EXTRACTION OF 'FIBRES' FROM PLANTS

Purpose

- To extract 'commercially useful fibres' from a plant stem and investigate their properties.
- To develop certain practical skills.

Using plant fibres

In this activity you extract the fibres from plants and then test their strength.

'Fibres' have been extracted from plant stems for centuries and used in the commercial manufacture of a wide range of textiles and paper. The term 'fibres' does not just refer to the sclerenchyma, but is used to describe a range of 'fibre-like' structures. These plant fibres have been used for different purposes, as indicated in Table 1. Their use is dependent on their properties.

Fibre	Useful part of the plant	Applications
Flax	Stem of flax plant	Linen for clothing
Cotton	Hairs on the seeds of plant belonging to the mallow family	Cotton for clothing
Hemp	Fibres from the stem/leaves of the hemp plant	Used for ropes, backing for carpets
Coir	Fibre from the husks of the fruit of the coconut	Floor coverings, ropes
Jute	Fibre from the stem of the jute plant	Hessian, sacking and carpets
Manila	Hard fibres from the leaves of a type of banana	Marine cables and other ropes, nets and matting
Pulp	Softwood trunks	Paper, cardboard

Table 1 Fibres and their uses.

Fibres can be removed from plant stems by simply scraping away the upper layers of tissue, or by retting. This can be field retting – plant stems are cut or pulled up and left in the field to rot; microbial action breaks down the stalks. Alternatively, water retting may be used – stems are immersed in water. The latter produces more uniform, higher quality fibres, but is more expensive and produces nitrogen-rich waste-water that must be treated before discharge. During soaking, bacteria and fungi break down the soft tissues of the stems leaving the cellulose intact. It is then relatively easy to remove the cellulose-rich fibres. The procedures on the next page use these techniques to extract the fibres from New Zealand flax leaves or nettle stems.

Extracting fibres from New Zealand flax

SAFETY

Take care when using a scalpel or razor blade.

Wash your hands thoroughly after handling plant material.

YOU NEED

- Leaf of New Zealand flax plant
- White tile
- Scalpel or razor blade
- Forceps

Procedure

Carefully scrape the surface layer of tissue from each side of the leaf.

1 Separate the fibres using forceps. These 'fibres' are made up of the vascular tissue; including the xylem vessels, the phloem and the sclerenchyma fibres.

Extracting fibres from mature nettle stems

SAFETY

Wear eye protection and gloves when handling the unretted nettles to avoid being stung.

Wash your hands after handling the soaked fibres.

Use a tray to catch any falling masses.

YOU NEED

- Stems of mature stinging nettles or other plant stems
- Bucket or bowl
- Rubber gloves
- Paper towels

Procedure

1 Remove the leaves and any flowers from the stems of mature stinging nettles. Place the stems in a bowl/bucket of water so that they are completely submerged. This may have already been done for you. The stems are soaked for at least a week; leave them outdoors because they are very smelly.

2 Remove the stems from the water. Wash the stems to remove the softened tissue and then dry the remaining fibres. The outside cuticle and epidermal layer will rub away and the central pith will be left when you peel away the fibres. These 'fibres' are made up of the vascular tissue; they contain the xylem vessels, the phloem and the sclerenchyma fibres.

Investigating fibre strength

Strength can be defined as the maximum stress a material can withstand without failing (breaking). Tensile strength is the maximum stress caused by a pulling force that a material can withstand without failing. Compression strength is the maximum stress caused by a pushing force that a material can withstand without crushing.

You could investigate the strength of the extracted fibres: whether they are as strong as the intact stem; whether the strength of the stem is entirely due to the fibres or whether the epidermis and packing tissue make a major contribution. You could extract and compare some different fibres. You could design an experiment to find out if the plant fibres under tension are stronger or weaker than synthetic fibres.

1 Scientific questions and information research

Research relevant information and state what you are going to investigate – the first thing you need to do is decide what you are going to investigate and write down your idea as a question or hypothesis that you can answer or test. You should support your idea with biological knowledge: to do this it will help to research the background science and methods people have used to investigate similar problems.

2 Planning and experimental design

Your plan should include:

- a description of the apparatus and method that will produce valid results allowing you to answer your question or test your hypothesis
- identification of the independent and dependent variables and, where possible, controls or allows for other variables
- the range of values you will use for the independent variable and the range you might expect to find for the dependent variable
- a fully explained control if appropriate
- replicates if appropriate and an explanation of why these are necessary
- a statement of exactly what observations and measurements you will make and how they will be made to ensure valid, accurate and precise results are obtained
- a risk assessment that identifies any safety issues and describes how any risks will be reduced
- information about any sources of error and how these can be minimised.

Have your plan and risk assessment checked by your teacher/lecturer before starting your practical work.

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Ensure eye protection and gloves are worn when handling the unretted nettles to avoid being stung.

Wash your hands after handling the soaked fibres.

Take care when using a scalpel or razor blade. Demonstrate a safe method for cutting materials.

Notes on the procedure and developing practical skills

The methods for extracting the fibres from mature New Zealand flax and nettle stems are given in the Student Sheet. Students could do this themselves or it could be done in advance and the fibres provided already extracted from the stem. New Zealand flax is a common ornamental garden plant (see Figure 1 on Technician Sheet). Note that retting is a very smelly process.

The aim of this Core Practical is for students to develop practical skills through designing and carrying out an experiment to investigate the strength of extracted fibres. The Student Sheet guides the student towards developing some ideas to investigate and points that they should bear in mind when planning. The notes on the sheet follow the Developing Practical Skills Framework, which can be found in the support section of SNAB Online.

This can be a very straightforward experiment and although some might think it is KS3 level, bear in mind that biomechanical experiments can be fairly simple at whatever level they are performed. The aim here is to get students to think carefully about planning an investigation.

In fact, producing good results from this activity is quite fiddly and requires a certain skill.

The fibres could be clamped at each end. A force is then applied in the centre either using suspended masses or a force meter. The mass or force required to break the fibres gives a measure of tensile strength, although strictly, tensile strength should be measured in unit force per unit area (cross-sectional).

The tensile strength of the midrib vascular bundle of the coconut palm has been measured at 0.17–0.36 G Nm^{-2}.

Detailed guidance on the analysis and interpretation of results, and conclusion and evaluation are provided within the Practical Skills Support section of the website.

The stiffness of the fibre can also be investigated. Investigating strength and stiffness would extend this investigation for the more able student. The SAPS newsletter *Osmosis* number 22, Autumn 2001, describes testing of stiffness and strength. This is downloadable from their website; for details see the weblinks for this activity. However, there is no requirement to go into this amount of detail.

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SAFETY
Wear eye protection and gauntlet gloves when 'harvesting' the nettles. *Wear rubber gloves when immersing the nettles in water to avoid stings.* *Wash hands thoroughly after handling plant material.*

General note

Experiments planned by the students will probably require clamp stands, clamps, suspended mass carriers, masses, rulers and force meters. Bulldog clips can also be useful.

Requirements per student or group of students	Notes
Leaves of New Zealand flax	New Zealand flax is a common ornamental garden plant, see Figure 1. Students can extract fibres from flax themselves, using a scalpel or razor blade.
Stems of mature stinging nettles or other plant stems	Consider ventilation when retting stems; retting plants are very smelly. When soaking the nettles, it is best to remove all the leaves and flowers – they form a slimy mass as they rot and make the smell of the rotting nettles even worse. Once the nettles have been soaked for about a week (this depends on temperature: in cooler weather it may take longer) all the soft tissue, both outside and inside the vascular bundles will wash away in water. The ring of vascular bundles may need to be opened to wash out the pith within. Other stems can be used for comparison. The easiest to extract and test are New Zealand flax or celery vascular bundles. These do not need retting.
Bucket or bowl	Deep enough to completely submerge the stems.
Rubber gloves	
Paper towels	
Eye protection	
Scalpel	
White tile	
Forceps	

Figure 1 New Zealand flax plant.