# LOOKING GLASS WORLDS

Don L. Anderson

Ordinary science proceeds in the following way: once we have our ground rules, assumptions, protocols, and data, we are ready to make incremental advances in our chosen field. But how do we decide whether our paradigm is better than another? We know how to compare hypotheses, but how do we compare paradigms that involve the whole infrastructure of our research program, including the language we use? Statistical and logical tests often are of no help. Formal logic tells us that failed predictions and counter examples are not enough to falsify a proposition. As failed predictions and conflicting evidence accumulate, one might make continual adjustments to the theory. But it seldom occurs to a practitioner to jettison everything and start afresh with a blank slate; there is too much baby in the bathwater.

When Alice in Wonderland went through the looking glass, she entered a world with different rules. Few of us have had the experience of discovering that the rules that had been guiding our research for the past years or decades were all wrong, that the predictions of our theories were wrong, that the assumptions were wrong, that our professors were wrong, that our textbooks were wrong. This has happened famously in astronomy, cosmology, physics, and chemistry. Scientists abandoned Ptolemy, Aristotle, alchemy, astrology, and static universes. In a more recent paradigm shift, Earth became a dynamic planet with drifting continents and young oceans, exposed to giant impacts that created the Moon and extinguished dinosaurs. Uniformitarianism and fixed continents bit the dust; catastrophes became acceptable. The new ideas are now all part of conventional wisdom, and few of us recall the mindsets that were in place when a different conventional wisdom prevailed.

Young scientists are taught the scientific method and the rules of deductive logic, but are not taught how to deal with the trauma of having all the rules change in midstream, or even that they might.

What follows are two paradigms—looking glass images of each other.

The motivating question for your research program is "Why don't volcanoes exist everywhere?" You know that plates drive themselves; they are deformable, breakable, and ephemeral, constantly reorganizing; new plate boundaries form and old ones close up, forming volcanic chains that tap a hot mantle of variable fertility. You view volcanic chains as abandoned or incipient plate boundaries and fracture zones—consequences of plate tectonics. Fertile blobs entrained in the shallow mantle will appear to be slowly moving with respect to quickly moving plates and stationary with respect to slowly moving plates. You know that there can be no absolute reference system, or absolute fixity, in a convecting, rotating, deforming planet.

A group of young theoreticians comes along and challenges the status quo. They ignore your assumptions and make new ones; they ask different questions and do different experiments and calculations. They have decided that the deep mantle is rigid and the upper mantle well stirred. They presume an absolute fixity of volcanic islands, absolute rigidity of plates, an absolute reference frame, and absolute temperature. The upper mantle is isothermal and homogeneous, so deep hot stationary tubes are invoked to bring core heat to the asthenosphere to form island chains. Unfamiliar concepts, such as "absolute motions," "core heat," "box models," "reservoirs," and "primordial mantle" are introduced. Volcanic islands are renamed "hotspots" and "plumes." Volcanic chains are viewed as independent of plate tectonics and relabeled '"hotspot tracks."

You and your friends are asked to judge the papers of this emerging group of talented renegade investigators. The new ideas do not make sense to your peers. In the new theory the mantle is approximated as a solid with bizarre properties. It is fluid but rigid; it is homogenized by chaotic stirring; it is heated from below; it is not near the melting point; most of Earth's radioactivity is in the undegassed lower mantle. Conflicting evidence is accommodated by changing the properties of the tubes, or by blaming approximations in the theory or lack of resolution in the data.

Needless to say, none of these ideas will pass peer review. This is the way science works.

> Paradigm shifts in science seldom involve logic, rational discourse, higher-resolution data, or more-accurate calculations.

But suppose these ideas had come first and had become entrenched in the literature. Suppose that they reflected conventional wisdom. The two paradigms, essentially opposite in every respect, would be treated differently in these Looking Glass Worlds. The defenders of an entrenched paradigm literally do not understand the language and concepts of the invading paradigm. There is an asymmetry in the way new ideas and conventional wisdom are treated—the standards are very much higher for the new ideas. There is also an asymmetry in understanding. The Old Guard is not familiar with the new language, while the invaders know the old ideas very well and have found them wanting. The inability to communicate and to compare paradigms is called *incommensurability* by the philosophers of science; this is probably more important than the concept of *falsifiability*, which is always in the eye of the beholder.

The older readers of this column will remember when our professors ridiculed continental drift, extraterrestrial theories of extinctions, catastrophic floods, and magma oceans; we believed in uniformitarianism, tectogenes, vertical tectonics, and the static-mantle geosynclinal theory. We laugh at the old ideas of fixed continents, but we readily bought into the idea of fixed islands and tubes to the core.

When do not question today's conventional wisdom, we do so our peril—it too may look crazy to future generations.

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