutrients.

Phylum. Living things in each phylum have a body structure which is very different from living things in any other phylum.

Classes. Living things in the same class share several common features.

Order. Any of the taxonomic groups into which a class is divided and which contains more than one family group.

Family. Living things in the same family have similar features e.g. plants in the same family will have similarly shaped flowers with the same number of petals etc.

Genus. A sub–division of a family group. Includes closely related species. Inter–breeding between organisms in the same genus can occur but is not common.

Species. As general rule of thumb, living things of the same species can interbreed successfully whereas living things from the same genus but different species (like the Brown Bear and the Polar Bear) cannot interbreed. Below, is an example of how a ryegrass plant is classified.

Classification of Perennial Ryegrass : *Lolium perenne*

Classification example		Characteristics shared by the group
Kingdom:	Plant	*Living organisms that make their food from inorganic sources*
Phylum:	Angiosperm (Seed-bearing plants)	*Plants which produce seeds and have a well-*developed vascular system
Sub-phylum:	(Flowering plants)	*Seeds enclosed in a fruit or nut*
Class:	Monocotyledons	*Single seed leaf, long, parallel veined leaves*
Order:	Glumiflorae	*This order only has one family as described below*
Family:	Gramineae (Grasses)	*Hollow, jointed stems, sheathed by long narrow leaves*
Genus:	*perenne* (Perennial)	*Inflorescence (flowering structure) of spikelets flattened at 90 degrees to, and alternating on, a central stem to form a spike.*
Species:	*Lolium* (Ryegrass)	*Perennial, spikelets without awns (hairs).*

Classification

Experiment 9: Plant classification

Time check:
1 lesson

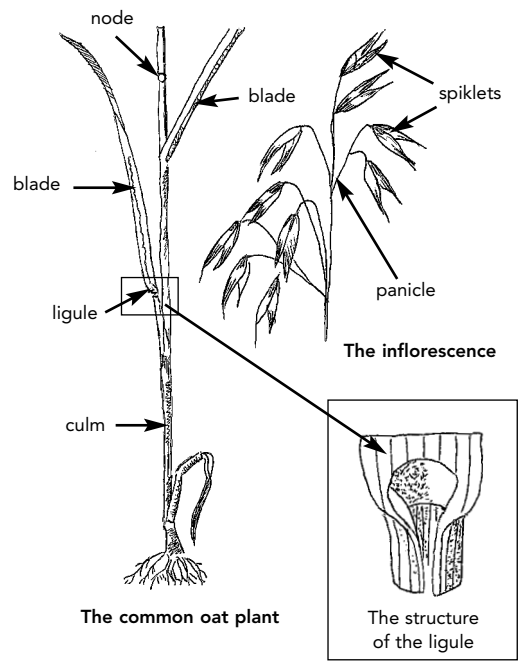
Part 1:

- Collect a number of stems of plants that you think are grasses (the best time to do this is in June or July when most British grasses produce their flowers). Habitats in which you might find a number of different grass species in flower are hedgerows, roadside verges, the edges of playing fields, arable fields or hay meadows.
- Compare the plants you have collected to the diagrams on this page. What features do your plants have which suggest to you that they are grasses?
- Under the heading '**My plants'** below, make a list of the main features of each plant you have collected. You might like use a separate piece of paper to draw a diagram of each plant and label it.
- Study each list and decide if each plant is a type of grass.

My plants:

To complete experiments 9 - 11 you will need:

- ✔ several fresh stems of plants which you think are grasses
- ✔ several trays or dishes
- ✔ sticky labels
- ✔ a reference book containing a classification key for grasses (optional)
- ✔ two spatulas or two needles
- ✔ a microscope
- ✔ microscope slides
- ✔ glycerol
- ✔ a glass jar or similar
- ✔ clear plastic bags (freezer bags are ideal)



Classification

Which grass is it?

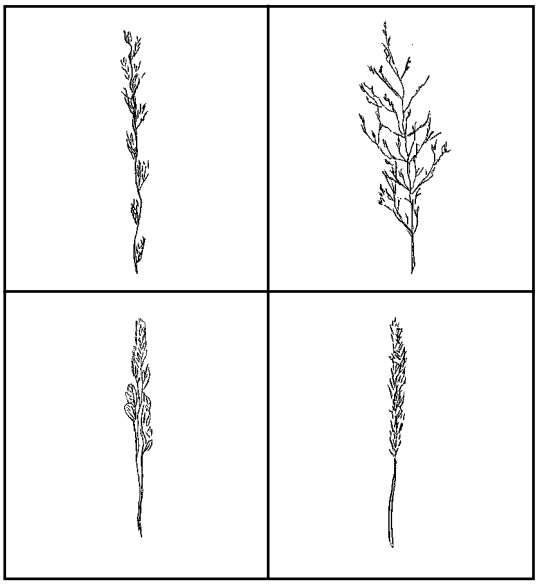
Part 2: Once you have identified a plant as a grass, the next step in classifying it is to separate it into **Genus** and **species**.

There are hundreds of different species of grass growing in the UK and thousands world-wide.

In the **grasses**, the important identification features that separate the different Genera and species are;

- inflorescence arrangements (the actual structure and shape of the flower as shown in the diagram on the right).
- the shape and size of the ligule and auricle if present at the junction of leaf sheath and blade.

Other features which help in classification include plant colour, texture and the hairiness of the leaves and stems. The habitats in which the plants are found can also provide clues as to which species they are.



The inflorescence arrangements of different grass species

Keys

Keys are often used to identify and separate species of plants and animals. They work by offering a choice at each level of investigation. A simple example is given below for separating five common grasses that can be found in hedgerows. (See also the classification diagram on page 20).

1. Inflorescence (the flowering area of the plant) is a branched panicle
2. Leaves softly hairy – ***Holcus lanatus*** (Yorkshire Fog)

2a. Leaves hairless

3. Ligule membranous, short (1mm)– ***Poa pratensis*** (Smooth-stalked meadow grass)

3a Ligule membranous, long (3-4mm) – ***Arrenatherum elatius*** (Tall Oat Grass)

1a. Inflorescence is a single unbranched spike

4. Spikelets are arranged with their edges adjacent to the stem – ***Lolium perenne*** (Perennial Ryegrass)

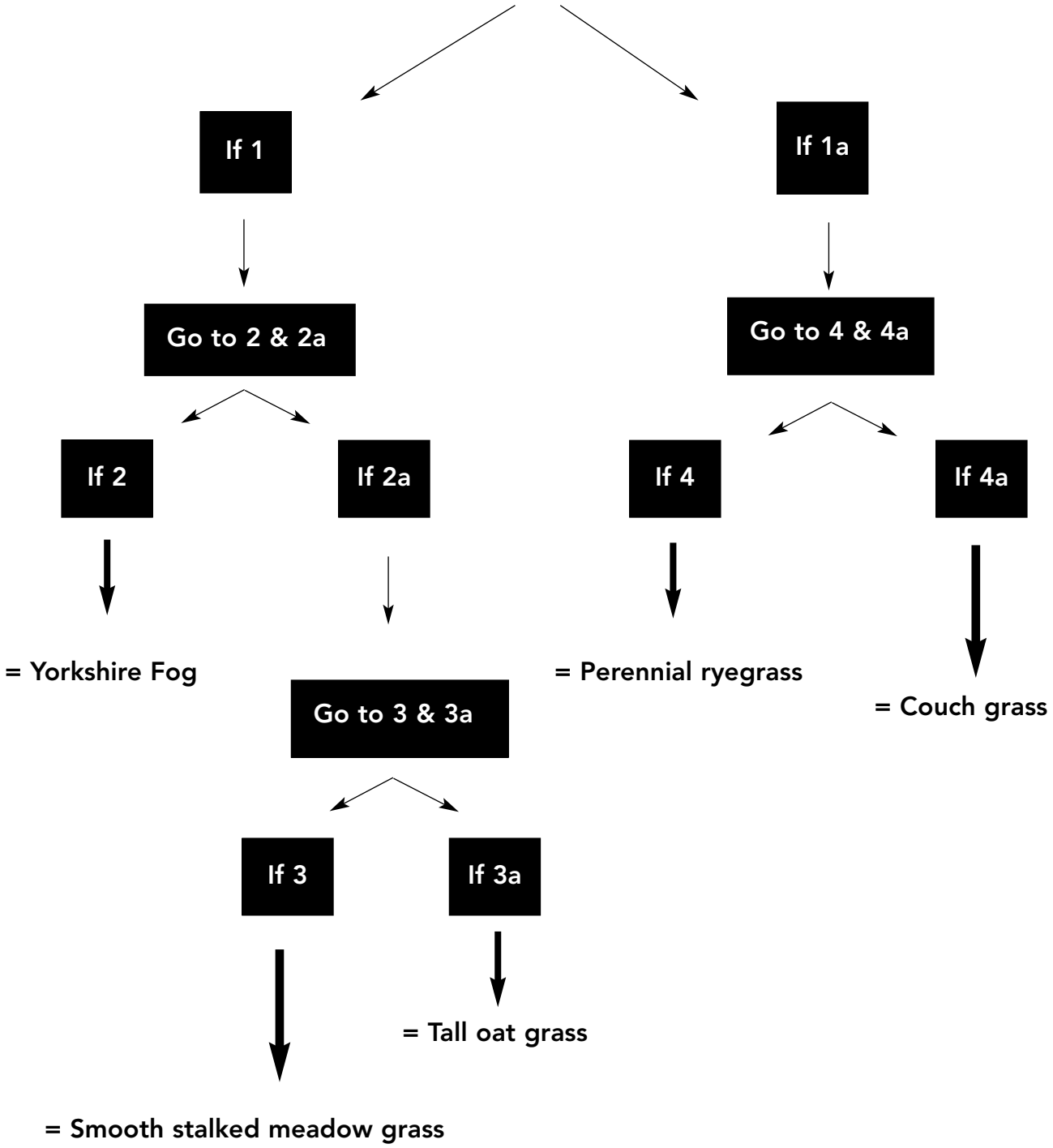
4a. Spikelets arranged with broader sides adjacent to stem – ***Agropyron repens*** (Couch grass)

- Using a reference book, identify as many of the grasses which you have collected as possible.
- Put these grasses on separate trays or dishes and label the bottom of each tray with the name of the grass
- Devise your own key along the lines of the one above. *If you do not have a reference book, you can still complete part 2 by labelling each of your grasses with a single letter and using these letters in your key.*
- Give your key and one of your grasses to someone else in the class and see if they can identify the grass (or letter or number code associated with the grass) using your key and **without** looking at the bottom of the tray.

If your classmates **are** able to identify the plant you must have created a key which works well. If they are not able to identify the plant, try to improve your key and then test it on someone else.

Classification

Start with pair of statements labelled 1 and 1a and determine which statement matches the description of your grass



Classification

Experiment 10: Flowers and sex

Time check:
1 lesson

Part 1: **Looking at grass flowers**

As we have seen in experiment 9, flower structures are one of the major characteristics used in classification of flowering plants. The flowers are the **reproductive organs** of plants.

All flowers have a number of essential reproduction structures but the number, size and colour of these structures will vary from species to species and some species may have additional structures, which, although not essential, can help increase the chances of the plant reproducing successfully.

A quick guide to pollination and fertilisation

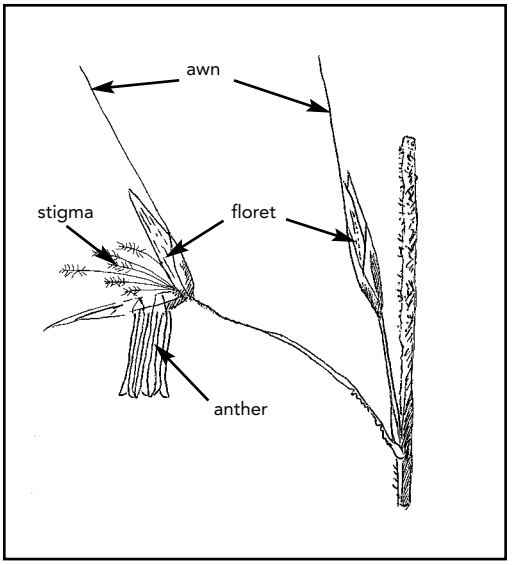
Pollen *produced by the* ***anthers****, is released and may land on (****pollinate****) a* ***stigma*** *(the tube which leads down to the* ***ovule*** *or egg). It then* ***germinates*** *to produce a pollen tube, which penetrates the* ***stigma*** *and travels via the* ***style*** *towards the ovary. Here* ***fertilisation*** *occurs (the nucleus of the pollen-tube fuses with the nucleus of the egg cell contained within the single ovule of the ovary). The resulting* ***embryo*** *develops into a* ***seed.***

The pollen of some grasses is able to pollinate the ovaries from the same plant. This is called ***self-pollination****. However, many grasses have a chemical mechanism, which prevents its own pollen from germinating on stigmas of the same plant. This ensures* ***cross-pollination****.*

Q *What advantages do you think cross-pollination might have over self-pollination?*

Look at the diagram on the right.

The male sex cell(or **gamete**) is called pollen, the female sex cell is called the ovule.
Most grasses are **hermaphrodites** i.e. they contain both male and female gametes in the **same** flower. However, some grasses are **monoecious** which means the male and female gametes are on the same plant but present in different flowers e.g. maize. (Hardy) grasses are **dioecious** which means the two sexes are on different plants.



Classification

- Using a fresh grass plant with well developed flowering parts (inflorescence), draw and label the inflorescence in the space below.

Q *How many anthers are there per floret?*

Grasses are wind-pollinated.

Q *What makes the anthers particularly suited to wind pollination?*

Q *Grass plants produce a large amount of pollen. Why?*

- Collect some pollen on a piece of clean paper. You will notice that individual grains do not clump together. They move easily and are quite dry. This is another adaptation to wind pollination and means that pollen grains can be distributed over as large an area as possible. If possible place some pollen in a drop of glycerol (a colourless, syrupy liquid) on a slide and study under a microscope.

Part 2:

Looking at the stigma, style and ovary

If you observe an open floret carefully, you may be able to see two white feathery stigmas which become exposed.

- Remove these structures from the florets by gently pinching the base of the floret until the stigmas and associated style and ovary pop out of the floret. The two stigmas lead down to a single style which in turn leads to the ovary which contains a single ovule waiting to be fertilised by a pollen grain.
- Carefully remove a stigma/style from the ovary with a spatula/knife/needle and mount it in glycerol on a microscope slide. Look at the structure under the microscope and draw what you see in the space below.

Q *What are the features which help the grass stigma to catch pollen effectively?*

Q *Why are grass flowers so small and seemingly insignificant compared to some other flowers?*

- List three differences between plants which rely on wind pollination and those which rely on insect pollination.

Classification

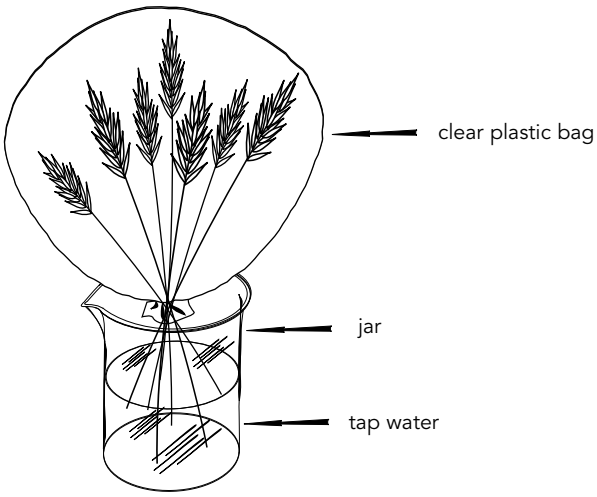
Experiment 11: Gone to seed

Time check:
Up to 28 days

- Pick several grass stems of the same grass species and place in a jar of ordinary tap water. Grass inflorescences will flower and produce pollen when grown as cut stems. They will even produce seed after a period of time.

Tip

To help the pollination process, cover the inflorescences with a cellophane bag, gently shaking the bag at regular intervals to ensure good pollen distribution.



- **After 7 days,** study your cut grass stems carefully. As the ovaries at the base of each floret develop into seeds, they change colour and enlarge. Look at the plant again after **14 days** and then after **21 days** and, if possible, at **28 days**. You might like to keep a diary of your observations.

- **After 21 to 23 days**, remove **some** (but not all) of the developing seeds and examine them more closely.

- Using a dissecting (low power) microscope, try splitting the seed coat with a pair of needles. Gently pull apart the seed coat to reveal the white **amorphous endosperm** and see if you can observe the developing embryo.

- **At 28 days** some seed will be quite mature. You will not be able to separate the leafy outer coverings of the floret from the seed coat. **Note:** although the inflorescences, at this stage probably look quite dead and brown, these inflorescences will have produced viable (healthy) seeds. Harvest the mature seeds and have a go at getting them to germinate.

If you completed the germination experiments described at the start of these worksheets you will now have investigated all stages of the life cycle of a grass plant. Well done!