

## Are Microscopes Too Sophisticated?

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*Thoughts provoked by attending the Microscopy Society of America's annual meeting in Cincinnati in August 1993.*

I bought my last useful pocket calculator in 1975 and I still use it regularly. Every time I pick it up I know how to use it, since all the functions I need are printed on its buttons, and I expect to be using it when I retire, if I can still get the batteries. My son bought a "more sophisticated" calculator for his A-levels in 1988 and I inherited it shortly thereafter. It lies in my desk drawer but I cannot use it because it offers so much *more* than I need and there is too much printed on and around each button. I would need to read the manual every time I wanted to use it. On the desktop close by sits my telephone: It has 46 buttons and a 17-page manual and offers an enticing array of facilities. Unfortunately I only need each of these "facilities" about once a month and have never been able to memorize the necessary procedures: As a result all I can do is answer it when it rings and dial out.

Both of these examples illustrate what I call over-sophistication - the would-be user cannot avail himself of the full potential of the instrument because the necessary procedures are not sufficiently self-evident for the occasional user. There is a second, related, problem that some of the over-sophistication is caused because there may well be facilities which are not actually needed. It is not clear whether an instrument without unwanted facilities would necessarily be cheaper but it ought certainly to be simpler.

The point I wish to discuss in this short article is the extent to which these problems also exist in microscopy. Let me start by considering a relatively "simple" microscope, the SEM. The primary reason for using a

microscope is to evaluate, qualitatively or quantitatively, the morphology of a specimen and this is still most commonly achieved by producing an image and interpreting it some time later using the (human) eye of experience. At the recent RMS Bank of Scotland lecture in Leeds we heard Mr. M.J. Cookson describe how the best computer-generated 3-D reconstructions are performed in 1993. Between recording each image and entering it into the computer a human operator indicates which features are which! The role of the microscope is only to produce a modest image interpretable by the experienced scientist, and to preserve, in two dimensions, the spatial relationships between its key features. We may ask one further routine thing from a modern SEM: the composition of a selected local region. An analytical facility is helpful to most users but beyond this there are a large number of further possibilities, each of which is attractive to a *minority* of users, and the main problem lies in their very proliferation: How many individual scanning microscopists need EBIC *and* rocking beam methods *and* a full range of voltages *and* backscattered imaging *and* built-in image analysis *and* EDX?

My central argument revolves around the question, who are to be the users of the instrument? It is my belief that, with the exception of instruments primarily used for routine quality control, most SEM time is taken up by occasional users. This ought to determine the design philosophy for a modern instrument, were it not for the countervailing point that most instruments are bought (or specified) by specialist enthusiasts, or instrument freaks as they might be called. As a consequence most installed microscopes fail the Goodhew test, which is: Can I, or any other out-of-touch but reasonably knowledgeable microscopist, sit at the instrument and produce, unaided and without the manual, good interpretable results? I apply this test to computer software, cameras, cars and calculators as well as to microscopes. Only cars routinely pass, but computer software is getting better. Microscopes, I am afraid, fail every time.

There are three possible approaches to making a microscope which is properly usable by the occasional user. The first is to make the instrument extremely simple and ensure that its (manual) controls correspond to the principles which the microscopist understands. For example, in an SEM the fundamental issue is to bring a circular beam of known convergence angle carrying a specific current to focus on the specimen. Implicit in this is a minimum possible beam diameter, which is easily calculable from the other parameters. The necessary controls should therefore be labelled "convergence angle", "beam current" and "focus" and there should be an additional read-out giving the minimum beam diameter. Subsidiary controls are of course necessary for astigmatism correction and gun alignment but they too should be explicitly labelled.

The second approach is to develop a full-automated system which usually (but not necessarily) operates as a black box and obscures the principles from the user. This solution is superficially very attractive since it appears to offer high quality results to the uneducated user. Such a microscope would need automatic gun alignment and saturation, automatic astigmatism correction, automatic focusing and exposure control, together with automatic diagnosis or specimen/image problems such as charging and semi-automatic kV selection. Most of these features, while available in principle, do not yet work reliably enough to be worth paying for. We are at the level of the current "point and click" camera which boasts auto-focus, auto-exposure and automatic flash. All these work in a limited set of circumstance but are not suited to taking a photograph through a window or maintaining good depth of field. And we must all have laughed (or cried) at useless auto-flash exposures inside cathedrals. Again the only semi-automatic device well-developed enough to be acceptable is the car, in which automation has been strictly limited but is very effective. I have no wish to change gear ever again.

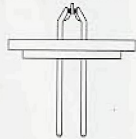
A third approach is being adopted in some recent instruments: The microscope is driven via the graphical user interface of a computer, for example under Windows. This offers - if well done - several key advantages, the most important of which is that the controls offered to the user can be individually configured. Thus in principle one could sit at a very sophisticated microscope and be offered the choice of using it at "novice" level, at "just passed the driving test" level or at "arrogant state-of-the-art microscopist" level. There could even be a special configuration for the "out-of-touch 1960s microscopist". This sounds fine in principle but is let down in all the systems I have seen by the difficulty of designing a universally-understood user interface. The widespread use of icons



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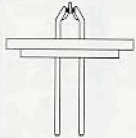
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does not help - very few are instantly recognizable and each manufacturer seems to feel the need to design theirs to look different. I am a Windows fan but still need, on a microscope, words in addition to icons. Incidentally this facility is available in WordPerfect for Windows™ so I am not alone in thinking that it might be useful.

The ideal user interface then consists of only four or five buttons (each with text plus icon) one of which must be "Switch to Idiot Mode" - I do not know what the icon for this might be, perhaps a dunce's hat. Even this versatile, individually tailored, idiot-proof interface does not solve the user's problem since using a mouse only permits one control to be changed at a time, and then only by the relatively non-intuitive dragging of a mouse or the equally clumsy clicking on one of an offered list of possibilities. Knobs which rotate (one in each hand) are, I am afraid, intrinsically faster and easier to use for such purposes as focusing. My patent inability to specify the ideal system is mirrored in the vast range of combinations of real knobs, touch screens, keyboards, trackballs and mice offered by commercial SEM manufacturers. The community has clearly not yet settled on the best arrangement. Before it does so, let me offer a further thought. If a great deal of effort is to be put into the user interface (and it should be) why should we not have diagrams on the screen showing us *inter alia* the optical conditions we have selected?

If we now consider the TEM we meet a further set of problems imposed by the intrinsic mechanical complexity of the instrument. TEMs have fewer users but a lot of moving parts, their "accessories" (EDX, EELS, etc.) are themselves complex and they must be designed with a specific unchangeable gap between the objective lens pole pieces. Most TEMs are, in consequence, both a compromise and too complex and unreliable for all their elements to work at the same time. I believe that the solution to over-sophistication in this case is different: TEM is not a "simple" technique and there will be no substitute for considerable knowledge and skill, but we need several simpler microscope columns, each configured to do one job optimally. Unfortunately the microscope (Continued on last Page)

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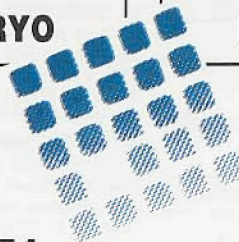
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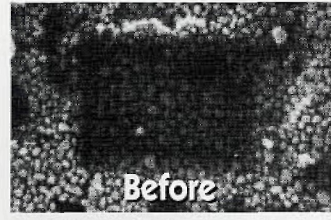
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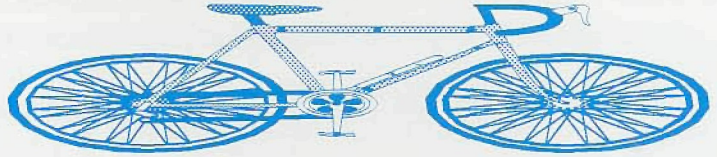
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## Are Microscopes Too Sophisticated? Continued

column is (and will continue to be) the expensive part of the microscope and therefore it makes little sense to try to save money by driving several columns with one set of electronics. The area we need to work on is the high quantity transfer of specimens between columns. A universal standard for specimen holders would be a start, followed by the development of affordable vacuum transfer devices. Then, probably most difficult of all, we need manufacturers to build relatively straightforward single-purpose microscopes, with the appropriate pole piece gap and only the ancillary equipment needed for a single job. Instead of a top-of-the-range analytical microscope I want five compatible microscopes, one (very modest) for specimen checking, one for high resolution imaging, one for diffraction, one for EDX and one for EELS. Not only might four of them be fully functional on any given day but as a bonus, four people could be working simultaneously. It is of course implicit that the same area of specimen could be located with seconds in each of the five microscopes. All I ask is that this package should not cost very much more than the alternative super-AEM!

Although I have addressed my comments specifically to SEM and TEM instruments I am fairly sure that much of what I have said applies also to light microscopy. Perhaps someone would like to submit a follow-up article to the editor extending (or contradicting) my views. ■

*The above article has been reprinted from the October 1993 issue of Proceedings, thanks to the courtesy of the Royal Microscopical Society. Microscopy Today will accept follow-up articles extending (or contradicting) Dr. Goodhew's views.*

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