Of Seeds and Continents:

Reliability, Predictability, and Scientific Knowing

Michael D'Aleo

"I am not interested in what you think will work or what should work theoretically; build me a working model!"

This statement was repeated many times in the engineering career I had in the electronics industry prior to my teaching career. The owner and CEO of the company for which I worked had a Ph.D. in physics from Purdue University and had also served in the Navy. He had built the company from nothing, and the key to his success was that every product the company sold would work the first time, would be easy to use, and would be reliable for a long time. He knew all the reasons why something should work, but he was interested in spending time only with the designs brought to him for approval that were actually working models. A successful businessman and scientist, he wanted to see them, feel them, interact with the equipment; he respected the evidence of his senses.

Engineering is different from science because, at the end of the day, you need something that works. During the design phase you develop possibilities, you test them, and, in the end, try to knit these ideas into a whole fabric. You don't need to do a statistical analysis on the likelihood of your computer crashing or your automobile failing to start in the morning. If those things happen regularly, you will cease using the unreliable items and replace them with something that works. If the company that manufactures the product fails to remedy the poor performance, it goes out of business as customers refuse to purchase something that should work but in fact doesn't.

The situation becomes more complex when we leave the created world of the engineered product, a machine, and enter any scientific endeavor in which we are working with an aspect of the natural world. Many engineered products are designed to be worlds unto themselves. The engineer's task is to create a space in which the only laws that matter are those for which the engineer accounts. All interactions are generally lawful because a certain input always results in the same specific outcome. Would you want to drive a car that usually starts when you turn the key? How about a computer that sometimes writes left to right and, at other times, right to left? Nothing annoys a user, or the creating engineer, more than a "bug," an interaction in which an unexpected element has crept into the apparent world of complete control.

That sounds wonderful for machines, but what about living organisms? What are the interactions or variables that control the growth of a plant? We are now beginning to enter that aspect of the natural world in which predictability, expected in the "machine world," becomes less possible. The world of machines is based primarily on inorganic and causal relationships, but the world of living creatures and beings is not. Instead, the organic world is more complex, more environment-dependent, and less predictable or linear.

Seeds of Change

Behind my house there is a small patch where I grow a few vegetables. Early on, I became curious about biodynamic agriculture. I put a few biodynamic preparations on the garden and attended to the effects. When I learned of the availability of biodynamic seeds, I wasn't initially interested. My belief was that it must be the biodynamic preparations that are important; to think the seeds important would be materialistic thinking, right? My curiosity in these seeds was piqued, however, and one spring I potted three different seed suppliers' seeds, working with ten different varieties of plants. The first group was from an organic supplier, the second were heirloom varieties from an organic seed exchange, and the last were the biodynamic seeds. To be fair, I gave all of them the biodynamic preparation and watered them all at the same time. I mixed up the peat pots so that the labels were visible only when the pots were taken out of the flats.

When it was time for transplanting, I removed all of the pots and placed the plants in their three groups for examination. The differences were clear, visually apparent, and not what I had expected. For nine of the ten plants that I had selected, the biodynamic plants were larger, had more leaves, were more upright, and appeared more robust than the other varieties. The one biodynamic plant that didn't do better was corn. The seed exchange, Native American variety, bred locally for hundreds of years, beat the biodynamic corn hands down. I recall that Guenther Hauk, the biodynamic gardener in Spring Valley at the time, laughed about this when I told him of the results with the corn. "Of course," he said, and continued, "this plant is native to North America, and no German biodynamic corn is going to stand a chance against it!"

I could have continued and done all types of tests to check for the yield of each crop, the mass of the plants, their resistance to various diseases, or when they first yielded edible fare. At that point, I didn't feel it was necessary to perform any further investigation. For the type of gardening that I was doing the impressions I had received from looking at the health and vitality of the three groups of seedlings in front of me spoke much more strongly than would any series of charts and graphs proving what had happened.

What I learned from this little experiment was to be open to getting results other than what you expect. What you see in front of you is usually more important than what you expect to see. No one type of seed will always be the best. Understanding why the native corn had grown more vigorously would have required a much longer study, but I did note that this corn had been grown and developed in local conditions near Saratoga. I had chosen the corn, in fact, because it was local, but I had not anticipated any particular result.

As a trained mechanical engineer, I have developed a deep appreciation and love for creating and experiencing how all of the pieces fit together in a lawful and expected manner. This is the gift of a materialistic worldview. Without such a view we wouldn't have any of our present machines. There is an interesting distinction, however, between a science based on physical objects (materialism) and one based on relationships or interactions. The first focuses primarily on the product, the thing. How we create or engineer it is often not so important. This can have important and often negative implications for the environment and space around the desired object. If you have ever been near an old paper manufacturing plant, for example, you may have experienced what I am driving at. The air of the town and the water of the river are usually adversely affected until regulations force the manufacturer to take into account the environment around the plant.

Note that we focus on the product, a physical object, as a noun, while a focus on process or relationship is much more verb centered. Such thinking points toward a move from a science primarily of nouns to one that equally emphasizes verbs. This brings us to a second approach, one based on interactions and relationships.

In this second approach we don't simply focus on the end product, but attempt to make conscious every aspect of the process. This approach often finds complex sets of interactions, even approaching the level of complexity that is found in nature. Often it is not possible to test every possibility. If you have to analyze water purity, the level of testing can be overwhelming. Do you want to check for bacteria and parasites or for heavy metals? What about agricultural runoff, fertilizers, industrial cleaning agents, or trace levels of radiation? Usually a local water engineer will rely on his experience of what might be a problem locally and suggest just those particular tests, a balanced and appropriate approach, but not a definitive one. Here, the complementary strengths of object-oriented and a relational orientation can be seen as mutually beneficial.

Integrating Approaches

Interest in and appreciation of a more process- or relationship-oriented approach to science, as opposed to a strictly object (objective) one, is increasing. Over the past few months I have noted a new pattern in the questions and comments that follow the lectures I give on phenomena-based science to Waldorf school communities and other interested groups. Previously, every single question and answer session contained at least one comment similar to the following.

The comment usually began by relating an appreciation for the implications of a phenomenological approach to science. This was followed by an articulation of a frustration with the classical statistical method in which the questioner had been trained and either presently or recently employed. All of these comments were from persons associated with the medical field and, particularly, the field of medication and pharmaceuticals. These were trained chemists, physiologists, statisticians, and specialists. Most of them had Masters degrees or Ph.D.s in their field.

Each of them stated that the statistical method for proving the efficacy of drugs—a practice they were themselves often engaged in—was no longer effective. Most of them used even stronger language to suggest that the testing had become compromised by a desired outcome that ignored side effects, overstated the product's effectiveness, and often relied on data that was tainted. In short, no one was really paying attention to the whole reason for developing the medication in the first place—the health of the patient. Instead, the sole objective was to show statistical correlations (even if minimal) between specific symptoms and particular substances without significant regard for other possible effects.

One person, focusing on the statistical side of the field, said, "If you take any specific symptom you can likely cite a study somewhere that shows a statistically significant correlation to any drug that has been tested for that symptom." It was sad to hear such frustration and despondence from such talented and obviously dedicated people. One can understand their keen interest and sincere desire to know more about an integrated approach to science, one that focuses on relationships and interactions as strongly as on results.

The possibility of integrating a classical or object-based approach with a phenomenological or relational and integrated approach is potentially exciting. A classical approach must be limited because it is looking for a single causal material effect that can be affected or eliminated by another singular curative material solution. A phenomena-based approach constantly looks for relationships and, therefore, seeks to understand a group of interactions in relationship.

We could, of course, make the claim that all good classical science must be a part of a phenomena-based approach since, in truth, no phenomena should ever be discarded. While this is correct, I have tried to draw the distinction between these two approaches more on the worldview underlying them and not on the investigative approach to phenomena—perhaps defined differently in each worldview—that they share. It is precisely this distinction of which we are trying to make teachers aware in the upper elementary school science teacher training called "Teaching Sensible Science."

I am reminded of the work of Alfred Wegener, the German scientist who first articulated, in 1915, a fairly detailed description of the possibility of continental drift as the means by which our present landmasses have come into being and by which they change over time. Wegener's approach was unusual for his time, and likely ours as well, in that, rather than staying in one area of specialization, he tried to synthesize many different phenomena from many different fields of science. He was initially inspired in his thinking during two successive trips to Greenland in 1906 and 1912 by observing the process of isostacy, the process whereby the earth rises or rebounds after glaciers recede or melt. Wegener thought: If the earth can move up and down, why not side to side?

He then proceeded to investigate many different phenomena relating to the apparent similarity between the eastern coastlines of North and South America and the contours of Europe and Africa at comparable latitudes. Wegener investigated the similar geology of these regions and the common flora and fauna. Even the older fossil records had much in common. In short, Wegener dedicated the next 15 years of his life to trying to show that all these common phenomena pointed to the fact that the contents must indeed move. During his lifetime, his work was generally rejected, ridiculed, and unaccepted.

It took almost 40 years until a number of scientists, generally geologists, could no longer ignore the observations and relationships that Wegener had pointed out. This was aided by the significant number of new observations that had arisen from the regular use of the submarine during and after World War II. By the late 1950s and early 1960s, the scientific world was ready to consider his theory. Today, with the development of accurate Global Positioning Systems, we can actually measure annual changes in distance between the continents. Perhaps we are now ready for a more open view or approach to science in other fields as well. We might say, although this takes us too far afield to consider here, that the best scientists have always worked this way.

Around 1920, when Rudolf Steiner was asked by some of the teachers at the first Waldorf school, what they should be teaching, one of his responses was that in high school, students should be exposed to some of the new thinking that was going on at that time. Steiner saw that a materialistic worldview was beginning to loosen its grip on scientific thinking. One of his suggestions to the high school teachers was that the students in the Waldorf school should become familiar with the work of Alfred Wegener.

This should prompt in us the question: What are the appropriate ways of thinking that are being developed today that will still be valuable for students in schools 100 years from now?

Endnote

1. In the fourth edition of his book, *The Origin of Continents and Oceans* (he was to write five before his death), Wegner once again found it necessary to defend his work and advocate for a more open approach to science. Constantly criticized for crossing the clear lines of specialization that existed in his time (and ours?), he penned the following:

> Scientists still do not appear to understand sufficiently that all earth sciences must contribute evidence toward unveiling the state of our planet in earlier times, and that the truth of the matter can only be reached by combing all this evidence. … It is only by combing the information furnished by all the earth sciences that we can hope to determine 'truth' here, that is to say, to find the picture that sets out all the known facts in the best arrangement and that therefore has the highest degree of probability. Further, we have to be prepared always for the possibility that each new discovery, no matter what science furnishes it, may modify the conclusions we draw.

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