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Intro to the History of Technology
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does knowledge separate or connect us?

What are “science” and “technology”? What is the difference between science and technology, or discovery and invention, or Ω and λ , as Mokyr puts it?

Joel Mokyr, in *Gifts of Athena*, offers a social, economic, and political history of science and technology. His analysis is, truly, a historical one. Even so, his argument is based on the abstract and philosophical idea of “knowledge.” Instead of philosophizing about the origins of “knowledge” in man or solely rooting knowledge in isolated historical events, Mokyr defines knowledge in terms of the actual and intellectual (or historical and philosophical) relationship between science and technology.

But Mokyr is careful about using the terms “science” and “technology” in his text, for today, these words are loaded with both big picture philosophical meanings and every day consequential and matter-of-fact definitions. In his argument, Mokyr constructs two *new* conceptions of knowledge, Ω and λ , to show the historical evolution of knowledge in relation to “science” and “technology.” He roots his distinction of the two kinds of knowledge, which I will explicate in a moment, in historical innovations and inventions, such as the telegraph, the color mauve, Aspirin, and electricity, while also considering social, economic, and political climates. Mokyr tells the story of the relationship between science and technology.

In this essay, I first define what Mokyr calls Ω and λ knowledge and deconstruct the ideas of “science” and “technology” in light of Mokyr’s definitions. I then discuss the *relationship* between “what” and “how” knowledge by examining the evolution of the

uses of knowledge. Finally, using Mokyr's idea of the "Industrial Enlightenment" and the history of the dye industry, I explicate how these two types of knowledge fundamentally changed nature of work. I seek to show that even though Mokyr asserts that "what" and "how" knowledge *are* in dialogue with one another, it is the division of these knowledge-types that radically changed the structure of society and politics by socially and politically elevating the possessor of knowledge while lowering the one who lacks knowledge.

Mokyr limits his discussion of knowledge to useful knowledge. Since he is primarily concerned with science and technology, Mokyr only defines knowledge in terms of objects and ideas that can be employed. His task is to observe *how* humans interact with and use "the world." Here, Mokyr divides "useful" knowledge into two types, "what" and "how" knowledge. "What" knowledge consists of beliefs about the world while "how" knowledge refers to the use of ideas.

"One is knowledge 'what' or *propositional* knowledge (that is to say, beliefs) about natural phenomena and regularities. Such knowledge can then be applied to create knowledge 'how,' that is, instructional or prescriptive knowledge, which we may call techniques. In what follows, I refer to propositional knowledge as Ω -knowledge and to prescriptive knowledge as λ -knowledge." (Mokyr 4)

λ knowledge consists of ways to employ Ω knowledge. In this definition, science refers to "what" knowledge and technology refers to "how" knowledge (Mokyr cautions and warns the reader of this understanding, saying that science and technology are not simple terms with basic definitions, but for the sake of brevity and ease of understanding, I will risk making this connection). From the start, Mokyr sets up these two types of knowledge in relationship with each other.

Propositional knowledge has two forms, according to Mokyr. The first form relates to the mastery and identification of nature while the second is about the creation of new ideas about nature. Ω knowledge is passive and represents a direct connection to nature. “What” knowledge is vast, and, as Mokyr says, as long as people believe this information to be correct, the information will exist in the massive body of propositional knowledge (Mokyr 6). Mokyr also asserts here that this what knowledge is societal knowledge: “In the end, what each individual knows is less important than what society as a whole knows and can do” (Mokyr 7). Propositional knowledge is collected by and intended for a community, not solely by and for an individual.

Prescriptive knowledge is, then, Ω knowledge in use. The body of λ knowledge consists of *ways to do* things. “Techniques are the fundamental unit of the technological knowledge set. They are sets of executable instructions or recipes for how to manipulate nature...” (Mokyr 10). For Mokyr, “how” knowledge is employed or expressed knowledge. Mokyr relates how knowledge to the production of a thing, or an invention. λ knowledge consists, “...of designs and instructions for how to adapt means to a well-defined end...” (Mokyr 10). How knowledge tells us how to use our prescriptive knowledge.

Mokyr now asks whether or not this distinction is useful. He notes a fundamental difference between additions to each body of knowledge: “An addition to Ω is a *discovery*, the unearthing of a fact...that existed all along...An addition to λ is an *invention*, the creation of a set of instructions...” (Mokyr 12). He continues on to say that this difference *really* means that Ω knowledge can be correct or incorrect, while λ can only be successful or unsuccessful (Mokyr 12). Mokyr again asserts the dependency of

λ knowledge on Ω knowledge: a technique is dependent on a body of “what” knowledge.

As Mokyr points out throughout the rest of his book, “what” and “how” knowledge had a strong relationship. Ω knowledge and λ knowledge were codependent. “The two types of knowledge, propositional and prescriptive, kept reinforcing each other” (Mokyr 85). Both types of knowledge interacted in new ways -- they were “co-evolving.” Mokyr says more explicitly that Ω knowledge was constantly being mapped onto new techniques, or λ knowledge. Here, he identifies a “positive feedback” system between “what” and “how” knowledge. “The other direction in which useful knowledge moved, back from λ to Ω , provided the positive feedback between the two types of knowledge and led to continuous mutual reinforcement” (Mokyr 96). Mokyr identifies three types of feedback, including the ideas of research and experimentation. He says that the advent of research science aided this feedback. He continues on to say that the relationship between “what” and “how” knowledge was the very basis of the Industrial Revolution (Mokyr 101). Mokyr attributes this relationship to what he calls the “Industrial Enlightenment.” “Yet...by 1800 or so, the mutual interaction between propositional and prescriptive knowledge reached the critical area...This was precisely the nature of the Industrial Enlightenment” (Mokyr 65). For Mokyr, this new notion of enlightenment, or the relationship between Ω and λ knowledge, bridged the gap between the emergence of “science” and the actual Industrial Revolution.

I turn now to take a look at the evolution of the dye industry, for its story tells of the importance of knowledge and shows *how* knowledge changed society and the world of work. In an essay on the “Industrialization of Invention,” George Meyer-Thurow offers

an economic history of the dyestuffs industry. He starts by saying that it was the dye industry that occupied the space between “what” and “how” knowledge. “In the early years chemist-entrepreneurs...bridged the gap between theory and practice” (Meyer-Thurow 365). To Meyer-Thurow, it is the dye industry that explicates the development of the role of knowledge in the Industrial Revolution, or what Mokyr would call, the evolution of the Industrial Enlightenment. Meyer-Thurow notes the importance of academic research and science in the development of the dye industry, but still realizes that much of the innovation in the dye industry was due to inadvertent realizations. “Until the 1880’s progress was due to chance discoveries, which relied in part on empirical trial-and-error, in part on the results of academic research” (Meyer-Thurow 366). One can see here that the dyestuffs industry slowly started to use Ω knowledge to build new techniques. In other words, the positive feedback created by the relationship between Ω and λ knowledge aided the advancement of the dye industry.

Meyer-Thurow also considers the economic influence and the effects of society on the development of the dye industry as agents of progress. He cites the growing presence of large corporations and the increased significance of research in the dye industry.

“Economic factors encouraged institutional change in response to this rapid advance of scientific work in the field of dyestuff chemistry. A small group of big corporations...now dominated the market and therefore possessed enough financial power to risk investing in the uncertain future of research...In addition...research offered a strategy that might reduce dependence on the ups and downs of the business cycle.” (Meyer-Thurow 267)

In addition to the roles of “what” and “how” knowledge, the economy and the appearance of the research-corporation were important factors in the progression of the Industrial

Revolution. Meyer-Thurow also references the rise of German patent law as a key factor, inasmuch as it encouraged collaboration between the academic world and the industrial world. He says that it was actually the legal warfare in the world of dyestuffs that brought the two closer together. “Thus cooperation between academic scientists and industry, characteristic of the early history of the dyestuffs industry, continued to be important” (Meyer-Thurow 368). This relationship made chemists, who started out as simple tinkerers “playing” with nature, more academic. In the dyestuffs industry the production of knowledge became important.

It is the relationship between the “knowers” and the “doers” (or the manufacturers and the scientists, or the Ω and the λ) that fundamentally changed the nature of the factory, the corporation, and society. In the 1880’s, Meyer-Thurow says that the laboratory contributed to this separation and the division of labor was reinforced (Meyer-Thurow 373). He says that even though the differences between a university research lab and a corporation research lab gradually diminished, the polarity between the owners of the research lab and the workers in the research lab increased. “But the personal contact between management and scientists diminished, confronting management with the problem of...how to control the process of invention” (Meyer-Thurow 373). Even though “what” and “how” knowledge were in perfect dialogue with each other, the people who used this knowledge became increasingly more detached. As corporations such as The Bayer Company grew, the actual work each individual chemist did became more specialized.

It is precisely this specialization that striped all control from the individual chemist or worker. According to Meyer-Thurow, in the dyestuffs industry, “Specialization meant

that the investigations of the chemist working in the main scientific laboratory were restricted to a very narrow field of dye chemistry” (Meyer-Thurow 377). Unlike in the early days of the dye industry, when it was the chemists themselves who directed their own research, the new chemist in the research corporation no longer saw the result of his research. He became separate from the big-picture consequences of his chemistry, since he was told to work on isolated projects. The chemist himself no longer knew what he was doing.

I have attempted to briefly define what Mokyr calls Ω and λ knowledge, or “what” and “how” knowledge, and to show that even though Mokyr says that there is a positive feedback between these two types of knowledge, this positive feedback fails to be visible in the expression of knowledge, or in work. By showing a brief history of the dyestuffs industry in relationship to the Industrial Revolution and the Industrial Enlightenment, I have clarified *what* the division of knowledge does to society. I have, admittedly, ignored the entire evolution of the field of Information Technology, which Mokyr says attempted to reduce the cost of access to knowledge and aimed to “even” the playing field, which I have shown to be unbalanced. I will end with a question; how would the user/producer aspect of the Internet affected the dye industry? Would individual chemists have taken the initiative and published their own findings on their own? Would an unbiased system of Information Technology with the ability to both be a producer of knowledge and a user of knowledge have changed the way the chemical industry functioned?

Works Cited

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