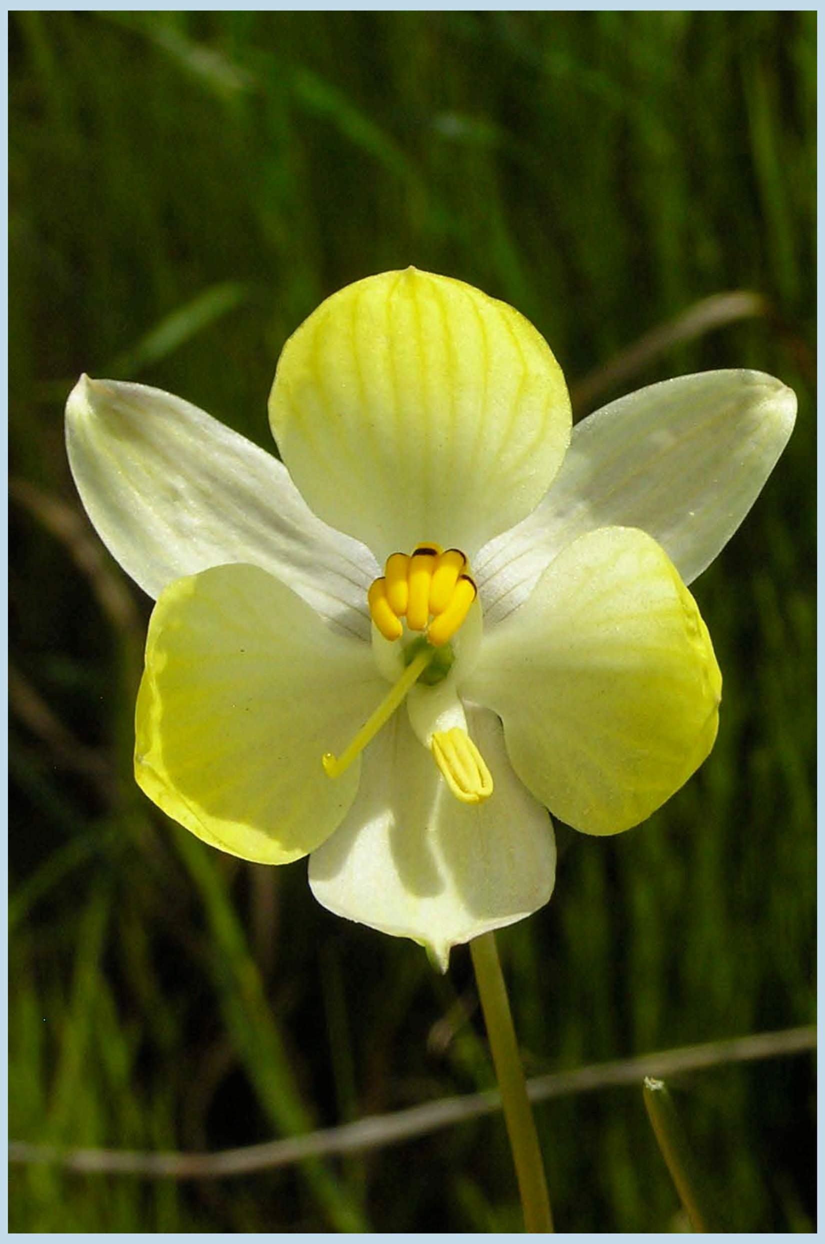
Welcome to

Flower Power for the 21st Century

Whatever your age, we hope you will enjoy exploring why flowers are the shapes they are, how they make seeds and how they are a vital part of our world.

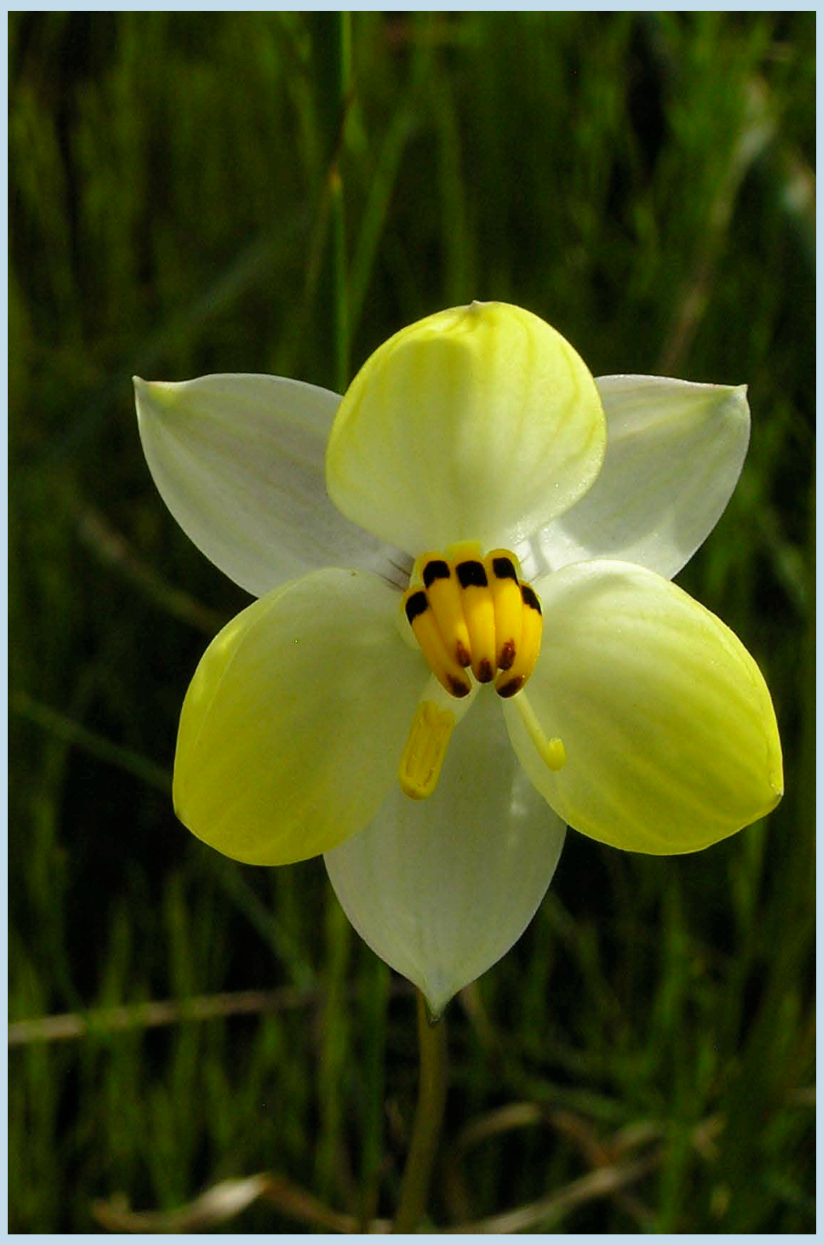


Credit: Spencer Barrett, University of Toronto

Examine flowers, pollen tubes growing, and chromosomes under the microscope

Have a go at some flower-based games, and talk to world leading researchers.

Free refreshments



Credit: Spencer Barrett, University of Toronto

The exhibition is hosted by the XXI International Congress on Sexual Plant Reproduction and is supported by the Biotechnology and Biological Sciences Research Council.

BBSRC
bioscience for the future

EPJ Photo / Flickr

Flower Power for the 21st Century

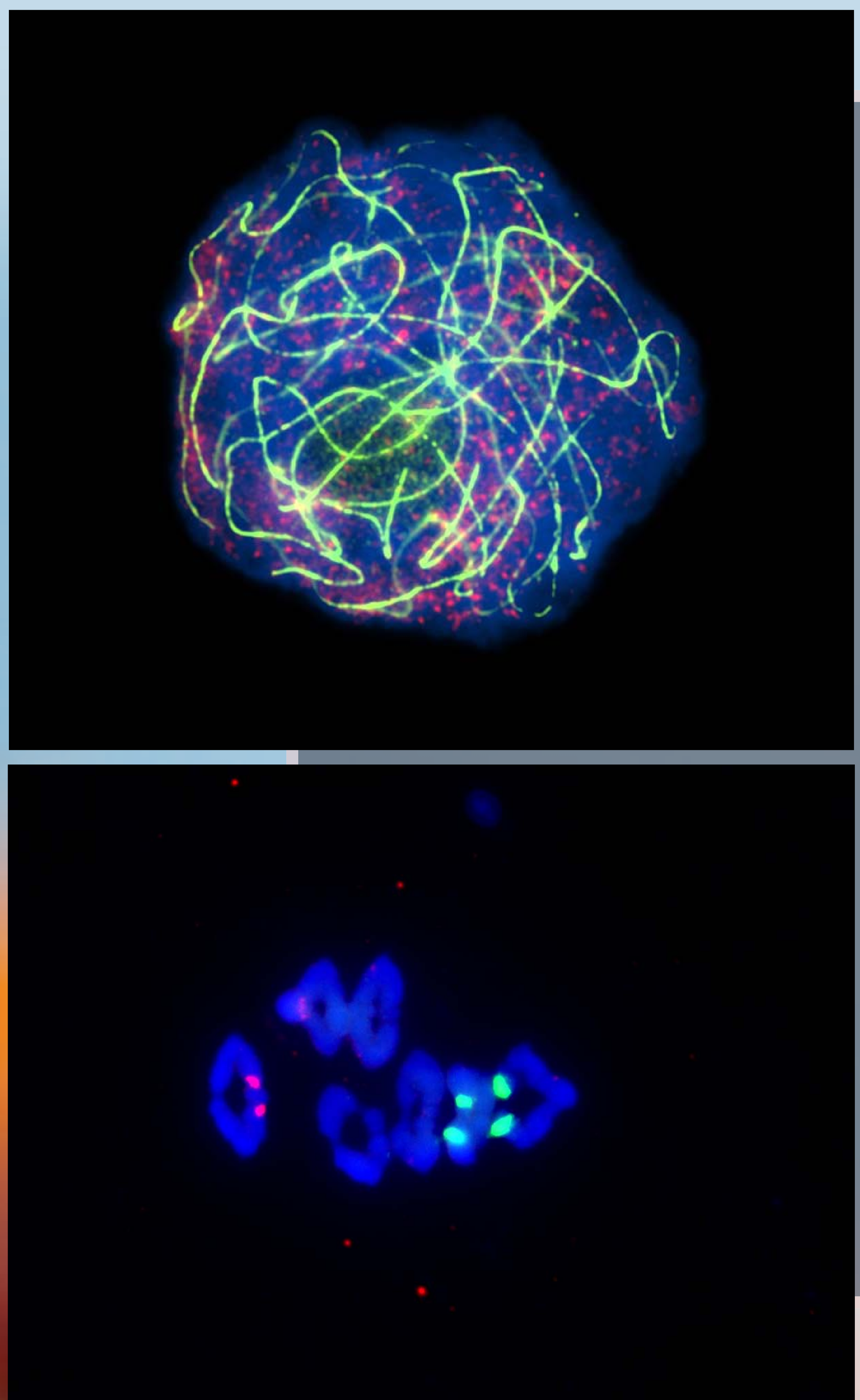
Improving plant breeding

Understanding evolutionary relationships allows scientists to transfer their knowledge from a well studied plant to others that may one day prove very important, perhaps as crops or sources of new raw materials.

To generate new varieties, plant breeders make use of the natural genetic variation that arises during the process of meiosis, when plants produce pollen and eggs. A better understanding of meiosis will allow us to develop more effective methods of breeding crops. To achieve, this scientists are using a combination of genetics and cell biology, together with newly emergent "systems biology" which makes use of computers to understand how numerous individual genes and proteins combine as a complex network to control biological processes.

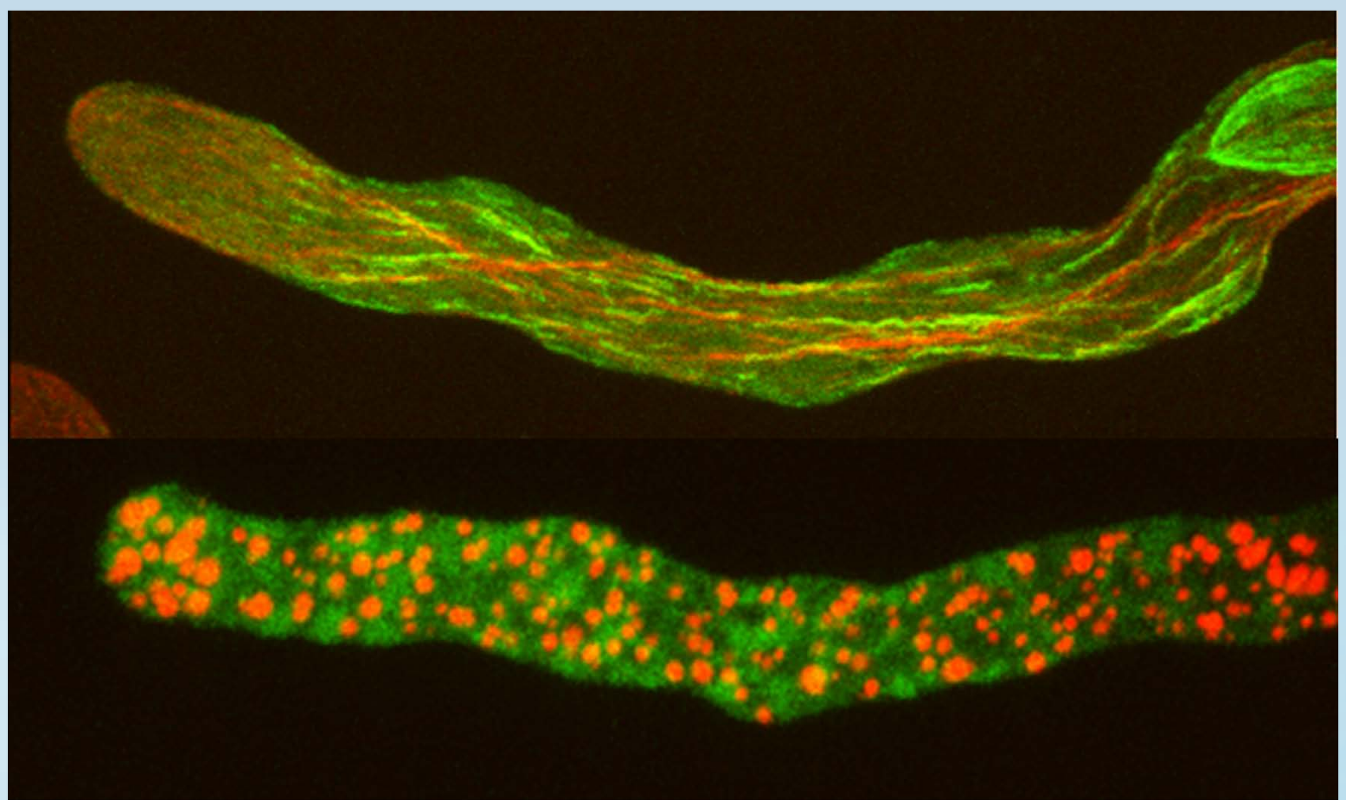
Some plants are able to recognise and reject or destroy pollen if it comes from a closely related plant (or itself) – this is called self-incompatibility. In the wild, this means that these plants avoid inbreeding. However, for many crop plants, breeders want to be able to cross closely related plants to produce the best crop varieties. Scientists are discovering the mechanisms behind this pollen recognition and hope to be able to help breeders develop strategies for breeding crops.

A small number of species are able to produce seeds without the egg being fertilised by the pollen, so the offspring are identical to their mothers. This unusual process is called apomixis. Understanding how it works will allow scientists to transfer this trait into crop plants. This will be important as many crop plants are F1 hybrids that don't breed true using traditional breeding and so this could dramatically reduce the cost of providing hybrid seed to farmers.



Credit: James Higgins and Chris Franklin - University of Birmingham

Meiosis recombines genetic information and accurately segregates chromosome to form male sperm and female eggs. The bottom image shows late meiosis when the chromosomes are condensed - it is possible to see the points where genetic information is being exchanged by using fluorescent antibodies that recognize proteins which "zipper" the chromosomes together.



Credit: Natalie Poulter & Noni Franklin-Tong. University of Birmingham

Self-incompatibility is a good example of a cell-cell signalling and recognition system. Self-recognition triggers major changes in the actin cytoskeleton organization. This triggers a process called "programmed cell death" which is a neat way to kill unwanted "self" pollen.

These images show two components of the cytoskeleton stained with fluorescent probes and visualized using fluorescence microscopy: actin in red and tubulin in green. The top image is a normally growing pollen tube; the bottom one shows a pollen tube after self-incompatibility.

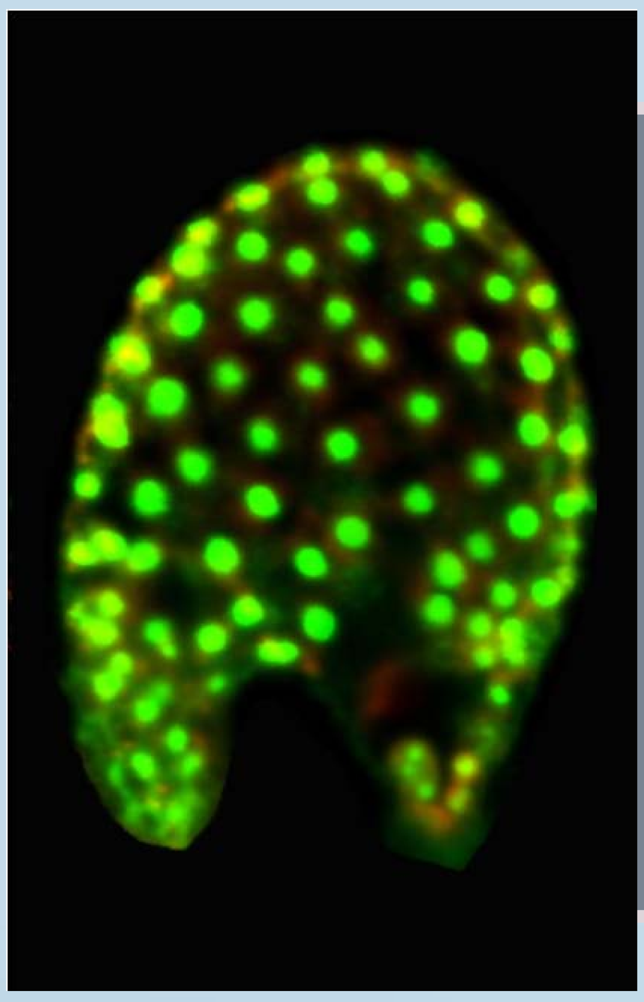
Flower Power for the 21st Century

Seeds

Seeds provide the majority of food for humans, either directly, for example as grains for bread making and breakfast cereals, or indirectly to feed animals for meat and milk production.

Understanding how seeds develop and grow is important both to help us develop strategies to improve our diet and to increase the yield of seeds, helping us meet the food needs of a growing world population.

djcodrin / FreeDigitalPhotos.net

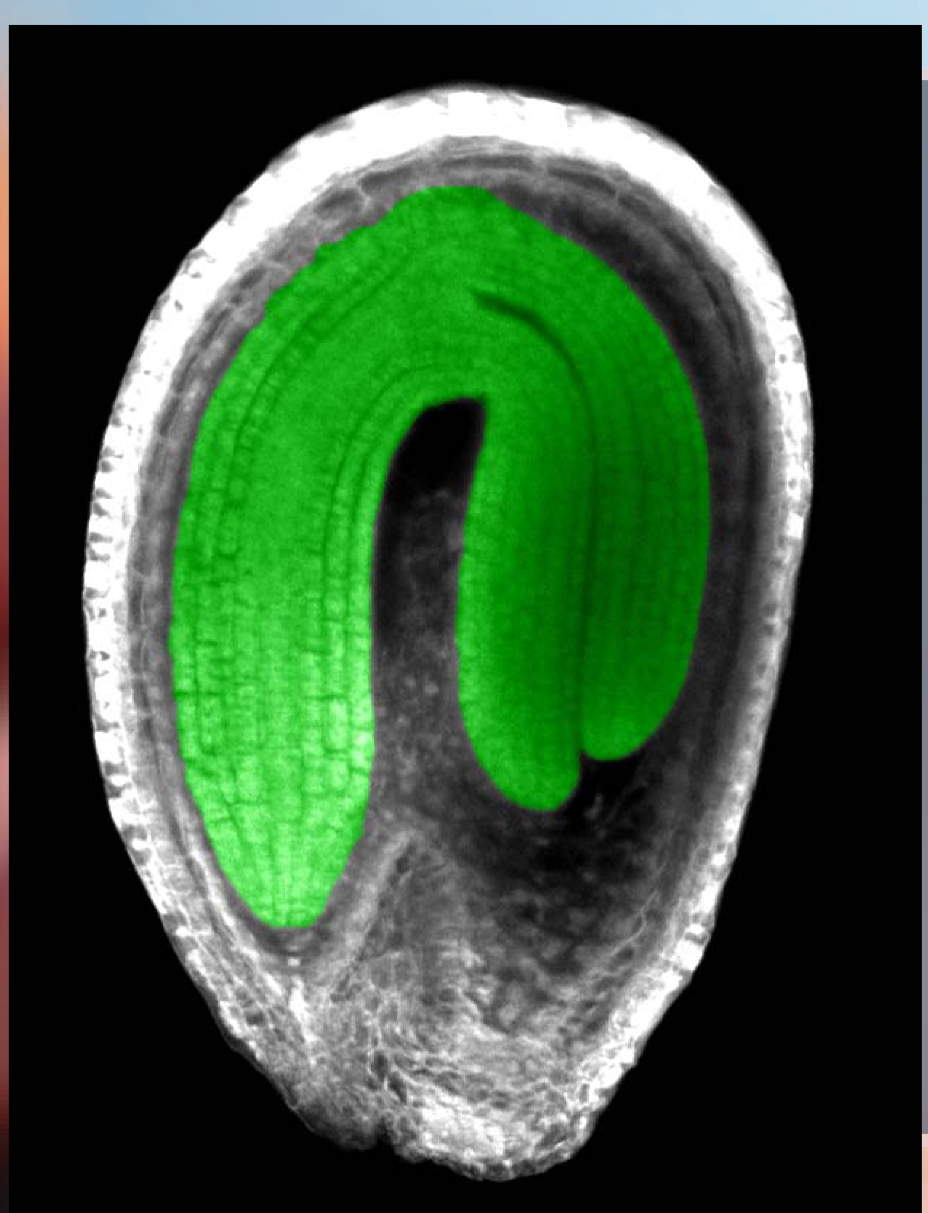


Credit: Sushma Tiwari, University of Bath

Here we see inside the embryo sac of an *Arabidopsis* seed. The bright green spots are the nuclei of young endosperm cells. The endosperm of cereal crops provides the bulk of our food. The green colour is produced by a protein called Green Fluorescent Protein (GFP) that originates from a jellyfish. Using GFP allows scientists to understand what genetic factors are important in endosperm growth. This information could help increase crop yields.

This image shows a fertilised embryo. The embryo is firmly attached to the base of the seed by a suspensor. The surrounding tissues will eventually give rise to the seed coat and fruit.

Credit: Susan D. Johnson & Anna Koltunow, Adelaide, Australia



Credit: Melissa Spielman, University of Bath

Here we see the nearly fully developed embryo (artificially coloured green) of the laboratory model plant *Arabidopsis* inside its embryo sac and surrounded by the maternal tissues (coloured grey) that protects it when the seed is dispersed from the mother plant. We study the genetic factors that regulate the size of the embryo and seed to learn how to increase crop yields. The image was taken using confocal microscopy, which makes virtual optical slices rather than physical slices; this saves a lot of time and expense.

EPJ Photo / Flickr

Flower Power for the 21st Century

Flower Structure

Ornamental flowering plants and cut flowers give us great pleasure. The interaction between plants and the animals that pollinate them determines the shape of many flowers.

Flowers pollinated by insects are shaped to attract the right insect and ensure that the visiting insect picks-up or deposits pollen.

Credit: Spencer Barrett, University of Toronto

Calceolaria uniflora

Credit: Spencer Barrett, University of Toronto

In some species of plant there are separate male and female individuals, but this is rare and in most species the male and female reproductive organs are present within the same flower. This can lead to self-fertilization and flowers have evolved many ingenious structural and physiological mechanisms to prevent it.

Cyanella alba has two forms of flower which are mirror images of each other; this subtle structural difference promotes cross pollination between the two flower forms.

Bee orchids, in the genus *Ophrys* trick their pollinators - male bees - into thinking they are female bees. Whilst attempting to mate with the flower the male bees pollinate the orchid.

Credit: Simon Hiscock, University of Bristol

Ophrys lusitanica:
Iberian 'bee orchid'

Credit: Tim Robbins, University of Nottingham

This is a special "laboratory strain" of the cultivated garden petunia developed by researchers in The Netherlands in 1986. The spots and stripes indicate that this strain carries an active "jumping gene" that has disrupted the synthesis of flower pigment. Researchers at the University of Nottingham are collaborating with colleagues at the University of Nijmegen to use these jumping genes to understand the genetic control of self-incombatibility in petunia.

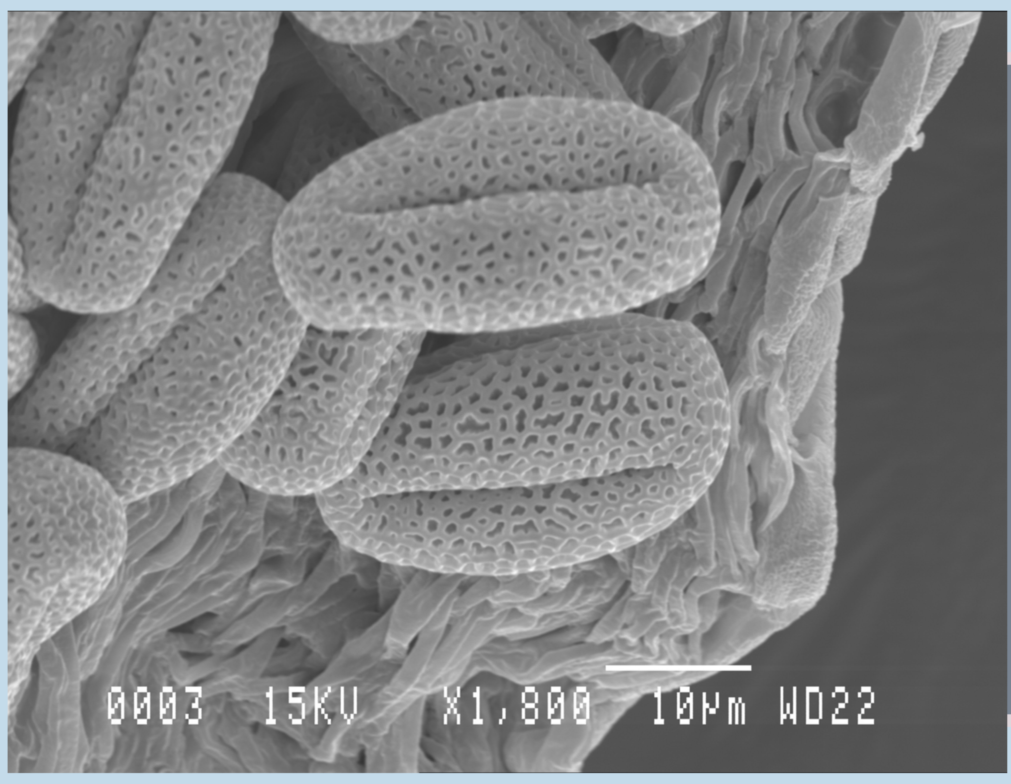
Flower Power for the 21st Century

Pollen and Egg

For plants to be able to make seeds, they need to have their eggs fertilised by pollen that is produced in the anthers. This requires the eggs and pollen to be ready at the same time; it would be no use having pollen made six months before an egg was ready. Scientists are delving into the cells and molecules of plants to understand how plants synchronise pollen and egg production.

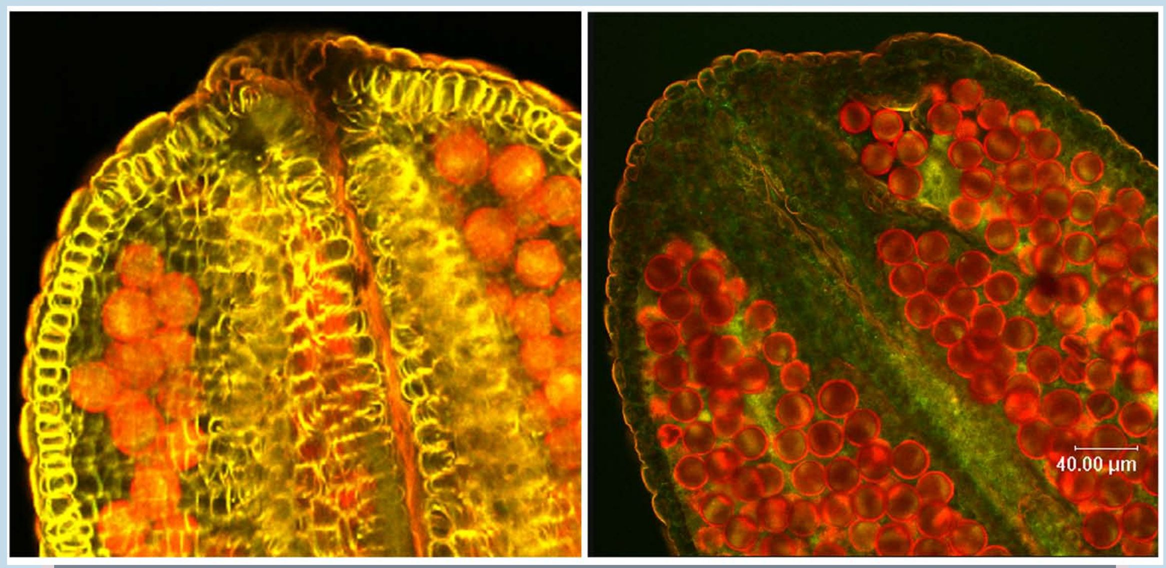
When a grain of pollen lands on a plant's stigma, it produces a tube that grows through the female tissue and fertilises the egg. What happens next is not yet very well understood – how do the pollen and egg recognise one another and then trigger the development of an embryo and seed?

The new knowledge scientists are gaining from studying pollen, eggs, fertilisation and seed development is important for understanding the fertility of our crops and will help develop better breeding technologies.



Credit: Caiyun Yang & Zoe Wilson, University of Nottingham

Scanning electron micrograph of *Arabidopsis* pollen that has been released from the anther, showing the ornate patterning of the pollen wall.

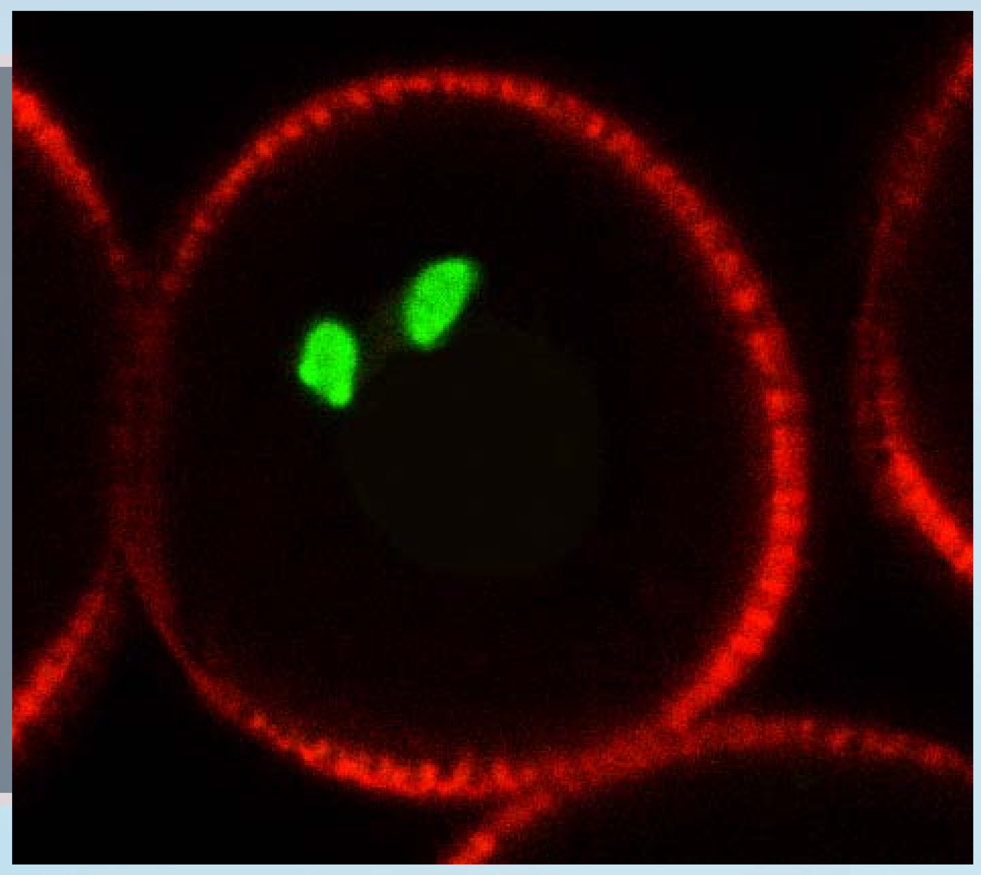


Credit: Caiyun Yang & Zoe Wilson, University of Nottingham

These images show the anthers, the male part of the flower containing the pollen, which have been stained to show the thickness of the cell walls.

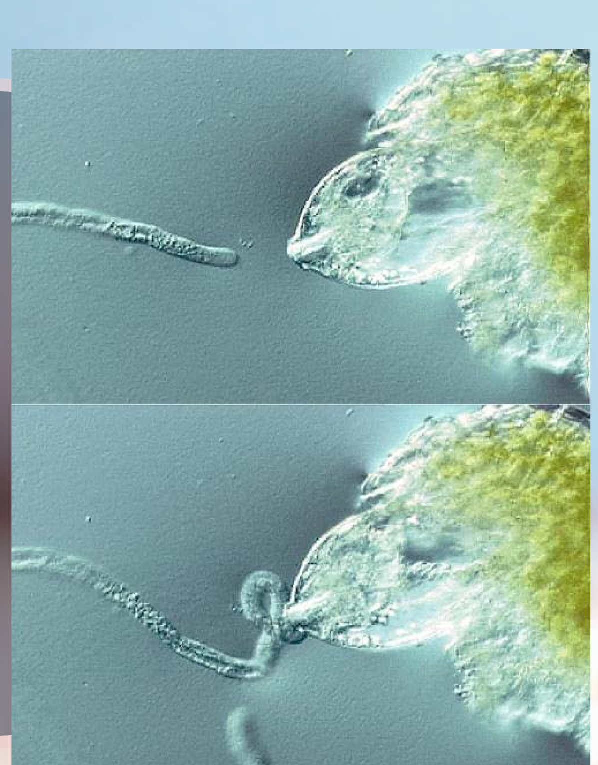
The left image shows a normal anther with thick walls that, as the anther dries out, provide the force that opens the anthers to release the pollen.

The right image is a plant that lacks these thick cell walls, so the anthers don't release pollen.



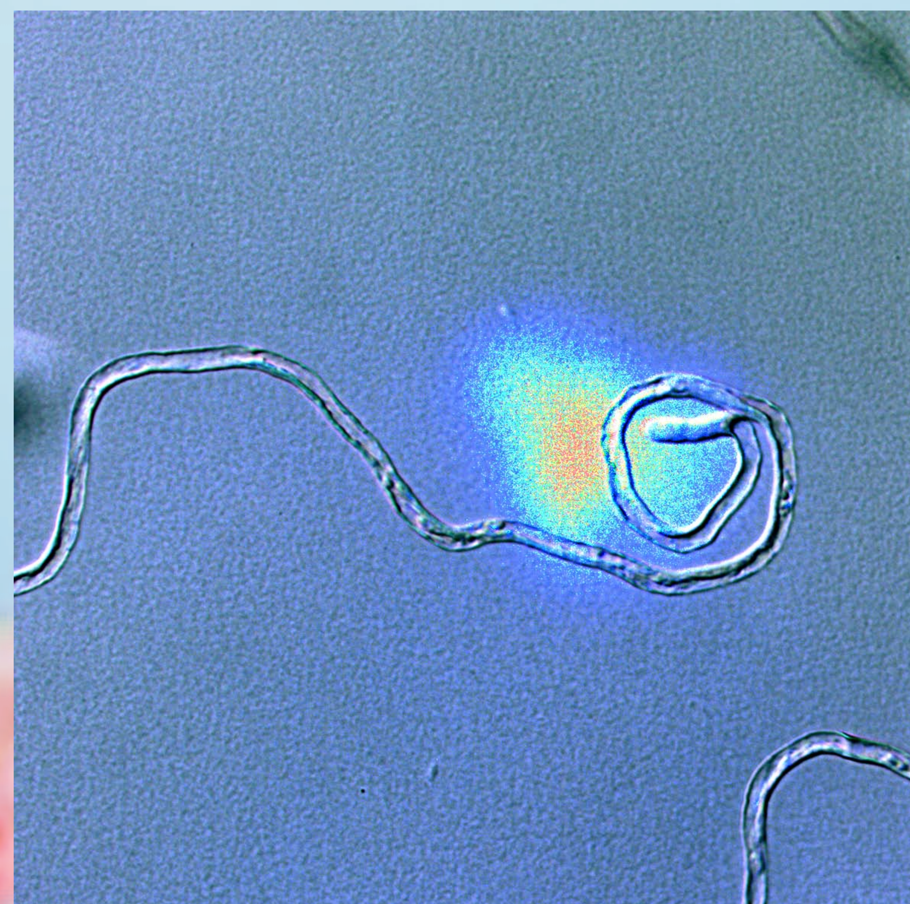
Credit: Lynette Brownfield & David Twell, University of Leicester

Here we can see the precious twin sperm cell cargo present within each pollen grain which are delivered to the egg cell by the pollen tube. The green fluorescent protein is very useful in tracking the activity and delivery of sperm cells.



Credit: Tetsuya Higashiyama, Nagoya University, Japan

The pollen tube grows towards the egg as it detects chemical signals from two neighbouring "synergid cells"



Credit: Tetsuya Higashiyama, Nagoya University, Japan

Scientists have found a peptide produced by the plant *Torenia* (wishbone flower) that attacts growing pollen tubes.

The diameter of a pollen tube is 1/100 mm.

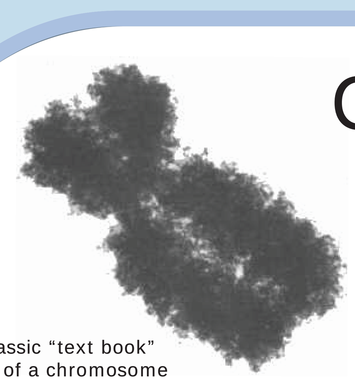
Flower Power for the 21st Century

Looking at plants

Scientists use a wide variety of methods to study plants such as genetics, cell biology and biochemistry. Microscopy is used in all these approaches to study cells, their components and how they work.

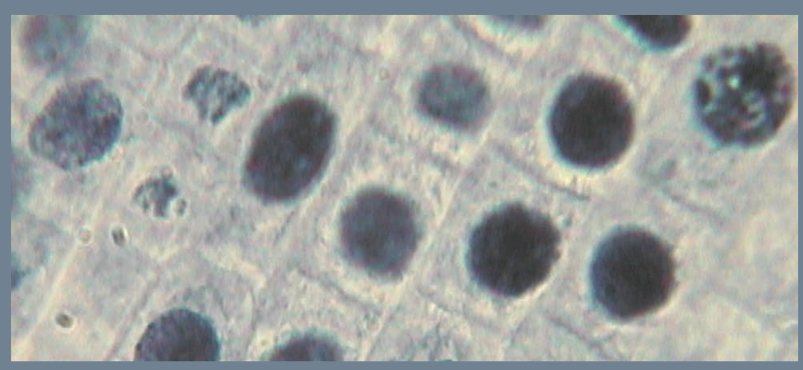
Flower Power for the 21st Century

Plant reproduction: chromosomes to pollination



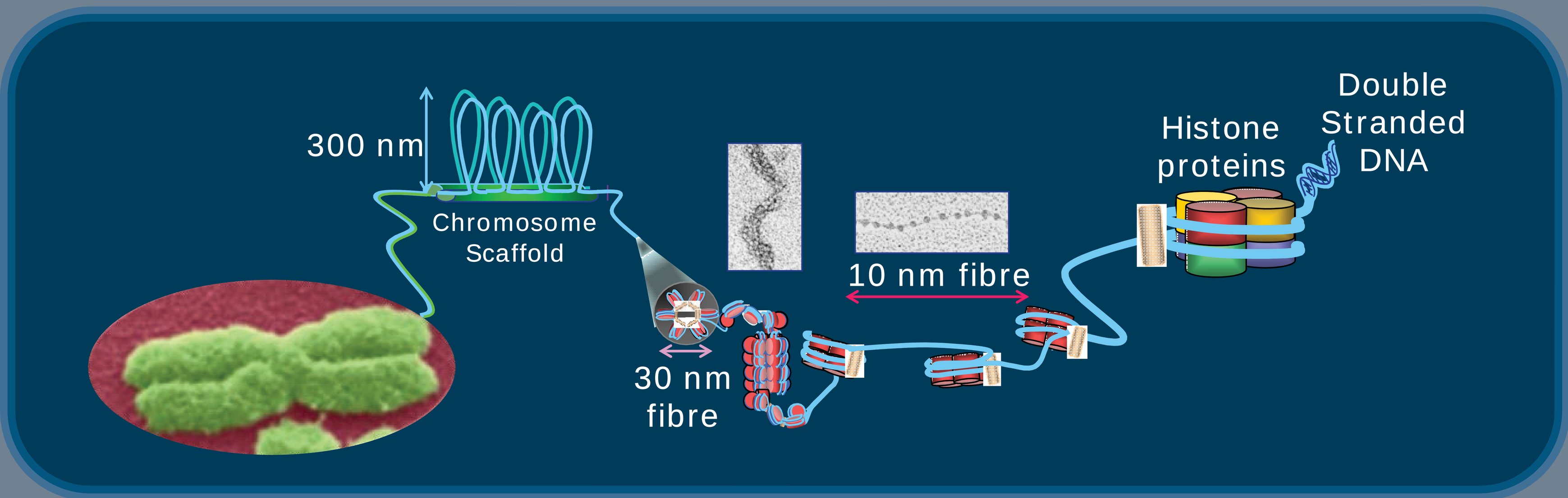
The classic "text book" image of a chromosome

Chromosomes contain the DNA that encodes the genes that are the blueprint for life.

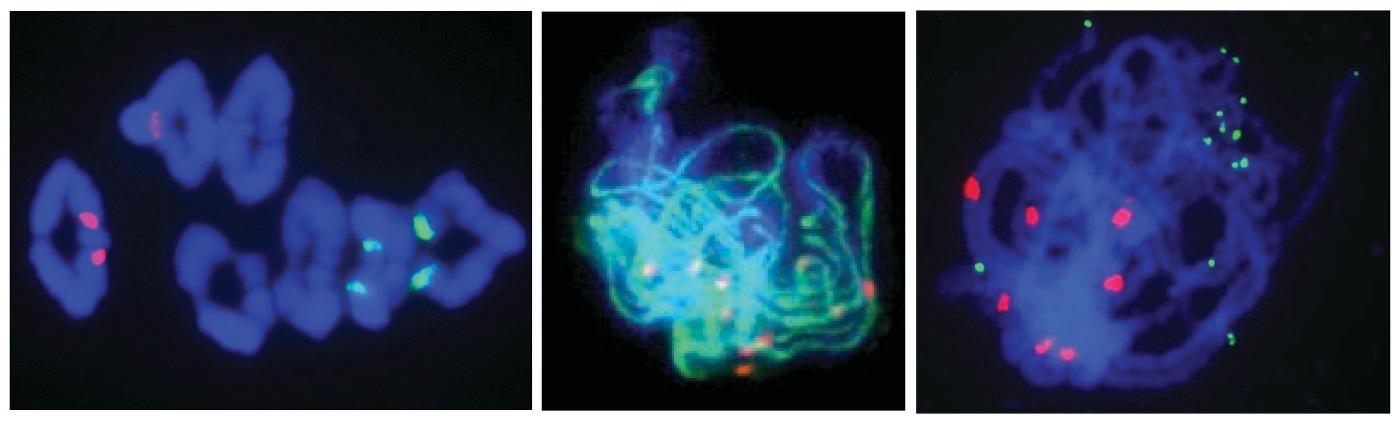


Plants and humans have similar numbers of genes ~25,000. However the number of chromosomes and amount of DNA varies dramatically between species. For example humans have ~2 metres of DNA in the nucleus of each cell. Onions (shown here) have ~10 metres and lilies have ~54 metres!

But the nucleus is small, about 5-10 µm in diameter (1 metre = 1,000,000 µm) so each chromosome's DNA is wound around proteins called histones and tightly folded to make it fit into the nucleus.



Chromosomes undergo "programmed" changes in their organisation that enable them to be duplicated and passed on when cells grow and divide.



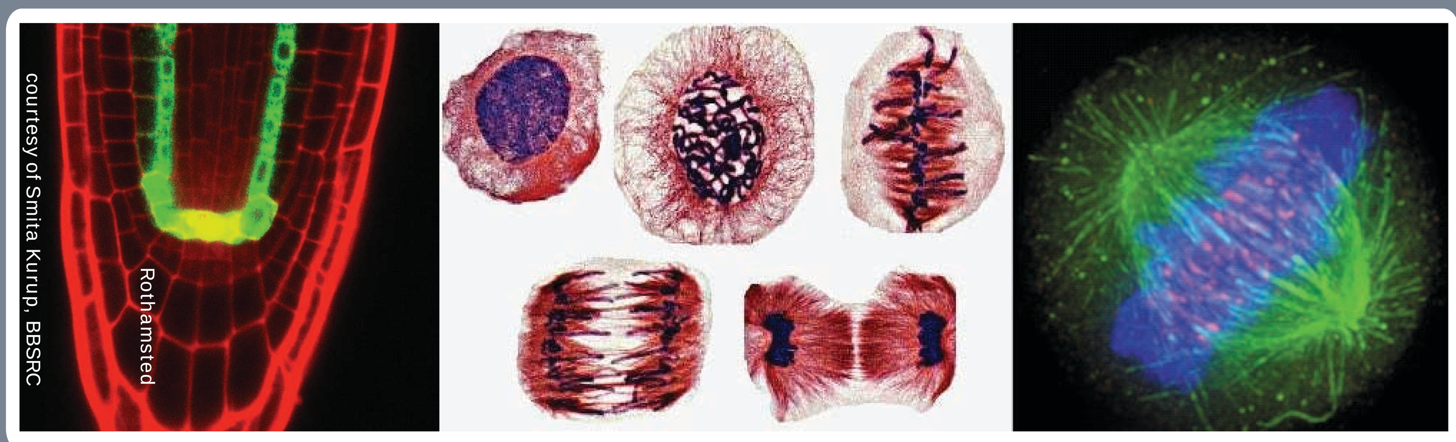
During meiosis the pairs of parental chromosomes become physically linked and genetic information is exchanged.

Sites of genetic exchange can be detected with a fluorescent antibody (coloured red).

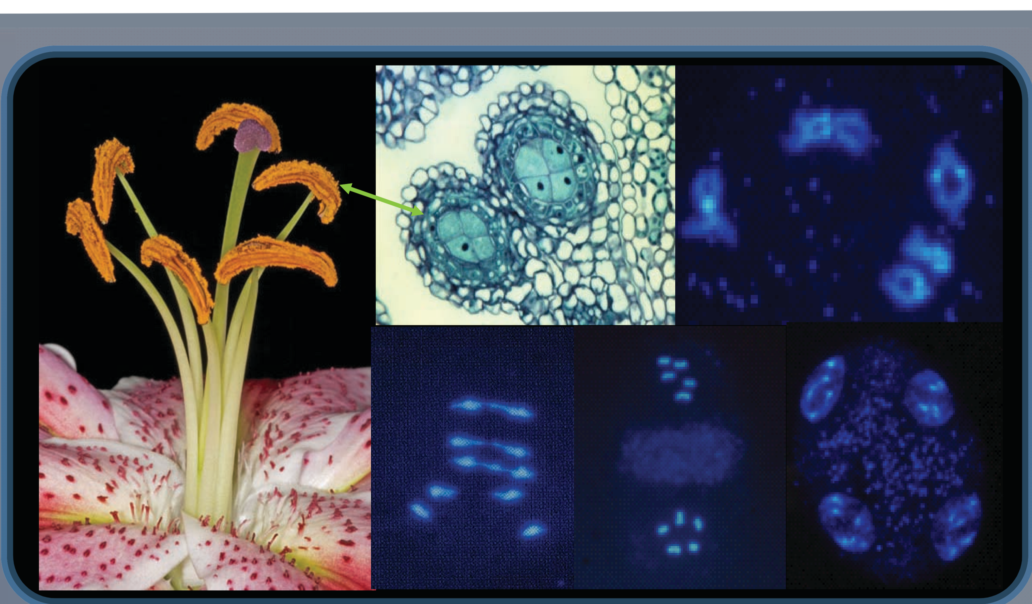
Telomeres (coloured green) protect the ends of the chromosomes.

Centromeres (coloured red) are important for chromosome division.

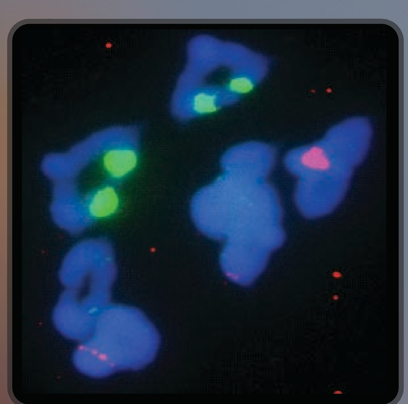
During cell growth chromosomes divide by a process called mitosis. During mitosis each chromosome is duplicated so that each new daughter cell gets a full set of chromosomes.



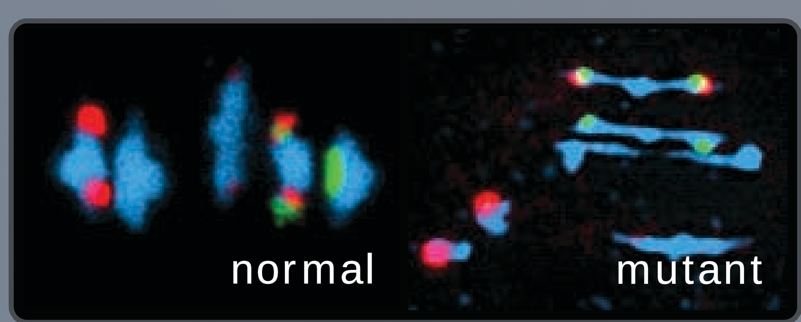
Meiosis is a special form of cell division that occurs in reproductive tissues.



It halves the chromosome number so when fertilization takes place the normal chromosome number is restored. During meiosis genetic information inherited from the parents is "shuffled" this introduces the genetic variation that is important to plant breeders.

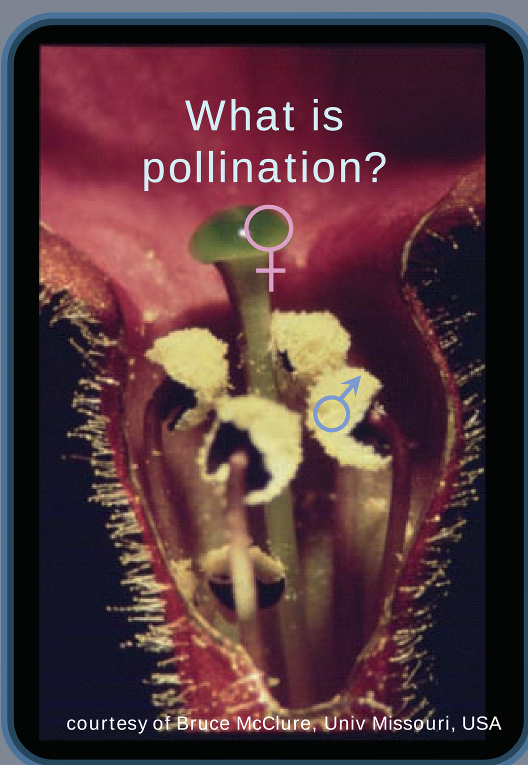


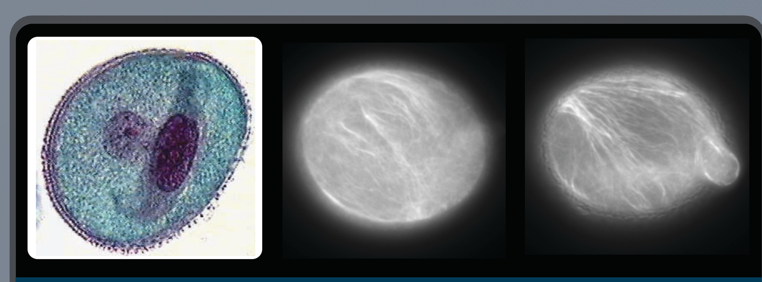
In cereals such as barley, "shuffling" of genetic information in meiosis tends to be restricted to near the chromosome ends (hence the doughnut shapes). As a result genes in the middle of the chromosomes are rarely "shuffled". This reduces the amount of variation for breeders to use. We are currently trying to overcome this problem.



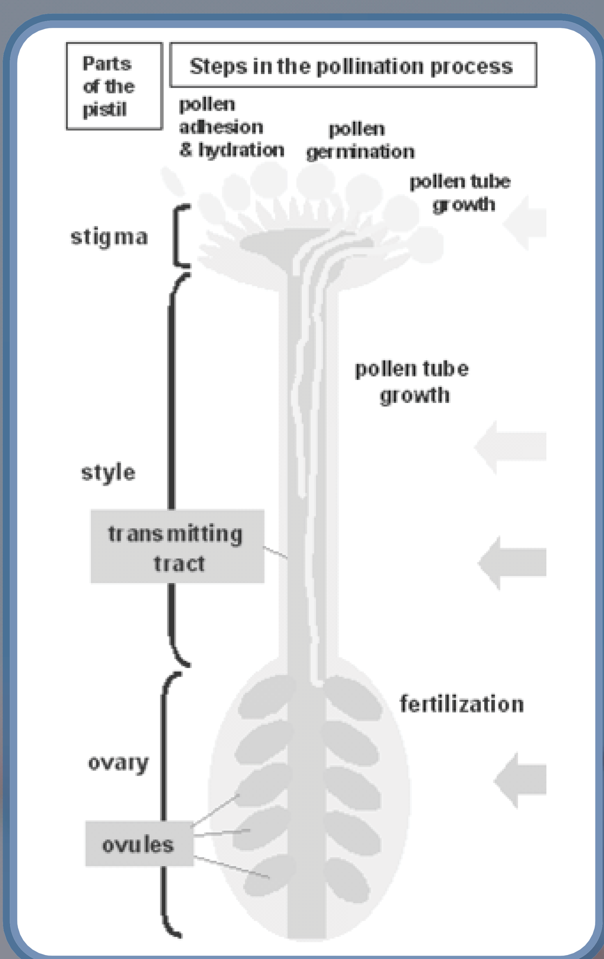
Meiosis is a complex process controlled by many genes. We can study it using mutants. This mutant is unable to make an important protein so not all the chromosomes pair as normal – as a consequence some pollen is produced with the wrong number of chromosomes.

The goal: SEX (delivery of sperm cells) by the growing pollen tube.



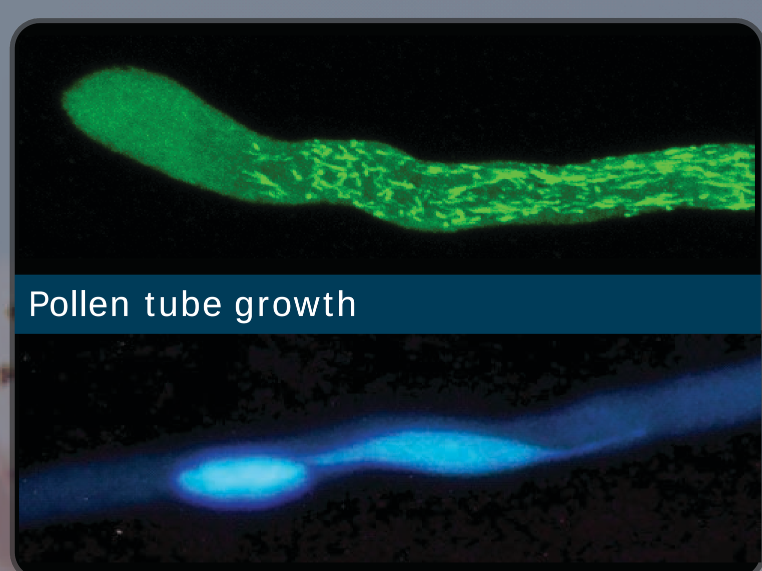


Pollen hydration and emergence of the pollen tube



Researchers have identified a protein that helps guide sperm to the egg in flowering lily plants.

A protein called Chemocyanin guides pollen tube growth on the lily stigma.



Pollen tube growth

SEVENTH FRAMEWORK PROGRAMME
BBSRC bioscience for the future
MeioSys
UNIVERSITY OF BIRMINGHAM

Images - Univ of Birmingham, UK
Noni Franklin-Tong, Chris Franklin'
Sue Armstrong, James Higgins,
Kim Osman, Natalie Poulter,
Eugenio Sanchez-Moran

Flower Power for the 21st Century

Plants and us

Plants are incredibly useful to us, for instance they...

...release oxygen into our atmosphere and take carbon dioxide out of the air.

...feed us and our animals: 80% of the plants we eat are in the form of seeds.

...clothe us: cotton and linen are made from plants.

...shelter us: timber is used to construct our buildings.

...give us renewable energy: from log fires to 2nd generation biofuels.

...are important habitats worldwide: rainforests, tundra and hedgerows.

Help yourself to a discovery sheet and see if you can uncover
7 things you never knew about plants

The answers to the questions on the discovery sheet are on the posters – can you find them all for a prize?

EPJ Photo / Flickr

Flower Power for the 21st Century

Discovery sheet

1. Name one way plants can avoid inbreeding

2. Which part of plants provides us with most of our food?

   ◯ Seeds ◯ Roots ◯ Leaves ◯ Stalks

3. Name a laboratory model plant

4. Do plants always have both male and female parts?

   ◯ Yes ◯ No

5. Why have flowering plants evolved to attract insects?

   ◯ Pollination ◯ To drink their nectar ◯ Defence

6. How wide is a pollen tube?

   ◯ 1mm ◯ 1/10mm ◯ 1/100mm ◯ 1/1000mm

7. Circle the bee that finds its way to pollinate the flower