Microcosmos: Digital Media and the History of Science

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Adrian Johns, Associate Professor in the Department of History at the University of Chicago, discussed the ongoing development of *Microcosmos*. *Microcosmos* is an online system to aid students in their study of the scientific method and the history and philosophy of science through interactive exercises utilizing primary sources from past scientific work in astronomy.

By way of introduction, Johns explained that *Microcosmos* uses digital media to teach the history of science in a way that printed media can't, particularly, by allowing learners to simulate the use of scientific tools and engage in the success and failures of scientific discovery. Johns rooted this work in the conceptual historical study of science, an emerging field that has grown since the 1920s and that is centered on the meaning of practices, where science is actually done. Johns continued that to "do" history today is to look at knowledge-in-the-making, and especially, science as the teaching of skills. Johns related these trends to Michael Polanyi's notion of "tacit knowledge" — knowledge that is not written down but rather transferred through apprenticeships; in other words, knowledge understood as the possession of skills. Johns reported that these arguments have recently been extended to theoretical science, where they direct attention to such questions as how today's physics grew to be largely dominated by theoretical mathematical physicists.

Johns then recounted *Microcosmos'* genesis. He traced it back to the 1990s and an opportunity to compete for a large award to support utilizing digital technologies in the history of science. He briefly described his proposal as having involved producing digital images of historic and modern laboratories (and particularly, the instruments contained in them) as a means to teaching the dynamic aspects of the history of science. He said his proposal didn't win but that the sponsoring institution did fund a small part of it, which became "Microcosmos: Pathways of Thinking."

Johns next described the site (http://microcosmos.uchicago.edu/microcosmos_new/index.html). He explained that it is divided into four parts related to ways of doing math (or historical systems of astronomy: Ptolemaic, Copernican, Keplerian, and Newtonian). Each has associated with it a set of readings or texts, instruments, and experiments. He directed special attention to a section devoted to student projects, which, he specified, consist of reproductions of debates, not essays. He provided a few examples. First was "Glass Works," which recreates Newton's glass prism

experiment from start to finish (having set it up, users can then run it). Johns noted in doing so it also reproduces the problems Newton faced in conducting the experiment. He clarified that this is the kind of project he wants to get students to write.

The second example was, Johns said, a bit more mathematically complicated; it recreates the prediction of the future arrival of a comet. Johns explicated how figuring out the ellipse based on a location on earth had originally done this and which comets have that parabola. Johns indicated that the project reconstructs these steps. Citing a third example, that of the "Virtual Orrery," Johns stated that it provides a good sense of what it was like to create such a model in the 18th century.

Elaborating on the latter point, Johns indicated that the core of the more complicated projects, in general, is the replication of how people made mathematical theories. One project embodying Pre-Kepler preconceptions and/or assumptions aims to explain the path of planets based on circular motions. Johns clarified that this is not easy to do because planets retrogress; thus, he continued, one needs a combination of circles. He reiterated that the exercise demonstrates what it was like to produce something like this at the time it was produced. Johns said that the precedent for the project was a model of how the planetary system works that had been printed within a 17th century book, which included an actual slide rule {and threads} that illustrate planets' paths. Johns expounded that these were essentially analog computers, and were how one learned to be a mathematical astronomer. He noted that one could use the original 16th century model to calculate quite accurately the position of mars at any moment in history. He further noted that the digital model is less accurate, because developers were unable to render its (actual physical) threads finely enough.

In closing, Johns said that the core of what Microcosmos is trying to do is develop a way for users to make their own astronomy theories, by providing the mathematical tools and allowing one to, for example, set Earth slightly off-center. He said the system lets one build a whole planetary system that one can then compare to the real. He reiterated that his hope is that it will encourage students to a discussion of what it took to develop the model of a whole system like this. He elaborated that creating a model with Earth wobbling on its axis, for example can get at something that was a real puzzle for scientists of the past.

Johns also reiterated his desire *not* to over-digitize microcosmos such that users become acquainted with only with online tools and resources and to instead make it such that they

interact with actual physical objects. By offering PDFs or blueprints that users can print out and paste onto cardboard, he illustrated, they can create a sort of renaissance computer. He said they could do this for every planet. He ended by restating Microcosmos' instructional purpose; namely, to capture theoretical practice and get to something consequential about partial and finished theories.