Teacher's Guide

Achoo! Pollen does more than make us sneeze.

Grade Level: Middle school

Subject area(s): Physical science; general science; biology

Time required: 2 hours class time; 1.5-2 hours remote access

Learning Objectives:
Students will: 1. know how to measure size of objects in images with different scales; 2. understand importance of pollen and what forces drive the diversity of pollen size and shape.

Summary: Harness the power of a scanning electron microscope to let students see that pollen is more than just the yellow dust that makes us sneeze sometimes! Students will watch an introductory video to learn basics of pollen biology. They will then learn to use scale bars to interpret size on microscope images, thus meeting math as well as science standards. Using that knowledge, students will extract the sizes of pollen grains from scanning electron microscope images, and see the wide range of pollen shapes and sizes. They will also learn to make inferences about allergic potential and modes of dispersal of different kinds of pollen. After these class activities, student really engage by collecting their own pollen samples and sending them to either the Research Triangle Nanotechnology Network (RTNN) lab or the Remote Access Instrumentation for Nanotechnology (RAIN) network where images will be taken of the samples with a scanning electron microscope. For this part of the activity, RTNN will send you the images and interact with the students (video/skype/in-person) to answer questions and analyze their own pollen images or RAIN can do a remote SEM session.

Lesson Background Information:
Size and Scale:
It is recommended that you do an optional background activity on size and scale to get students thinking about small size scales and small units (micrometers and nanometers).Two recommended activities are: Size and Scale: https://www.nnci.net/node/5305 and Number Line Activity: https://nanosense.sri.com/activities/sizematters/sizeandscale/SM_Lesson2Student.pdf
Listed below are some online interactive links on size and scale to further their understanding of the nanoscale:
http://www2.mcrel.org/NanoLeap/multimedia/
http://www2.mcrel.org/NanoLeap/multimedia/Nanosize_me.swf
http://scaleofuniverse.com/
http://www.eamesoffice.com/the-work/powers-of-ten/
http://www.cneu.psu.edu/edToolsActivities.html
http://www.cellsalive.com/howbig.htm
http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/
Pollen: To have students learn about pollen watch 4 min video to become acquainted with basic parts of a flower and pollen biology:

https://www.youtube.com/watch?v=djPVgip_bdU. A good overview about pollen can be found at Encyclopedia Britannica online: https://www.britannica.com/science/pollen

Understanding scale bars:
https://www.bbc.com/bitesize/guides/z3vypbk/revision/3
http://www.fmfranco.com/Text/ib_biology/mag_size_scale_bars.pdf
https://www.youtube.com/watch?v=zINFE1TcJ3k
https://www.youtube.com/watch?v=YqOk0grW9v4

Pre-requisite Knowledge: Basic knowledge of magnification; metric system; where pollen comes from

Materials: (groups or 3-4)

- Print out of SEM images available here: https://multires.eos.ncsu.edu/www-rtnn-ncsu-edu/wp-content/uploads/sites/12/2017/01/SEM-images-of-pollen.pptx
- Rulers
- Paper/writing utensils

Safety Information: There are no safety issues with this activity

Directions for the activity are in the student worksheet below.

Vocabulary and Definitions:
Scanning electron microscope: a microscope that uses electrons that are in a focused beam that scans the surface of a sample. Because it uses electrons and not light to image an object, the resulting image is in black and white.
Pollen: the male fertilizing agent of flowering plants, trees, grasses and weeds. It often appears as a powdery substance that consists of thousands of pollen grains.
Stamen: the pollen producing part of a flower. It typically consists of the pollen containing anther and filament.
Scale bar: a line or bar divided into parts of a defined length such as microns, kilometers etc.
Nanoscale: objects measured in nanometers, with one nanometer equal to $1x10^{-9}$ meters.

Advance Preparation:
Contact RTNN (rtnanonetwork@ncsu.edu) or RAIN (http://nano4me.org/remoteaccess) to schedule your SEM session and learn requirements for the collecting and imaging of pollen samples.

Print out all images that students will use for measuring in Part 2. It is suggested to laminate images so they can be re-used with other classes and stand up to student "abuse".

Assessment:
Students correctly use scale bar to determine pollen size. Students use images and research to tell the story of the pollen that they collected.

Next Generation Science Standards

MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

Optional activity associated activities. You may want to have the students experience a virtual SEM at the My Scope website or learn about SEMs at the Hitachi website.

- Try virtual SEM http://myscopeoutreach.org/virtualSEM_explore.html
- See how the same samples look as you zoom in with a light and then scanning electron microscope. http://myscopeoutreach.org/letsZoomIn.html
- Hitachi learning labs about SEMs: https://www.inspirestemeducation.us/teaching-tools/k-8/

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Student Worksheet (answers in red)

Achoo! Pollen does more than make us sneeze.

Introduction: Do you know what pollen is? We all think of it as the stuff that makes us sneeze in the fall and spring. Pollen is the male fertilizing agent of flowering plants, trees, grasses and weeds. It is very important in plant reproduction and, in turn, our agriculture. Pollen grains are very small from 5 to about 200 micrometers or microns ($1x10^{-6}$ m). Do you know how small that is? If you look at a meter stick there will be 100 millimeters ($1x10^{-3}$ m) in one meter or the smallest divisions on the meter stick. 100 mm make up one centimeter (1 inch = 2.54 cm). If we put the pollen size in inches it would range from .000197 inches to .00787 inches. Pretty small, right? The other word you will hear in the activity is nanometer or $1x10^{-9}$ m. If you put the pollen size into nanometers, it will be 5000 nm to 200,000 nm. A nanometer is really small.

You will learn about a high technology microscope called a scanning electron microscope (SEM) which allows us to see very small things like pollen as well as the details of the pollen surface. The surface of pollen plays an important role in fertilization and allergies. Scientist need to know what the size of the pollen is and you will learn how to do this from images of pollen.

Have requested permission to use image from Purdue author.

Directions for the Activity:
Part 1.A. Scale in microscope images.

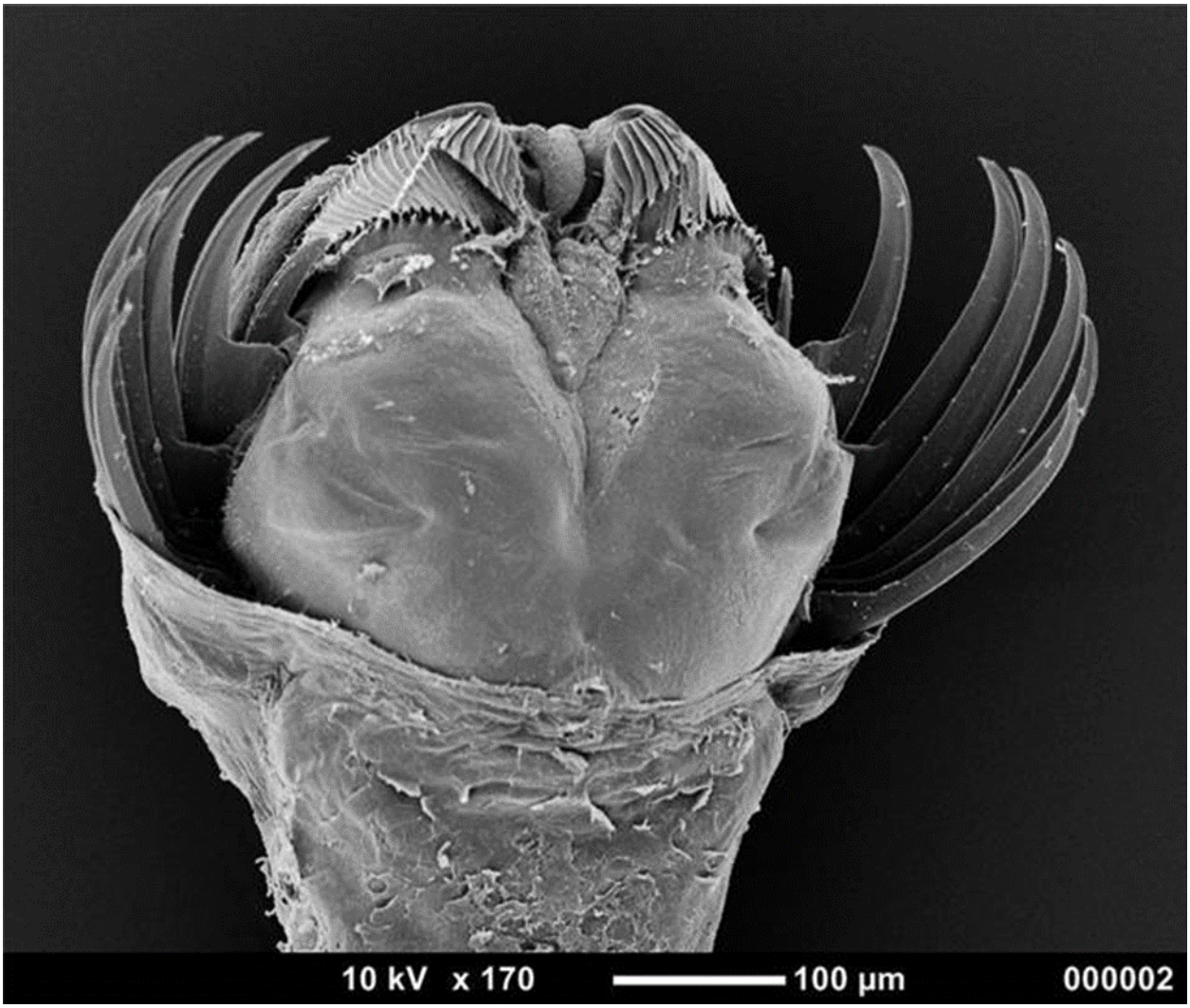
When looking at images from a microscope, how do you tell how big something is?

When scientists take pictures with a microscope, they put something called a scale bar on the picture. This is a line showing the scale of the picture. The length of the line is shown in the picture.
For example, the head of the worm looks like something out of Star Wars, like it could eat you whole.

Can you use the scale bar to figure out how big across the head of the worm pictured below is?
Measure how big across the worm head is with a ruler in inches.
Measure how big the scale bar is in inches.

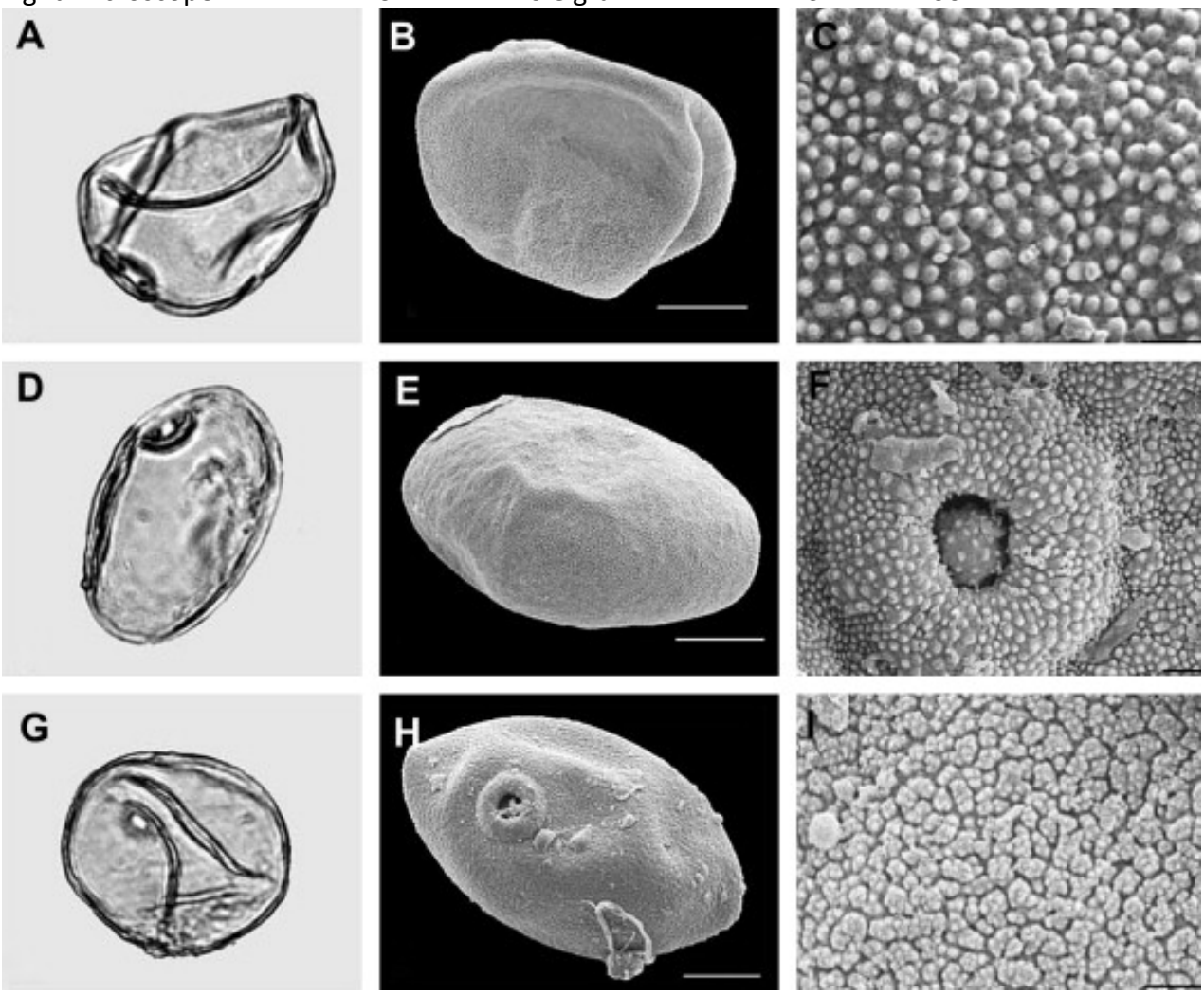
Use the following formula to calculate how big the worm head is:

Size of scale bar (in microns, µm) * size of worm head (in inches)/size of scale bar (in inches) = size of worm head (in µm)
Bonus info: These worms are chaetognaths. They are tiny worms that live in the ocean.
https://en.wikipedia.org/wiki/Chaetognatha



Part 1.B What kind of microscope is good for looking at pollen?
Here are some images of pollen grains taken with a light microscope and with a scanning electron microscope (SEM).

Light Microscope SEM -whole grain SEM -zoom in

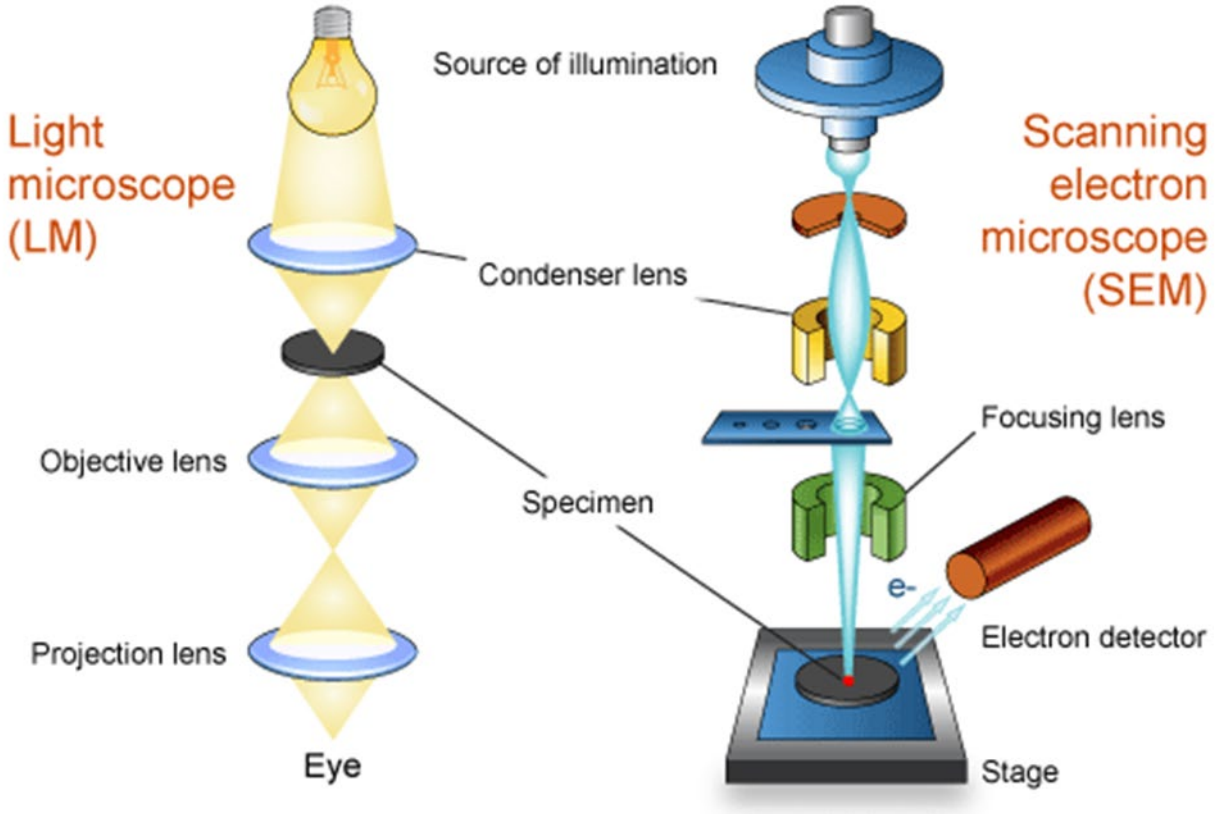


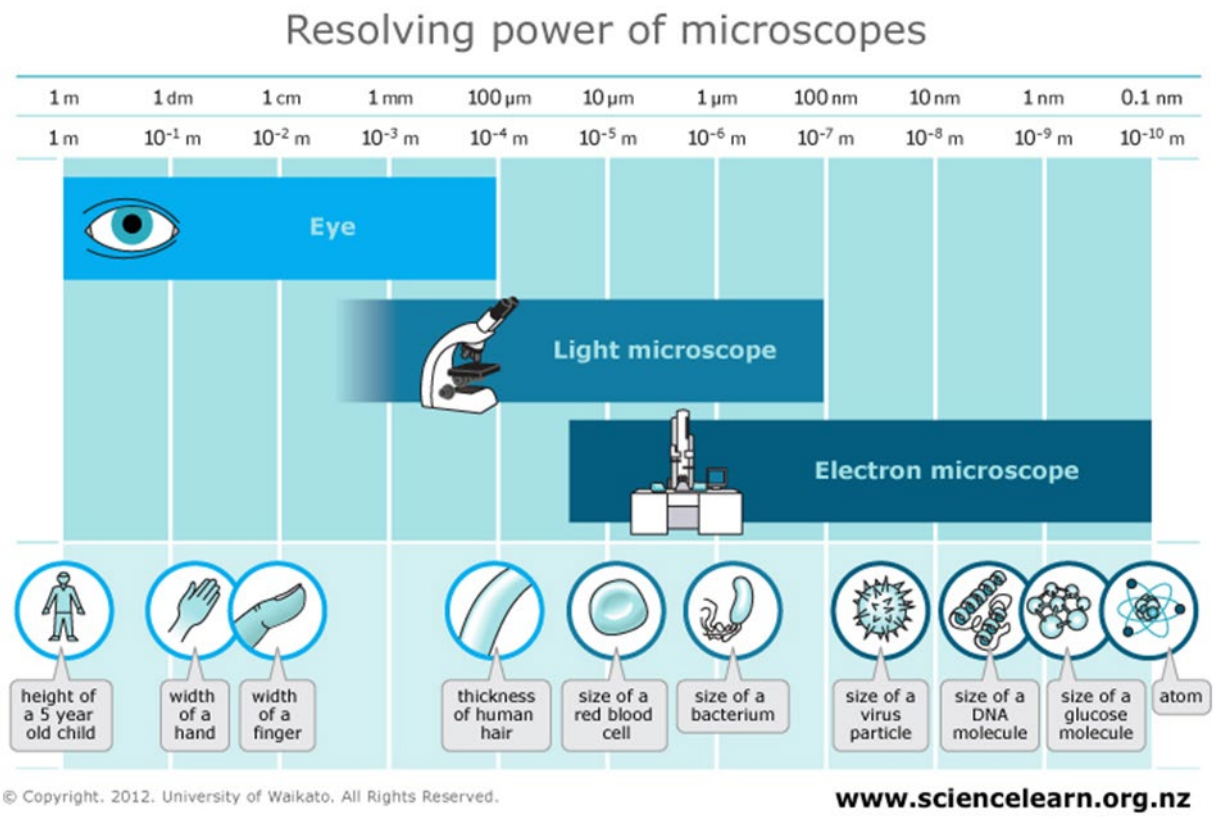
http://dx.doi.org/10.1016/j.quascirev.2008.12.025

Which microscope would you choose? Why? Why do you think they are different?

The SEM works like a light microscope, but uses electrons instead of light to form an image. Electrons are smaller, so you can zoom in further than the light microscope. The SEM also shows the surface of the pollen grains better because it uses electrons that bounce off the surface to create the image, while the light microscope uses light that passes through the grain to create the image.

Below you can see the part of the SEM and what the resolving power of microscopes. This information should help you decide on what microscope you would choose.





Part 2. Pollen Diversity

Pollen diversity:

Pollen comes in many shapes and sizes.

Largest pollen is from squash: 200um

-twice the thickness of a human hair (100um)

Smallest pollen is from forget-me-not flowers: 5um

-about the size of a bacteria (1-10um)

See an image of this diversity here: http://www.micronaut.ch/wp-content/uploads/2012/12/%C2%A9-Micronaut-Pollen-Morphology-white.jpg

Why do you think pollen might come in so many different shapes and sizes?

Have students speculate and write down some ideas
-mode of transport-wind vs insects, birds, bats
wind dispersed pollens tend to be smaller and smoother
creature dispersed pollens tends to be larger and bumpier

For many people pollen causes allergies. *"The average grain of pine pollen is about 60-90 micrometers in diameter. This is too big to get very far up your nose. Oak pollen is much less visible. Even though there is about as much oak pollen in the air in my neighborhood as pine pollen, you don't see the oak pollen unless you shake it on to a dark surface. Oak pollen is tiny, 24-38 micromters, or less than half the size of pine pollen. You may not notice oak pollen, but your nose does."*

http://www.planetexperts.com/allergic-to-pollen-its-getting-worse/

What are some symptoms of a pollen allergy?

Pollen allergy symptoms most often include:

- *nasal congestion*
- *sinus pressure, which may cause facial pain*
- *runny nose*
- *itchy, watery eyes*
- *scratchy throat*
- *cough*
- *swollen, bluish-colored skin beneath the eyes*
- *decreased sense of taste or smell*
- *increased asthmatic reactions*

What factors influence how likely a particular pollen is to cause an allergy?

-wind pollenated plants-increase exposure, plus need to be smaller for greater dispersal

-size of pollen grains –some are too big to cause allergic reaction

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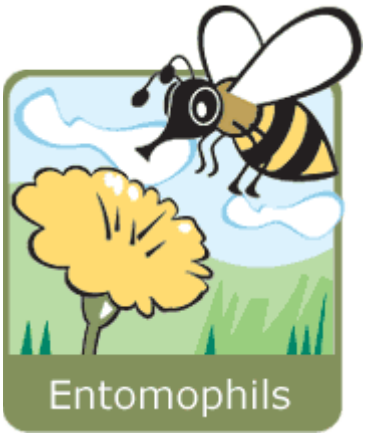

- **Entomophils** (from the Greek Entomos= insect) ➔ these plants reproduce themselves by means of insects. These usually have very eye-catching and beautiful flowers in order to attract insects, and so their pollen is normally quite sticky. When an insect alights on a flower to suck the nectar, pollen sticks to the hair on its legs. Then, when the insect goes to another flower, some of this pollen sticks and thus fertilizes the plant.

- **Anemophils** (from the Greek Anemos = wind) ➔ these plants reproduce themselves by means of the wind. They do not have beautiful flowers, because they do not need to attract insects. So, they usually have small pollen, that comes off very easily and in great quantities when the wind blows, and is carried by the wind great distances ("aero-roaming"), thus permitting the fertilization of other plants of the same species.

For each of the pollen grain images, fill out the table:

Plant	Scale bar size (uM)	Pollen Size (cm)	Pollen Size (uM)	Shape	Method of dispersal	Sneeze?

Part 3. Outdoor activity

Collect your own pollen samples. Look for blooming flowers and try to scrape some pollen off of the stamen. Look for the less obvious flowers of the wind pollenated plants (like grasses and trees). Take notes about where your pollen came from and label your sample holder.

If you have light microscopes in your class room, take a look at your pollen with the light microscope. Draw what you can see.

Your teacher will send the pollen you have collected to a university laboratory which will image your samples with a scanning electron microscope. You will get SEM images of the pollen showing the size and shape. Look up information about your pollen, the plant it came from, and write the story of your pollen.