The value of practicing practical history

This is a call for 'practical history'. By that I mean both the history of practice and history as practical. In particular, I suggest that practical history is good for the history of science, and that history of science is good for science and for improving scientific literacy. To some this will seem odd, since they do not see the point of looking again at antiquated practices. Bill Gates is popularly quoted as saying that his goal with Microsoft is to make the past obsolete. Yet taken too far, that approach would miss much of what life is about, and Gates himself enjoys classic works of art and history. History is a key to unlocking the treasure chest of excitement about past discoveries and the process of discovering. It is important, however, to get the history as 'right' as possible, and that is more likely when historians and scientists work creatively together. This is where the practical history comes in.

In 1971, Edwin Clarke and J. G. Bearn called for the practice of 'practical history'. Looking particularly at medical history, they pointed to the role of experimentation for resolving uncertainties or contradictions in the available written record. They cited several anatomical puzzles: what could Aristotle possibly have meant when he claimed that 'the brain lies in the front part of the head' and that 'The back of the head is with all animals empty and hollow', or what did anatomist Malpighi mean by the 'glands' in the cortex? We can speculate, but why not explore by replicating as nearly as possible Aristotle's and Malpighi's conditions? Clarke and Bearn believed that history depends on evidence as much as science does and that practical history can provide the 'fresh evidence' without which history could not be properly scientific and could not make progress, Thus, the historian should seek 'to recreate and then study a past event or situation, whether it be an experiment, an observation, or a custom'[1]. In fact, this parallels the scientific interest, on occasion, to replicate published experiments and observations.

Experiment and practice

Recreating the past through experiment and practice is not easy, of course, and not always even possible. Yet, when possible, 'the actual recreation of historical events or situations will invariably heighten one's appreciation of, and interest in, the past'[2]. Just as we can reconstruct a naval ship or an historical raft like the *Kon-Tiki*, or ancient food preparation techniques, they suggested, and just as we can learn a great deal by re-enacting past events, so we can reproduce past scientific and medical conditions and events. We can carry out dissections under conditions as nearly as possible contemporary with the texts we wish to elucidate. We can discover details not mentioned, and uncover assumptions not articulated. The excellent film reproducing William Harvey's presentation of his case for circulation of the blood demonstrates the historical and pedagogical value of such recreations[3].

Clarke and Bearn's paper and other efforts during the 1970s by historians of medicine notwithstanding, there things stood. Individual historians carried out their various selected individual studies, looking at the history of ideas, individuals, institutions, or social contexts. Only a few pursued practical history in Clarke and Bearn's sense, and they usually did so quietly.

Then something happened. Focus on 'practice' became a trendy sociological emphasis. Studies of 'laboratory life' popularized initially by Bruno Latour, and other related work, turned widespread attention to practice as creating knowledge[4]. Images of lab-coated researchers interacting and carrying out techniques and methods and sometimes unarticulated and unspecified 'black boxed' practices: these appeared in more and more articles and lectures on practice. This was good, in part, but somewhere along the way we lost track of thinking, ideas, argument, evidence and justification as critical parts of the creation of scientific knowledge. Essentially, we lost track of the rational components of science and strayed too far from science as science is really done. Much of science is practice, but it is practice in aid of ideas and explanations. Practical history must keep all components of the creative scientific process in view and not just active life in the lab. Otherwise, we lose the excitement, passion, wonder and sense of progress with respect to increased understanding of the natural world that science seeks. Science is not just some post-modern story-telling, but rather a finely honed set of evolving methods for understanding nature. Appreciating this and the way practical components play out is essential for scientific literacy – for understanding science as science is really done. By making science more accessible and more 'real', practical history can help promote interest in scientific literacy and to improve science education.

The lack of scientific literacy today is well-documented and often lamented. This failure is hardly new, but the recent resurgence of standardized mandatory school testing in many subjects including mathematics and sciences has led to newly articulated expectations – and wider awareness of the failures. International comparisons, such as that offered by the Third International Mathematics and Science Study, revealed the depths of the lack of scientific knowledge in the USA and have focused public attention on what has been widely and immediately accepted as a problem. US education leaders have expectations, and at least for now these seem to be shared by enough state and local leaders to have created a national movement. We seek scientific literacy for Americans – and at least in principle for all Americans.

Promoting scientific literacy

Discussions over recent years also demonstrate clearly that we know how to do a better job of promoting scientific literacy, even while we do not articulate explicitly and often would probably disagree about what we mean by that goal of literacy. Notwithstanding, leaders at the National Science Foundation, the Department of Education, the National Research Council of the National Academy of Sciences, and the American Association for the Advancement of Science, and many other scientific organizations have agreed in numerous widely-cited publications that we should teach 'science as science is done', that 'science is a way of knowing', and that above all we should develop the creativity and critical thinking involved in 'scientific habits of mind'.

There is also evidence that history can help with all this. Yet in the 20 years that I have been in this field of history and philosophy of science, historians and scientists have talked substantively to each other on only rare occasions. Science and the effort to understand science is only rarely informed by history. Even the great advocate for scientific understanding, Carl Sagan, rarely drew on the history of science to help make his last case for banishing the 'demons' of superstition[5].

A few examples offer hope. John Moore's project with the American Society of Zoologists (now Society for Integrative and Comparative Biology) explored with a team of biologists how to use historical study of 'science as a way of knowing' to teach biology[6]. At the high-school level, Harvard Project Physics and the AAAS's Project 2061 share an emphasis on historical thinking. Science is done by scientists, and James Rutherford, Gerald Holton, and the other leaders of both projects, make the point that to understand and to appreciate science, we must appreciate – and really understand – scientists. Instead of reading just about Kepler's laws, for example, we should learn

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about Kepler's family background, his philosophy, and the reasoning process that led him to think in terms of laws. We should have the joy of reproducing Galileo's inclined plane experiments or gazing at the night sky to see why Tycho's observations were so remarkable or how Galileo provided something new, ideally with a telescope that we have made ourselves with rolled-up cardboard and basic lenses.

While some science studies proponents would demand that we need still more, including social context and a greater understanding of the choices and values and problems of science, accepting that demand does not undercut the point that greater understanding of how science has developed over time provides a better and richer understanding of how science works now. And since science involves studying the world, any study of 'science as science is done' will also involve studying the natural world – as well as studying previous studies of the natural world and their contexts.

Hence practical history

Douglas Allchin and Joel Hagen offer examples, in their *Doing Biology*, of how to use historical cases and even replications to teach biology[7]. Both teachers of undergraduate biological sciences, and both trained in biology and in history and philosophy of science, they offer materials and examples that other instructors can use to walk students through the reasoning processes involved in past scientific triumphs. They are well aware that few science faculty members will be likely to spend much time on the 'failures' of science, but they do show how the reasoning process works in ways that allow discussion of why something succeeds or not.

Beyond high-school and undergraduate education, the approach has value in research and graduate education. The Dibner Institute for the History of Science and Technology has offered a History of Biology program at the Marine Biological Laboratory for over a decade, and has recently developed a similar summer program in the history of physical sciences. These programs have led the mixed groups of scientists, historians, philosophers, school teachers and others the way into the field and into the lab. With the history of biology program for example, we have taken collecting trips, bringing up the dredge to gather a diversity of organisms and to learn more about the challenges of classification. We then move into the lab to explore what we can learn about neurobiology with giant squid axons, or about development with *Caenorhabditis elegans*, or with a variety of marine invertebrates. What does a field trip to the nearby salt marsh tell us about how to study the ecosystems ecology, and about the role of history in the ecosystem and in our understanding of the ecosystem? A decade of programs has led to different approaches to different questions, but the assessment remains unanimous: practical history always teaches us a lot about science. As one philosopher put it quite emphatically one year, 'what I learned most immediately was humility. Laboratory science is hard!' He returned the next year to learn more. We learn that science is difficult, that it involves choices and techniques and practices that remain largely unarticulated and sometimes 'black-boxed', as sociologists like to put it. That tells us much about how science works. Sometimes we learn specifically about details to which we have no access otherwise. When I studied American embryologist Ross Granville Harrison's work on nerve fiber development for my doctoral dissertation, my dissertation director Fred Churchill, minor advisor embryologist Robert Briggs, and I all realized that the written record only told us part of the story[8]. We could not retrace Harrison's steps nor fully appreciate the decisions he made nor the assumptions on which he based those decisions without further information. I had spent the previous summer at Woods Hole in the lab. talking with retired embryologists and reproducing a variety of old studies with their help. It was a great thrill to be in the same place, doing the same thing with some of the same equipment, same organisms, and even the same people, as work done even 75 years earlier. Added to the library research, archival exploration and oral interviews, this practical experience gave me a much richer feel for the science. And it gave me an enduring enthusiasm for teaching about the process of scientific discovery.

Science as science is done

Briggs thought it would be fun to reproduce Harrison's experiments of 1910, experiments for which Harrison almost surely would have received a Nobel Prize in 1918 had WWI not intervened to prevent awarding the prize that year. We removed the frog lymph, as Harrison had described, and made a culture medium on a glass plate. Then we transplanted selected pieces of tissue that normally give rise to nerve fibers. For Harrison, this process yielded beautiful nerve fibers growing out into the surrounding medium. It was, when Harrison did it, the first successful tissue culture ever. Whatever we did, we could not obtain sufficiently aseptic conditions.

Did Harrison do something he wasn't telling us, or was he such a better researcher than we? This led to further questions. Eventually, the combination of historical techniques paid off. Interviews with scientists at Yale gave clues, and the archival and institutional record revealed that when Harrison first arrived at Yale from Johns Hopkins, his lab. was temporarily just down the hall from that of the resident bacteriologist. Study of contemporary bacteriological techniques provided enough clues, and we ended up with a much richer sense of the various factors that went into the first successful tissue culture. Just taking Harrison at face value did not really reveal 'science as science is done', as it was too simple and unrealistic. And failing to ask would just have left a mystery. Practical history made a difference for our understanding of the history and for our appreciation of how the science works. Clearly, this parallels the process through which contemporary scientists replicate experiments and observations, and discover unarticulated assumptions and hidden variables.

Practical history shows directly that science is great fun. And historical science is great fun, too. It is fun to learn about some important person and his or her marvelous discovery, then to work it through and see how they really operated, making systematic, clever, informed and just plain lucky choices. This process reveals the critical evaluative thinking and the creative process that makes up the scientific habits of mind that we seek. Practical history is a powerful tool in promoting science and scientific literacy. It can also make both science and history more fun. All it takes is some imaginative historians and scientists eager to lead the way with productive collaborations so that others can follow.

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