Training Trends And Their Implications for Microscopy

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Microscopy training has always been labor intensive. As the need grew for electron microscopists so did the need for methods of training to maintain quality while increasing the quantity of people trained. Various trends in scientific research needs, development of various types of microscopies, environmental concerns and increasing computer sophistication brought about significant changes in microscopy training and service facilities.

In the **1960's** TEM research flourished. Many single user facilities appeared with scopes provided by grant funds, especially in biology. There was a great need for people trained in EM. In the mid 1960's, commercial SEMs became available, and SEM research flourished. Many EM instruments were grant funded both in the biological and material sciences. SEM geological research flourished as the SEM provided the necessary 3 dimensional images replacing the TEM replica technique used until that time. Abundant EM training courses developed in the Universities. In 1969 a two-year certificate program for electron microscopists was established at San Joaquin Delta College, a California Community College. This was a visionary accomplishment for the time, at the Community College level.

In the **early 1970's,** grant funds for EM research was readily available. There were an increasing number of EM instruments available, many with energy dispersive x-ray (EDS) analysis. There was a continued need for more people trained in EM which resulted in an increasing number of EM courses offered. Audio visuals developed to expedite labor intensive EM training, i.e., films, tapes, sound-on-slide, etc. With the advent of EDS (~1969), computers began to play a part in microscope control, but required knowledge of a specific computer language and were not particularly user friendly. In the **mid 1970's,** EDS came "of age" in materials science, and analytical microscopy was a reality. Several instrumentation centers were funded and microscopy training increased. In the late 1970's, grant competition for instrument funds stiffened markedly. Labs found it more difficult to meet operating expenses.

In the **late 1970's and early 1980's,** there were still an increasing number of EM courses. An electron microscopy course/lab survey was taken in 1981[1] itemizing hundreds of labs, courses and microscopes world-wide. The problem of the labor intensive microscopy training remained. Extensive audio visuals were used as training aids. There were a limited number of computer generated training aids developed. Many facilities were centralized because of increasing costs. Difficulty in getting instrument grants increased with a preference for interdisciplinary projects in centralized facilities. The availability of personal computers because of decreasing costs initiated greater use of computers in microscopy, but their use was still not routine.

In the **mid 1980's,** even centralized facilities had to get "leaner and meaner" and be innovative to support operating costs including equipment maintenance. Because of staff reductions and training costs, some facilities decreased training availability. Interest in specialized specimen techniques increased, e.g., freeze etch, variety of cryo-techniques, immunolabelling, convergent beam electron diffraction (CBED). Many specialized short courses were offered. Interest increased in image analysis but equipment was expensive and not particularly user-friendly. Molecular biology turned its attention to gene manipulation instead of morphology. The Apple Macintosh as first introduced was truly user-friendly although not able to run instruments at that time.

In **late 1986,** a resurgence of interest in TEM, flourished because of the asbestos laws (AHERA). Use of the TEM was required by federal law to clear school abatements. Personal computers with more memory started to become affordable to the routine lab.

In **1987,** specialized TEMs just to do asbestos came on the market and older instruments became more valuable. This year also saw a resurgence of interest in light microscopy, e.g., confocal microscopy and fluorescence.

1988 and 1989 was the 'height' of the TEM asbestos analysis courses, including TEM training. Mass training of non-microscopists and biological microscopists occurred to do analytical EM and diffraction analysis. Short courses flourished. TEM instrument sales skyrocketed.

In the **late 1980's**, facilities had an increasingly hard time justifying service contracts and operating costs for EM. General EM training decreased. Many labs tried to get in the asbestos analysis business and other environmental analyses to stay alive. Computer software was developed for running microscopes. The user friendly Mac allowed more people to easily use the computer. Windows software became popular on the IBM. There became an increasing need for SEM/FIB (focused ion beam) installations in the computer industry as integrated circuits got smaller. Scanning tunneling and atomic force microscopes were introduced and confocal microscopy flourished.

In training, from the **early 1990's** to the present, we see a decreasing interest in EM theory. Specimen preparation is taught in separate courses. Student enrollment at specialized microscopy programs at community colleges increases. SEM programs for high schools are initiated throughout the country. Increased computer software is being developed and is becoming an integral part of training. Software is still designated for either Mac or Windows environment. Central EM labs on campuses become more service oriented. There is an increasing need for general microscopists with emphasis on image analysis.

Labs and societies are restructuring to accommodate various types of microscopies. Many single user microscopes on campus are phased out. Many small labs set up just to do asbestos analysis go out of business. Lots of used microscopes and operators come on the market.

In the **equipment area**, all new microcopies are digitally computer controlled but instrumentation is not totally computer integrated. More powerful Macs with more memory get lower in price. NIH Image, which is a public domain program since late 1980's, makes image analysis available to anyone with a Mac. Photography becomes less necessary for labs with large memory intensive computers. The computer industry has an increasing need for SEM/FIBS.

There are certain trends that seem to be emerging for the **late 1990's** and the turn of the century in training, labs and equipment. In **training**, there will be a shortage of those trained to do EM from universities and a dependence on technologists from accredited microscopy programs in community colleges, etc. Finding skilled microscopists will become more difficult. Training will increase on microscopes via computer terminals (>1 per microscope) with microscopes operating remotely. Networking and reasonable transfer speeds will allow the microscope to effectively come into the classroom. Students and researchers will have remote access to microscopes, perhaps as easy as using electronic mail. Effective integrated microscopy training will be developed. The term "microscopy" will integrally include image processing and analysis. Microscopists will be looking more critically and developing methods to compliment discipline needs. There will be an increasing need for public relations and salesmanship necessary to justify funds. Microscopists at all levels will have to be computer literate and well-rounded BUT still have specific skills. There will be an increased interest in microcopy localizations at the gene level, epitope labeling, etc.

Labs will be more centralized integrated resources with all types of microscopies and spectroscopies. Funding for large instruments will be for interdisciplinary, centralized, instrumentation centers on campus or regionally. Microscope companies will have to use innovative techniques to package service contracts. The economy will dictate that all successful labs run a "tight ship".

In the **equipment area** there will be a continued need for electron and other types of microscopies, all of which will be image analysis intensive and computer controlled. There will be an increased availability of AFMs and STMs and other microscopy technologies now in the developmental stages. Instrumentation will get smaller, but computer power larger, accommodating the ravenous need of images for memory. Less photographic work will be necessary in routine labs. Mac and Windows formats will easily be available to routine labs on one computer. There will be an integration of computer systems on microscopy work stations.

The implications seem straight forward with regard to what we need to do. In general, today's microscopist and the successful lab should not only be good at what they do now, but be looking ahead to solve tomorrow's problems. They must find out what it will take, and get it, or set up training for it, BEFORE tomorrow comes and, then, always remain FLEXIBLE and encourage an interdisciplinary approach - making use of existing equipment whenever possible. ■

1. Murphy, Judy A. 1981. Electron Microscopy Teaching Survey/81, Southern Illinois University, Carbondale, IL, pp 1-23.