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"Why Study History for Science?"

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Abstract. David Hull has demonstrated a marvelous ability to annoy everyone who cares about science (or should), by forcing us to confront deep truths about how science works. Credit, priority, precularities, and process weave together to make the very fabric of science. As Hull's studies reveal, the story is both messier and more irritating than those limited by a single disciplinary perspective generally admit. By itself history is interesting enough, and philosophy valuable enough. But taken together, they do so much in telling us about science and by puncturing the comfortable popular illusion about how science works. Ultimately, David Hull shows by his example that history and philosophy of science can make science better. I agree, and with its focus on the history of science in particular, this paper explores why.

Key words: historiography of science, interdisciplinary studies, scientific change

Perhaps scientists should NOT study history. That's what Stephen Brush suggested in his 1974 *Science* article "Should the History of Science be Rated X?" (Brush 1974, p. 1164). Studying history might undercut the reassuring myth about how science is done. Scientists do not really neatly observe nature in an absolutely "pure," "detached," and "objective" way. They do not begin only then to formulate alternative hypotheses to explain the observations and then to test those hypotheses in an unbiased and open process of experimentation. Instead, sensible scientists quite seriously develop hypotheses as they study the world, so that theory and experience are intertwined. And they quite reasonably design experimental tests that are at least as likely to support as to refute their hypotheses. If the tests suggest that their favorite hypotheses are inadequate, they also quite sensibly work at ways to fix the hypothesis and try again. No point in throwing out a perfectly good hypothesis that has worked in other cases just because it does not fully fit with the data at hand. Give it another try before moving on.

Of course, Brush did not really mean that scientists should not study history. And subsequently he and other historians have argued that a study of the rich examples of history tells us a great deal about how science works – and even about how we might make it work better. Furthermore, a case for studying history can be made much as Samuel Florman makes his wonderful argument that engineering students should study the humanities. Far from humanizing the presumably savage would-be engineer, which was the rationale traditionally offered for studying the humanities, that study would serve to show that, as he invoked Jacques Barzun to say, "The *Iliad* is not about world peace; King Lear is not about a well-rounded man; Madame Bovary is not about the judicious employment of leisure time" (Florman 1976, p. 39).

So, should we study history of science for similar reasons? Newton employed a fudge factor, Richard Westfall demonstrated in a 1973 article in *Science* (Westfall 1973, p. 751). Kepler was inspired by number mysticism (Koestler 1959; Holton 1973). Darwin was sickly and probably hypochondriacal and neurotic in a way that kept him at a particular project (whether coral reefs or barnacles) long after most would have declared a victory and moved on to other things (Desmond and Moore 1991). James Watson's story about the double helix work with Crick, reconstructed as it undoubtedly is, probably reveals more about the realities of the human scientist and his contributions than Watson realized or might wish (Watson 1968). History, then, can show the weaknesses and humanity of scientists. This can have a reassuring effect for prospective young scientists who see that scientists are, after all, only human and that they themselves have a chance to join the ranks. But beyond that, why study history?

Because history can also show the strengths in science, and the excitement, and because historical perspective can help to illuminate why some science works better than other science. Just as the best of those concerned with biodiversity have realized the essentially historical evolutionary character of ecosystems, and just as geneticists and developmental biologists realize the essentially historical process of individual development through time, so all good scientists should acknowledge the essentially historical nature of science. Science is not a static method, unchanging over time. Rather science incorporates innovations and responds to changing environments in ways that produce an important historical record. Some science is better than other science in answering questions about the natural world and in moving us forward. All science builds on past successes and failures and is both constrained and enabled by progress in the past.

Science involves a process of continual inquiry, but the methods of inquiry and the questions asked are no more static than the world we study. Thus, truly to integrate research and teaching to foster learning in science (as the National Research Council, the National Science Foundation, the American Association for the Advancement of Science, the United States Congress, and others are urging us all to do), we must accept science as it is really done (National Research Council 1996; National Science Foundation 1996; American Association for the Advancement of Science 1993; Executive Office of the President 1997).

Critics of all science studies, such as Paul Gross and Norman Levitt (Gross and Levitt 1994), have failed to understand the fundamental nature of the science they profess to admire so much. By silencing those who seek to explore the development of science and what makes it work, they would hide its beauty and its significant ability to adapt, change, overthrow old ideas and to explore new ones. They would take the humanity and the progress out of science. Such closed-minded science enthusiasts would presumably have us freeze science in time and assume that we know the best methods and approaches since they believe that we do not need to study and explore the alternatives and how they have played out. Instead, we need as Philip Kitcher urges, to explore science's full historical richness to appreciate *The Advancement of Science* (Kitcher 1993).

Let us examine traditional arguments for studying the history of science, then draw some conclusions relevant to science education and to the general current enthusiasm for promoting public understanding of science and increasing scientific literacy. This reflecting on the past in order to look forward with clearer vision to the future is valuable in informing our national discussions of science policy. Even well-intentioned Congressional science committees that are generally quite supportive of federal funding for scientific research and education would benefit from a deeper understanding of what science is, how it works, and how to make it better – all of which can be valuably informed by historical perspective.

My thesis is that history – both the history of science and the history of processes and objects in science – is an essential component of progressive science, that good science requires an historical perspective, and that pursuing the presumed cutting edge alone (both literally and figuratively in biology as we cut up organisms) is not enough. That is, we make progress in science (and in the history of science) by looking back as well as staring immediately forward at the cutting edge. This does not mean that every scientist in every bit of current research must study and incorporate history. Rather, overall science must recall and understand past failures and past successes in order to build on the latter and avoid repeating the former. Ecology needs evolutionary history, genetics needs developmental history, and science needs history of science to recognize and benefit from past constraints and opportunities in various ways.

To demonstrate the value of history at all levels, I look at classic arguments that history helps us to do the best science.

1. Why study history of science?

Traditional arguments cluster in five areas:

- Self-Improvement: history illuminates science and makes us better (Sarton)
- Efficiency: avoids repeating the past, we learn from mistakes (Mayr)
- Perspective: provides judgment and clarity, and thereby makes science better (Mach)
- Imagination: offers wider repertoire of ideas to choose from (Edison)
- Education: promotes public understanding of science and scientific literacy (Holton, Brush)

Self-improvement – of ourselves as scientists and as humans

George Sarton put forth this view. As America's premier (by which I mean first) professional historian of science, Sarton stressed that science is a human activity, which stresses man's special creativity and humanness. Sarton's own research explored the roots of science – which took him farther and farther back – to Babylonia and beyond. In his book, *The History of Science and The New Humanism*, he confessed some frustrations and doubts. One dreary, cold day, he was in a melancholy mood and asked about his own historical work,

> Is it worthwhile?
>
> That is what I could not help asking myself on that grey afternoon: Was it really worthwhile? Was I on the right way? Why interrogate the past? Why not let bygones be bygones? There was so much to do to go forward or simply to exist, so many practical problems the solution of which called for immediate action. Instead of taking infinite pains to unravel an irrevocable past, was it not wiser to raise crops and live stock, to bake bread, to build roads, to minister to the poor and suffering? Was I not like an idle man in a very busy world? In each of these homes yonder on the hills and in the valley, there lived people who took up one urgent task after the other; they had hardly time to think or to dream; they were swept away by the needs of life. Then I looked around me and for a while I forgot my own perplexity.

With that look around, he regained his confidence. He was, after all, in the hills outside Florence, Italy. To be sure, he noted "The study of history, and especially of the history of science, may thus be regarded, not only as a source of wisdom and humanism, but also as a regulator for our consciences: it helps us not to be complacent, arrogant, too sanguine of success, and yet remain grateful and hopeful, and never to cease working quietly for the accomplishment of our own task" (Sarton 1931, pp. vix, 190). So, for

Sarton, history illuminates the fundamental nature of science and the doing of science and makes us better – as humans and scientists. And our understanding of the natural world through science was a pinnacle of human achievement for Sarton. This made the history of science an intellectual pursuit central to science, a point he tried to make as he sought to establish a program at Harvard, as he established the journal *Isis*, and as he called for professionalization through academic societies and graduate training.

2. Efficiency

For the eminent biologist/historian Ernst Mayr (surely one of the most powerful and persistent biological minds of the 20th century) history plays various roles, especially for helping us to understand basic concepts better. This is critical since, for Mayr, concepts (such as "species" or "adaptation" or "evolution") have a rich historical development that influences their current meaning. In addition, history reveals the many mistakes of the past. Those mistakes place constraints on and otherwise influence our views. But recognizing the mistakes helps us get beyond them and prevents us from making the same mistakes again. "In science" Mayr notes, "one learns not only by one's own mistakes but by the history of the mistakes of others" (Mayr 1982, p. 20).

Examples of mistakes because of ignoring history abound. Evolutionary biology would have predicted the rise of mutations and adaptation, but society enthusiastically doused crops and forests with pesticides and produced populations susceptible to infestation. Similarly, dousing prostitutes with antibiotics contributed to the production of antibiotic-resistant "bugs." "Darwinian medicine" and study of the natural history of diseases has begun to acknowledge the need for historical thinking. Scientists who do not respect the contingencies of their historical research context are likewise susceptible to "infection," resistance to valuable ideas and lines of thinking, and thus loss of research vitality (Williams and Nesse 1994).

3. Perspective

Others such as physicist and would-be philosopher Ernst Mach have argued that history provides perspective and allows scientists to make better judgments of their own work and of that of others. Reflection provides clarity of vision. As Mach wrote, "They that know the entire course of the development of science, will, as a matter of course, judge more freely and more correctly of the significance of any present scientific movement than they, who, limited in their views to the age in which their own lives have been spent, contemplate merely the momentary trend that the course of intellectual events takes at the present moment" (Mach 1960, pp. 8–9).

This is especially true for developmental biology. As embryologist and historian of embryology Jane Oppenheimer pointed out, in embryology, even as the new becomes fashionable, the old is "never completely outmoded." Embryologists – like the embryos they study – never wholly discard the old, which is captured in successful (or adaptive) scientific ideas, just as the developing embryo captures successful adaptations from its evolutionary history. Thus the good embryologist might study the whole organism, then cut it up into tissues, then layers, cells, cell parts, all the while necessarily keeping the integrative powers of the whole and constraints from the past in sight as well.

As Oppenheimer put it "The integrative powers of the embryo, at all of its levels, are however so pervasive that they never permit themselves to be overlooked by those who avail themselves of the privilege of looking at the embryo at all. The result has been that when each of the practices just enumerated became fashionable, the previous one was never completely outmoded; and when at each stage of its development, embryology has added a new dimension to its studies, it has never wholly discarded the old ones" (Oppenheimer 1967, p. 9).

As developmental neurobiologist Marcus Jacobson put it in 1970, "History not only illuminates the present state of our knowledge but gives us a kind of foresight." Looking back, he saw neurobiologist Santiago Ramon y Cajal and others as having pursued valuable ideas and approaches that had been set aside in the rush of progress forward on certain selected cutting edge problems, each focused on the moment and losing sight of the larger picture (Jacobson 1970, p. v).

More recently, a series of articles in *Science* in December 1995 reflects the failure to keep history in mind – and the ability to rediscover what we once already knew. In discussions of chromosomes and the value of looking beyond genetics to notice that there are whole morphological chromosomes out there in the cells, one article ended: "Taken together, these studies indicate that chromosomes are not passive gene carriers of the cell division process, but complex organelles that possess both motor activities and the capacities to initiate and respond to cell cycle controls" (Science 1995, p. 1600). This may surprise some molecular geneticists, but the only surprise to leading cytologists and embryologists of the 1890s to 1930s would have been that anyone was surprised. It was only the seduction of the flashy cutting edge science that threw the strongest light on molecular genetics that allowed us to forget the past study of the chromosomes and other cellular parts as essential to the hereditary and developmental processes.

4. Imagination

Still a fourth view is suggested by Thomas Edison, who held that "many new ideas are simply clever adaptations of old ideas" (Wachhorst 1982). The richness of the past preserves old ideas and expands our imaginations, stimulating clever new interpretations and suggestions. Embryologist James Ebert pointed to this intellectual ferment in his 1965 text *Interacting Systems in Development*. "The field of developmental biology is alive;" he urged, "the pot is boiling, but it must be stirred vigorously . . . It is essential that, from the outset [researchers] grasp the concepts of the field and come to grips with the problems confronting us, the origins of these problems, and the framework and intellectual milieu in which they are being approached." Content and origins of ideas – and of embryos – must be central to developmental biology (Ebert 1965, pp. v–vi).

As biologist Edwin Grant Conklin had noted earlier, without a proper evolutionary and developmental perspective, biologists are a lot like squid "moving rapidly backward while excreting large quantities of ink" (Conklin, n.d.). And a more recent neurobiological contribution notes the value of moving beyond the particular focus on serotonin and physiology to explore the historical role of evolution. An article in *Science* (19 January 1996) showed that serotonin levels in individual crayfish are determined by the social relations and by reactions for competition and dominance. The work was called "a potentially incredibly exciting area of investigation" (Barinaga 1996, p. 290).

5. Education and public understanding of science

A fifth view stresses the public role of science, the way history of science promotes public understanding of science through education. This is particularly important with current concern about the eroding commitment to scientific careers and in the face of a preference for superstition over science, and a growing public willingness to inhabit a demon-haunted world rather than one illuminated by science. (Sagan 1995; Burnham 1987). The idea here is that history helps show how science is really done, by real people, who are fallible and who make mistakes even though science overall makes real progress. This makes science more accessible and more inviting, and discover-based experience produces excitement and effective scientific "habits of mind" (American Association for the Advancement of Science 1990).

6. Conclusion

The first four areas show the value of historical thinking for science and the scientific work done. The fifth argues for the importance of history in promoting public scientific literacy by getting “right” the story about how science works. We do this not only, as Florman suggested, to show that science is done by real, fallible, and sometimes confused and sometimes brilliantly creative humans. Nor only to show that science is not quite neat and tidy in conforming to a prescribed scientific method as the textbooks would have us believe. And certainly not at all, as some critics of science have asserted, to suggest that science is a dominating and undesirable social construction by (mostly male) humans.

Rather, the greatest value of history can be in revealing to scientists and a literate public alike that science is an essentially productive historical (and evolutionary) process. Scientists develop ideas and approaches, and they can at times compete quite viciously and energetically as David Hull has shown so effectively in his *Science as a Process* (Hull 1988). Scientists can change their minds dramatically, as T. H. Morgan did about the Mendelian-chromosome theory when his strongly argued articles against the theory appeared in 1910, just as his Nobel-Prize winning work on the white-eyed male *Drosophila* also appeared (Morgan 1910a, p. 120; Morgan 1910b, p. 449). Scientists can decide that they develop scientific knowledge to be used in advocating particular positions, as conservation biologists such as E. O. Wilson, Peter Vitousek, or Jane Lubchenco have done in recent years (Wilson 1992; Vitousek et al. 1997, p. 494). Individual scientists can persist in supporting a particular position in the face of overwhelming counter evidence, just as non-scientists can hold resolutely to a favored position no matter what. Yet science as an effort accepted by the larger community moves on, comparing and collecting and correcting such that some ideas are embraced as better-founded and more promising for future work, and other ideas are set aside.

Seeing such cases does make the doing of science seem more human, more exciting, and more accessible to potential young scientists. Seeing that despite the competition and imperfections and false turns, the system does work as corrective to produce good and useful knowledge: this is the greatest value of history. Science is an historical process, a dynamic, interactive, responsive process, infused with human values. And that makes it better. Therefore, the scientific community needs history of science. And we historians and philosophers of science benefit from reminders such as Hull’s to pay attention to our scientific audience. I first encountered Hull’s work in Goodbody Hall, in Bloomington, Indiana. That is home to the History and Philosophy of Science Department at Indiana University, and the modest library there has always provided a place for graduate students to gather, read former students’ dissertations, and to experience admiration and amusement at those earlier efforts. Thus, in 1972 as a new graduate student, I peered at Hull's 1964 dissertation on "The Logic of Phylogenetic Taxonomy." Its 239 pages included almost no history, but it was about science and it suggested ways that the history could fit too. For those of us so inclined, Hull suggested that it was possible to bring together philosophy and a little history while also actually paying attention to the science. This was something we aspired to, but did not see much hope for as the faculty members in history of science lined one side of the hall and the philosophers of science the other, and they had little contact with "real" scientists. Hull and a few others suggested, through their presence in those library volumes, that we could transcend these boundaries nonetheless, and we wondered who this guy was.

The more I learned of Hull and the better I have gotten to know him over the subsequent years (oops – decades now!), the greater my admiration has grown. He quickly became a model of why we should do history and philosophy of science, and I have enjoyed working with him in ISHPSSB (the International Society for the History, Philosophy, and Social Studies of Science, fondly called "Ishkabibble") and elsewhere. I have been impressed with his activity and leadership roles in biological organizations and have tried to follow his lead by working closely with biologists. David never settles for the obvious answer or the easy way of doing things. He cares about science, and he inspires others to care. He does not let us rest easily, but as a critic, editor, and colleague demands high standards and rigorous scholarship. He annoys us at times, and that is good. He inspires us as well, and we admire him and like him tremendously. David Hull's influence will remain alive in Goodbody Hall and other places where people really care about biological sciences and scientists. And he stands for using history of science (and philosophy of science, of course) in order to do better science and to enjoy science more. We should take his example seriously.

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