Understanding the Microscope - part 12. Buying a Microscope

First and foremost, the type of microscope you buy will be determined by your particular interest or chosen field of study. Those wishing to study opaque mineral ores may want nothing more than a simple stereo-microscope and a reflected-light stand. Others, interested in pond life may want an inverted transmitted-light microscope; field workers may wish to find a portable microscope. The majority of individuals wishing to find and purchase a light-microscope will probably be interested in an upright transmitted-light microscope for examining thin sections of tissue, cells, crystals or rock sections, for example. In practice, stereo-microscopes, portable microscopes and inverted transmitted-light microscopes are comparatively rare and far less easy to come by than reflected-light or transmitted-light stands. I assume, in this article, that you are not looking to buy a microscope for a child or school. Most toy microscopes sold in shopping centres or home shopping catalogues are too small for any serious use, and have inherently poor mechanics and optical systems. Do not be deceived by the high magnification claimed by these primitive microscopes: not only are toy microscopes useless at 500-1,000x overall magnification for, as explained earlier in this series (part 2), resolution of fine detail is more important than magnification alone.

Microscopists are often also interested in photography, yet both the new and the second-hand camera markets are vast compared to the much smaller new or secondhand market in microscopes. Nevertheless, the second-hand camera market will often have microscopes for sale. By and large, unless you wish to pay several thousands of pounds for a modern microscope the choice comes down to looking for a second-hand stand. Nevertheless, despite the smaller market, suitable microscopes can be found. Several firms advertise in the Quekett Microscopical Club journal (have a look on the Club website at http://www.quekett.org/resources/links/suppliers for an up-to-date list) and second-hand equipment can be found in the *Bulletin*. An Internet search can also produce several vendors' webpages, but most of these will be based in the USA, for example http://www.microscope-microscope.org/basic/buyers-guide.htm. A list of UK-based microscope sellers can be found at ~~http://www.microscopy-uk.org.uk/prodir/indexpro.html~~ (this now does not work, for the shop appears to have been taken over by Brunel Microscopes). Also, the microscopy webpage http://www.microscopy-uk.org.uk/ is useful for advice. If you prefer the idea of owning a new instrument, it is a good idea to have a very definite idea of what features you want in your new instrument to fulfill the job it is intended to do. It is also advisable to talk to other people who hold the same interests or work in the same field of study to ascertain what equipment they find essential, and what other items are merely useful.

Whenever you enter a field that is new to you, you have to build up a certain knowledge base to enable you to select and purchase equipment wisely, and it pays dividends to talk in depth, to listen to others and glean their experience. Do not be tempted to adapt your requirements to the instruments on offer, particularly where the market choice is small. Listen, take advice, draw up your list of requirements and stick to them. That applies whether you decide to buy a new instrument or an older second-hand one. The advice given by Arthur Barron nearly forty years ago in 1966 is still relevant, and I quote from his fourth chapter in Using the Microscope, which I recommend as further reading, particularly if you are considering purchasing a stand built in the first half of the twentieth century, or earlier:

> 'It is a waste of money and effort to purchase an instrument far beyond one's probable requirements, when simpler equipment will do all that is required just as efficiently and much more easily, but it is also a great mistake to attempt difficult work with an indifferent instrument bought perhaps because of an initial underestimation of one's future needs. The various components must of course bear some relation to each other. It is useless to have an elaborate stand for use with only low power lenses, and it is equally useless to purchase a wide-aperture objective of high quality without a correspondingly high-class illuminator, or to use components on a cheap stand designed solely for low power work.'

Without wishing to dwell on the issue, I mention these points because in the past I have had people asking for advice once they have realised that the first microscope they bought was either not adequate to the task expected of it, or found to lack a useful feature. For example, it may not be possible to set up full Köhler illumination because of a fixed diffuser in the light path, or the condenser is absent (a mirror stand), it may be impossible to centre the condenser, or it may be fixed and thus unable to be exchanged for another type such as a low power, dark-ground or phase contrast model.

General mechanical considerations

Most modern (e.g. made post-war) new or second-hand microscopes will be modular. That is, various accessories can be added to them, such as a reflected-light illuminator for epi-illumination, or a trinocular head with a phototube can replace the monocular or binocular head. These models may be more expensive, but they possess obvious advantages over those microscopes whose function cannot be altered because their design is fixed. So, I suggest that you glean information, draw up a detailed yet realistic 'wish-list', and opt, if at all possible, for a design of microscope that can be expanded at a later stage as your hobby or studies develop. Whatever the final list, I recommend that it should be possible to fix a binocular head to the microscope. The only disadvantage of a binocular head is that it will not allow the means of altering the tubelength by either optical or mechanical means to correct for spherical aberration. Whilst a monocular head will do this easily by means of a drawtube, it can be very fatiguing to use. Furthermore, an angled binocular head allows the specimen (particularly important with aqueous specimens) to rest horizontally on the microscope stage.

For a microscope stand to be really versatile, not only must it be modular in its design, and capable of accepting accessories and extra equipment, it should preferably have a self-contained built-in illuminator which removes the need for an external lamp source to be aligned on the optical axis each time it is used. Convenient, but not essential is a built-in transformer, generally rated up to 12 volts 15 Watts. This confers a degree of independence and portability to the stand: an extra (heavy) transformer is not needed, but the trade-off is the inability to change and upgrade the light to a 100 Watt source if the extra illumination is needed, say for dark-ground contrast enhancement. Careful selection of the substage mechanism which carries the condenser will permit a range of contrast techniques to be employed. Ideally the condenser should be able to be changed from the simple Abbe condenser to be able to do this. A good-quality rack and pinion that does not slip, a bracket that will accept various condensers and centring screws on the condenser are essential.

Plain stages with stage clips will suffice in an elementary model, but an attachable mechanical stage is preferred since it allows precise and reproducible positioning of the slide. If stage clips are fitted, ensure that they do not foul the front lens of high power objectives with a short working distance. Rotating stages are extremely useful for work with polarised light, where the specimen will almost certainly need to be set at a certain angle with respect to the crossed polars. Rotating stages are also useful for photomicrography so that the subject can be fitted into the film format without needing to rotate the camera housing (in some integral photomicrographic stands this cannot be done). Mechanical stages can also be used to grip a thin plastic carton for wet work, such as pond-life studies, if an inverted stand cannot be found. Most condensers will be able to focus through the thin plastic found in food cartons, and the optical quality of the plastic container will not interfere with work at low magnification.

Check all mechanical movements of the focusing controls (I should say here that I find coaxial controls more convenient than separate coarse and fine focus knobs) and the mechanical stage; they should be precise with little or no backlash. Often you will have to decide what tolerances are acceptable. This is particularly true if the equipment has been well-used. You may, for example, decide that you can live with a good-quality rotating mechanical stage that is very good in all respects save that one of the coaxial stage movements is slack. What cannot be tolerated is a stage that is not perfectly smooth and square throughout all its area to the optical axis. A stage out-of-true will necessitate constant refocusing, and the image may well be partly blurred over the field of view. Ensure that the limb (if the microscope design focuses on the limb) does not fall down under its own weight, or that of an attached camera, and drive the objective down on the specimen. Check that the stand is solidly-built yet not top-heavy, and will support extra equipment without suffering from instability or vibration. Finally, as with anything else you buy, the overall appearance of the microscope stand will tell you how it has been used and cared for. Avoid an instrument with corroded parts, enamel chips that have been filled with a different lacquer, dents, excessively worn and loose rackwork and screws with torn or gashed slots.

Optical considerations

The various optical components have been described in previous articles. The most important components are the objectives, and these in particular should be examined closely to ensure that they are optically perfect when bought. The objective is so crucial to the proper working of the microscope that really it *is* the microscope. This is why two of this series of articles (parts 4 and 7) are devoted to the objective. The central importance of the objective also explains why, in many cases, a microscope stand may be sold with less than its full complement of objectives, the more desirable items having been retained or sold separately. When evaluating an objective, there are a few simple tests that you can systematically carry out.

First a visual inspection, in the same way as with the stand, will tell you how well used or well looked after the objective is. Has the objective been fitted with an RMS thread, or is it intended for one of the more recent microscopes, where manufacturers have decided upon their own brand convention? Hold the lens up to a strong light and examine it closely, as well as looking through it at each end. Has the inscription around the barrel and the coloured identification ring been scratched or disfigured? Are there chips or dents around the mounting of the front lens element? On lower power objectives it may be possible to see if the anti-reflection coating on the front lens has been scratched. With a dry objective, look at the black matt area around the front lens element: is it intact and free from blemishes or scratches, which might otherwise have also affected the lens. Solvents such as acetone or alkalies will also damage this coating.

With oil-immersion objectives, ensure that no oil has remained dried onto the front lens (inspect it from the rear to ensure that all the lens elements in the barrel are clear). Also check that no oil has seeped into the barrel of the objective and lodged in the mounting holding the lens elements. Traces of oil films when checking the spring loaded barrel runs freely will usually indicate this. Check that any internal diaphragms turn freely, and are not damaged. Often an older secondhand objective will seemingly have dirt on the back lens element. It may, of course, be fungus growing between the elements as a result of poor storage in hot humid climates. Other objectives will exhibit separation of the lens elements. Newer lenses are cemented with a synthetic ultraviolet adhesive, older lenses used Canada balsam cement. The cement can break down over time, creating a gap between the lenses. This usually starts from the outside edge and works inwards. A lens that is separating, where the balsam has broken down, will have either a murky appearance, or show interference fringes looking similar to oil or petrol floating on water. The images from such objectives lack both definition 'crispness' and contrast. Inspect the back focal plane of the objective critically with a (phase) centring telescope.

The best test of an objective is to evaluate it using a variety of specimens. Use those that you are familiar with and, preferably, have inherent well-stained fine detail. I use a very thin section of renal glomerulus stained with toluidine blue. Commercial firms use quantitative interferometric testing to evaluate objectives, but using specimens well-known to you in this way can give a good picture of an objective's worth. Colourless specimens are essential for making a judgement about colour aberrations showing up as colour fringes around the edge of the object as you focus up and down through the plane of the specimen. I find the diatom *Navicula lyra* to be useful for this test. Residual colour will, of course, be present to some degree; more so in an achromat than an apochromat objective. In the absence of serious defects, the difference between a good and a poor objective will come down to how crisply the image contrast is presented to the eye. An Abbe test plate can be used to evaluate spherical, off-axis and colour aberrations, but this is rare, and not absolutely necessary. The star test will suffice, and it is possible to make your own test slide easily; for the details, see Fletcher (1988) or Oldfield (1994). To truly evaluate the resolving power of an objective, a resolution test plate fabricated by electron beam lithography should be used, but historically diatom frustules of species such as *Amphipleura pellucida* and *Pleurosigma angulatum* will suffice. Again, it is better to avoid natural variation by using the same selected specimen in a custom-picked test plate. Suitable diatom slides for objective testing are available from Klaus Kemp of Microlife Services.

These remarks concerning the objective also hold true for the eyepieces and condensers, where applicable. All glass should look clear, colourless and bright. Finally, ensure that the prisms of the binocular head are properly 'collimated' or in alignment. If the two fields of view are out of synchrony, then it is likely that the binocular head has been dropped at some time in its life, or is very poorly constructed. Either way, it may by impossible to view or fuse the two images properly into one, and this will cause eyestrain.

Maintenance of your microscope

I recommend the two articles by MI 'Spike' Walker (*Bulletin of The Quekett Microscopical Club* No.26, pages 14-16 , Autumn 1995 and 27, pages 18-24, Spring 1996) for further detailed information on maintaining the light microscope.

References

Barron, ALE (1966) *Using the Microscope*. Chapman & Hall, London.
Fletcher, JR (1988) The Star Test for Microscope Optics. *Microscopy* 36/2: 153-159.
Oldfield, RJ (1994) *Light Microscopy: an illustrated guide*. Wolfe Publishing, London. ISBN 0-723-41876-4