ASSIST INFORMATION SHEET:

Microscope choices for schools

Microscopes used in school science laboratories have traditionally been of two basic types, compound or bright field (high power) and stereo or dissecting (low power). Technology has advanced over the last few decades to produce digital microscopes and affordable options for capturing images and videos.

When choosing a microscope consideration needs to be given to the application, skill level of staff and students and budget. Microscopes range in quality and price and are used for different purposes.

Compound microscopes

Compound microscopes use a system of visible transmitted light and lenses to magnify images of thin specimens on microscope slides. The light passes through the specimen on the slide and the image is viewed through the eyepieces.

Most education quality microscopes contain a 10x eyepiece and three objectives of 4x, 10x and 40x. Magnification is calculated by multiplying the power of the eyepiece by the objective, so this combination allows a magnification of 40x, 100x and 400x. For many high power applications in schools, such as observing onion cells, root, leaf, stem and blood cells, a total 400x magnification is sufficient. The addition of a 100x oil immersion objective will allow magnification up to 1000x. This high magnification is required for observing greater cell detail and for studying microorganisms such as bacteria. In order to achieve the 1000x magnification you need to apply immersion oil to the slide and make careful adjustments to the contrast and focus.

Compound microscopes come with a monocular or binocular head. Monocular microscopes are generally a cheaper option. Cordless versions are now available and they come with a rechargeable battery and charger.

Important characteristics to look for include:

- Good quality optics to produce increased resolution.
- Ease of use. Models with mirrors can be hard to use, it is best to purchase a model with a built in light source. Monocular versions are easier to use than binocular microscopes.
- LED light source with dimmer for a longer bulb life and for extended viewing of live specimens due to the cooler light source.
- Mechanical stage for more precise slide control.
- Adjustable iris diaphragm to provide better image contrast.
- Fine and course focussing.

Stereo or dissecting microscopes

Stereo or dissecting microscopes generally use a system of reflected light rather than transmitted light.

These microscopes have a lower magnification power than compound microscopes. These microscopes have two eyepieces and two objective lens using separate optical paths. This produces a stereo or 3-dimensional image of the specimen. Magnification is calculated by multiplying the power of the eyepiece, usually 10x, by the objective, often 2x and 4x, so this

combination allows a magnification of 20x and 40x. They are used to examine larger objects in 3D, such as rocks, crystals, insects, leaves, fungi and fossils, rather than cells. For younger students the lower magnification (10x) is best as it produces a larger field of view. For more close-up and detailed work, including carrying out dissections, the higher magnification (40x) is recommended. Modern models utilise LED lights and can be purchased corded or cordless.

Digital microscopes

A digital microscope differs from a traditional microscope by being equipped with a digital camera, which allows images to be transferred to and viewed via a computer monitor. The main advantages of this technology include:

- Removal of the need to observe images directly through an eyepiece.
- Still and live images can be viewed on a variety of monitors such as computer screens, projector screens and smartboards.
- Images can be viewed by groups of students in real time and in remote locations providing education opportunities for students that were once unavailable. All students can get to see the same image.
- Images can be obtained faster and easier than trying to set up, adjust and view through a traditional microscope. Good for inexperienced users.
- Images can be saved, printed and emailed. Software is available to zoom in and out, count cells and make measurements.
- The quality of the images is generally better with digital microscopes.

Magnification is determined differently between a traditional and a digital microscope. With a traditional microscope magnification is the product of the eyepiece and the objective lens. A digital microscope has eliminated the eyepiece so the size of the monitor of the computer is the influencing factor of magnification and has the capacity for greater magnification than a traditional microscope. The computer monitor has varying physical dimensions and pixel resolutions, plus software that can resize an area visualised on the screen.

There are several options when looking to purchase a digital microscope.

- **Portable USB digital microscopes:** These are hand held units that can be taken into the field and are attached to a laptop or tablet. They offer low magnification around 1x to 200x and are used to examine larger objects like the traditional stereo microscopes. Final image quality is around two megapixels.
- **Digital eyepiece camera:** A small digital camera that replaces the eyepiece of a traditional compound or stereo microscope. The digital eyepiece camera is attached to a computer via a USB port. Computer software is provided that allows you to take still and video images. Compound microscopes with a digital eyepiece camera are able to view at the cellular level just like the traditional microscopes. Stereo microscopes with a digital eye piece camera are able to view larger objects just like traditional stereo microscopes.
- **Fully integrated digital microscopes:** These are microscopes that include a fully built-in digital camera. These are a more expensive option.

New photomicrography options and microscope alternatives

Photomicrography using compact digital cameras

Images seen through the light microscope can be photographed through the eyepiece with a compact digital camera with an auto focus, optical zoom and LCD screen. The intensity of the microscope light source is set to maximum and the camera lens is held against the microscope eyepiece.

The camera can be held by hand or set up on a tripod for stability. Looking at the camera's LCD viewfinder the position and distance between the eyepiece and the camera lens is adjusted to centre and focus the image. A picture is taken when the image is in focus. Short video can also be taken of motile organisms such as found in a drop of pond water.

Photomicrography using a smartphone

Images seen through the light microscope can also be photographed through the eyepiece with the lens of a smartphone camera. The camera lens is held to the microscope eyepiece and the image is viewed through the phone's screen. By adjusting the distance between the phone and the microscope lens the image fills the screen. The camera can be focussed and the image captured quickly. The image produced can be manipulated using the camera functions and can be emailed, sent by text or uploaded. The use of a smartphone in this manner brings an exciting new tool for students and teachers. Video can also be taken. Image quality is dependent on proper alignment of the camera and eyepiece lens, resolution of the image with the microscope, resolution, focal length and settings of the smartphone camera. These factors are dependent on the model of the camera and microscope being used. The main limitation is image blurring. It is difficult to remain steady whilst holding the camera and taking the photo. Peripheral darkening of the image can also occur.

Inexpensive and easy to use adapters are available to attach mobile phones to the ocular lens of a light microscope, which helps to address some of these limitations. They assist in making it easier to align the camera with the microscope eyepiece lens and remove vibration and blurring issues. Some are adaptable to the different type and size of phones and allow movement of the phone along the x and y axis for better alignment with the eyepiece optics. Others are specific to the type of phone being used.

Adaptor to convert a smartphone into a microscope

Technology has now developed clip and stick on lens units, which can turn any smartphone's camera into a basic microscope. They use additional lenses that clip or stick onto a smartphone plus the integrated flash of the phone. Many claim that they are capable of viewing microscopic organisms and animal and plant cells[1]. This clip-on can also be made using a 3D printer and purchasing a camera lens.[1,2]

Handheld microscopes

There is a wide range of portable pocket sized handheld microscopes available that may be cheaper options for primary schools or for fieldwork. These have either traditional or digital lenses and use either natural light or inbuilt battery powered LED light sources.

BioViewers

BioViewers are instruments like microscopes and are used to magnify slides (photomicrographs) of cells covering areas such as animal biology, plants, microbiology and ecology to name but a few. They require no power source, batteries or light source. They use ambient light focussed onto a white screen. They can be used in the classroom and in the field and are robust, lightweight and maintenance free. Sets of slides are available as BioSets. BioSets are strips of around eight slides accompanied by text information explaining each slide. These are available from science suppliers. See our list of school science suppliers (https://assist.asta.edu.au/resource/664/school-science-suppliers).

References and further reading

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