Bringing History, Philosophy and Science Together in the Lab

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Abstract for &HPS2

In recent decades many historians of science have engaged in replications of past scientific experiments, mainly for the purpose of supplementing or correcting the text-based understanding of the works of particular scientists. In this paper I propose a different motivation for doing experimental replications, and argue that this mode of experimental work provides a novel and effective method of integrating history and philosophy of science. These points are illustrated by reference to two recent experimental projects I have been engaged in: one on the boiling point of water and the other on early electrochemistry, both based on experiments from *circa* 1800. The presentation will be accompanied by some video clips of the experiments.

The proposed mode of experimental work is focused principally on the phenomena exhibited in the past experiments, rather than the exact circumstances under which those phenomena were produced. With this focus on phenomena it becomes very interesting to investigate points of *incredulity*, where past scientists report experimental results that sound unlikely or mistaken from the standpoint of modern science. These points of incredulity present us with possibly real phenomena that have become lost to science. A successful replication of the experiments in question can help convince us that the strange things that we have found in the historical record are genuine and reproducible phenomena, not transient anomalies due to errors, misrepresentations or idiosyncratic contingencies. Then we have a recovery of lost scientific knowledge through historical–experimental work.

From my own recent work, variations in the boiling point of pure water (under standard pressure) offer a wonderful example of such recovery. These unruly variations, depending on the material of the vessel employed, the exact manner of heating, and the amount of air dissolved in the water, were reported by a large number of 18th- and 19th-century scientists including De Luc and Gay-Lussac. These anomalous-sounding results were quite easily reproduced in my own experiments.

The possibility of such recovery of lost knowledge alerts us to an important function of historiography that is often neglected: to challenge accepted assumptions of the present, and to learn from such challenges. At least since Kuhn, historians of science have been sensitive to the triumphalist framing of history that scientists often

make, especially after a scientific revolution. If we take it as a legitimate and important task of historiography to challenge such tidied-up narratives, there are few better ways of doing so than digging up natural phenomena that are not supposed to happen, and highlighting the importance of those that are supposed to be unimportant. All this is a reminder of important critical role for history: knowing that thing were done differently in the past is a reminder of the contingency of certain assumptions that we tend to accept as necessary today. Learning the cogency of now-rejected theories can also serve the same function, but the recovery of phenomena forgotten in the course of scientific development tends to make a much more powerful impression.

The recovery of lost scientific knowledge also serves a fundamentally philosophical function, though perhaps not in the ordinary sense of "philosophical". At least in the philosophy of the special sciences, an important aim of philosophical thinking is to scrutinize the standard assumptions that scientists make. Focusing attention on lost or neglected phenomena is a most effective and powerful way of throwing fresh critical light on the modern theories that are broadly taken for granted. Much of this effect emerges in the attempt to *understand* the recovered phenomena, through which surprising gaps can be revealed in the modern understanding of the phenomena. For example, studying the details of the boiling-point variations reminds us that the traditional thermodynamic discourse on phase changes consists of phenomenalistic idealizations that are not well-founded on an understanding of microscopic or causal mechanisms.

This point is also illustrated very nicely through the replication of one of the simplest and most intriguing experiments in the history of electrochemistry, published by William Hyde Wollaston in 1801. Wollaston began with the well-known observation that certain metals dissolved in acid releasing bubbles of hydrogen. For instance, a zinc wire placed in hydrochloric acid (HCl) releases hydrogen. Add to this same pot of acid a copper wire, and no reaction happens on that side since HCl does not attack copper and other metals higher on the electrochemical series. Now if we make the two wires touch, hydrogen bubbles immediately start issuing from the copper as well the zinc. Wollaston used this experiment mainly as an argument in favor of the chemical theory of the Voltaic pile against Volta's own contact theory; trying to understand the experiment in modern terms reveals surprising challenges. Modern textbook accounts say that the H^+ ions in the acid take electrons from the zinc to turn themselves into hydrogen gas, which turns the zinc into Zn^{++} ions, which dissolve in the acid solution. But if that is what happens, why does the reaction generate any *excess* electrons that travel over to the copper side to make hydrogen gas there? Many intriguing variations can be made on this experiment, and all of them are quite challenging to explain in modern terms. It is also easily agreed that the topology of Wollaston's experiment is the same as that of the Voltaic cell: two different metals with an electrolyte between them. The investigation of these experiments show that the Volta–Wollaston controversy was never quite resolved satisfactorily, and that even in modern chemistry we do not have a ready understanding of the Voltaic cell. Further experiments and thinking should lead to some new knowledge and understanding.

In summary, the lab is one of the most effective places to bring together history of science and philosophy of science, with a shared critical aim. The history–philosophy integration here is achieved by the focus on phenomena, on nature itself. This critical mode of HPS serves to advance our knowledge of nature, which also makes it an inherently scientific enterprise. The aims of this mode of integrated HPS, which I have dubbed "complementary science" elsewhere, are in fact continuous with the general aims of science.