The wells of epistemology

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> The deep wells of science have smaller wells that feed on their knowledge; and these wells have lesser wells, thence goes epistemology.[1]

At the end of the last lecture of my career, a graduate course on fluid dynamics, I offered a philosophical statement to the students. This probably was not a surprise for them; throughout the course we folded in discussions of science philosophy and epistemology to go with Navier-Stokes and the rest of it. I introduced my final statement as a brief history of science. With an accompanying sketch on the chalkboard, it went something like this.

Early on we had natural philosophy and the things we now refer to as the humanities — broad wells of knowledge with incipient secondary wells (Figure 1). The barriers between wells mostly

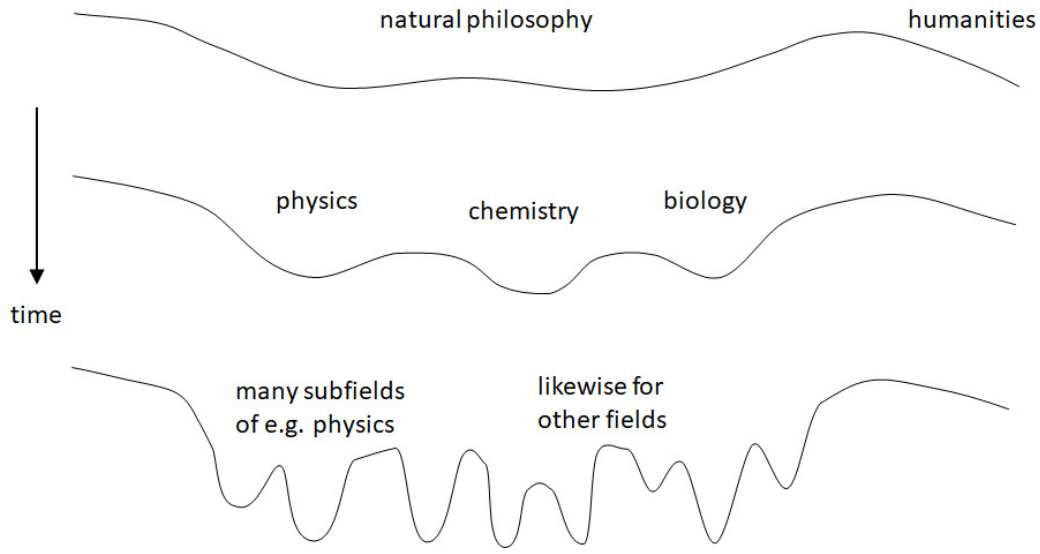

Figure 1: Cartoon showing the deepening wells of science knowledge with time. One can readily envision adding as many wells, and wells within wells, as desired to complete the picture.

were neither steep nor high. Then, particularly in the 19th and 20th centuries we experienced a deepening of these wells, with wells developing within wells. This has continued, with increasingly narrow yet deeper wells. Now the barriers separating many wells are steep and high. And we seem to gaze less toward the well of knowledge in the humanities — a serious mistake.

These are energy wells, in the sense that it takes effort and energy to get out of them and visit and examine what is in other wells. Moreover, the narrowing and deepening of the wells means

[1] I could not resist the allusion to the topic of turbulence and the energy cascade, that "Big whirls have little whirls, that feed on their velocity; and little whirls have lesser whirls, and so on to viscosity." (L. F. Richardson)

that many have become echo chambers.[2] We seem to imagine that the only things we need to learn exist within our own well — an unfortunate mindset. As a consequence we increasingly pursue mostly incremental science within our well, lacking the know-how to discover and bring fresh ideas from afar that make for disruptive science. And unfortunately our system now rarely rewards this type of effort. Nonetheless, let us resist:

> ...Thou art no slave
> Of that false secondary power, by which,
> In weakness, we create distinctions, then
> Deem that our puny boundaries are things
> Which we perceive, and not which we have made.
>
> William Wordsworth, *The Prelude*

Let us purposefully make an effort to get out of our wells. But how to do this?

Embrace the universal languages. This starts with mathematics, and then depending on our interests and fields of study, cascades to areas of physics, chemistry and so on. Acquiring new knowledge — learning — requires preexisting knowledge, and the universal languages are well suited to providing access to unfamiliar material. We of course cannot learn it all. So consider a style: Accept that learning is a stochastic process, then never stop being an eager student, opportunistically examining unfamiliar things and ideas. And let us not be afraid of — indeed delight in — rabbit holes. This semester we dived pretty deep into the basics of fluid dynamics, a universal language. To wit, recall our first homework question: to consider the manifold processes involved in the topic of your thesis work, and identify at least three that do *not* involve a fluid. A simple but hard question; and now we know why, with deeper insight.

[2] Indeed, many of the numerous wells in my own nominal area of expertise, Earth surface processes, have become echo chambers. Although the topic of a separate essay, one manifestation of this is the recycling of "accepted" physics and the surprising paucity of citations of the physics and mathematics literature, despite the claim of being a physics-based field.