with your own phenomenological model.

Then just wait for the comments of the referee! Inevitably he or she will criticize the *lack of a theory*, even though you have clearly stated that there is no theory as yet and that the old one is not applicable. You may even get an accompanying "comforting" letter from the editor advising you to put "some theory" into your paper. It appears that in the eyes of some referees and editors a physics article is not publishable without mathematical theory, while just which theory you use does not seem to be all that important.

I don't understand this strange point of view. Are we really so mesmerized by mathematics? Shouldn't mathematics be an *auxiliary* science of physics? Where are our intuition and imagination that help us to "see" electrons and ions gyrate around magnetic field lines and space potentials oscillate up and down? Do we really only believe in phenomena when they are clad in mathematics and wrapped inside formulas?

No referee would dare to reject a paper presenting a self-consistent theory that had nothing whatsoever to do with reality, so long as the theory was mathematically correct. Why then are referees often so quick to criticize and reject purely experimental papers because they lack a theory? I see this attitude as just another remnant of the ancient Western–Christian philosophy that the "spirit" (the mathematical theory) is something much more worthy than the "matter" (the experiment), a philosophy that has caused so many problems and taboos from which we all still suffer. Of course it would be ideal if an experimentalist could simultaneously present the experimental data *and* a theory that explained them in every detail. Since, however, most experimental physicists are normal mortals and not universal geniuses (otherwise most theorists would be unemployed), you have only two possibilities: Either try to strain the old and generally accepted theory to suit your experimental data, just to have some equations in your paper, even though *you know* that the theory is inapplicable, or withhold your publication until your theoretical colleague presents a new theory, even if this will take several years. But the first option is unethical, and the second is neither wise nor fair to yourself and your colleagues, who should get an opportunity to verify the new features of the phenomenon.

Just recently I heard a nearly incredible story that shows the contempt of certain theoretical physicists for experimental physics:

A young American colleague and friend of mine was working in the plasma physics department of a high-ranking European university. One day he had an idea for a new experiment and suggested it to the head of the department, a distinguished theoretical plasma physicist. The professor asked him whether there was a theory to explain the expected experimental results.

"Yes," my friend answered, under the impression that he had succeeded in attracting the interest of his superior. "There is a theory, and perhaps we could verify it for the first time with our experiment."

"In that case," the professor replied, "we do not need to carry out the experiment! It is enough that there is a theory."

If scientists of earlier generations had held this weird "Aristotelian" attitude, not even the neutron would ever have been discovered!

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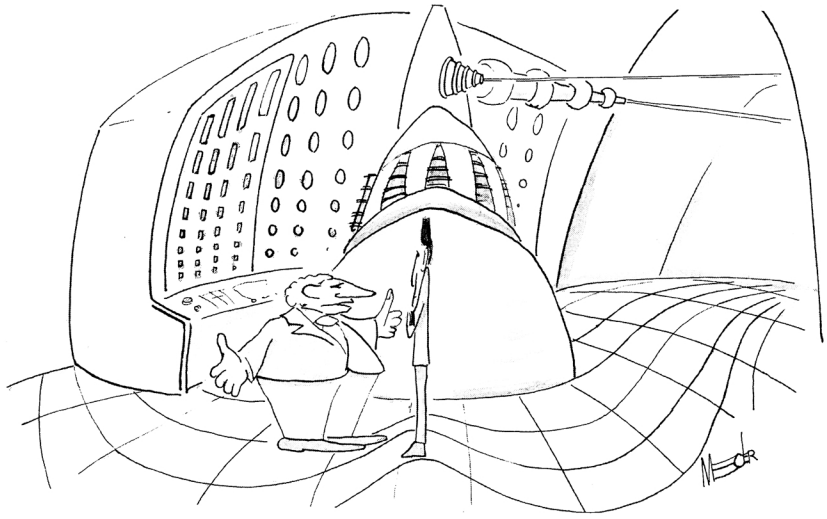
Stereopsis and Science

Arthur Sleight's perspective drawings of $YBa_2Cu_3O_6$ (June 1991, page 28) demonstrate an "obvious" phenomenon that goes virtually unobserved. Because a pair of views of adjacent unit cells is equivalent to the stereoscopic views of a single cell by adjacent eyes, we can see these diagrams in striking stereoscopic 3-D simply by crossing our eyes to fuse adjacent cells. This extension of perception can be used on any photograph of a repeating object that has a translation vector of symmetry normal to the line of sight.

Then we can turn the page 90°, cross our eyes to fuse the images of the two different structures, and instantly perceive the differences between them. The technique is a copy editor's delight—and it's virtually unknown. I have similarly detected planets, comets and asteroids stereoscopically.

Stereopsis is more often than not thought to be identical with depth perception. One physicist, when asked what characteristics we might expect extraterrestrial visitors to have, replied that two eyes with overlapping vision was one of the most certain. He reasoned that space travel implies good spatial reasoning, which implies depth perception, which implies stereopsis, which implies overlapping vision by two eyes. However, some birds have excellent depth perception but no overlapping vision and no stereopsis, and cetaceans probably have sound-wave imaging capabilities. Human "depth" is a coordinated system of many elements: relative motions of visual images as we move, converging lines, haze, stereopsis, touch as we reach out, plus many others.

Likewise, human concepts are coordinated systems of many elements. Missed elements commonly cause misconceptions. Misunderstandings of science have many roots here. The capacity to do work is a complex interaction of many properties of inputs and byproducts of a thermodynamic system but is often oversimplified into a single parameter, such as that expressed by the logical fallacy "Energy is the capacity to do work." An ill-defined, complex colloquial "en-



"Surely, Dr. Lowe, if there were gravity waves, we would have detected them by now."

ergy" is almost universally confused with the well-defined, simple scientific use of that word.

Newton's law of action and reaction is most often popularly seen as meaning that when we act something happens. The *inseverability* of the two forces constituting an interaction is missed. Even rarer is the recognition that Newton's doubt was resolved by the recognition of the third inseverable element: the exchange particle. Students persistently "forget" to give all components of vectors, and throughout human cultures measurement is almost never conceptualized beyond the scalar. Multiple-element measure does not admit a unique rank order: Bigotry and prejudice are thus built on the confusion of a myriad of measures of "quality" of people into some single (scalar) rank order. The complementarity of multiple elements forming an inseverable multielement whole is also frequently missed: **E** and **B** fields, particle and wave, position and momentum (allowing Boltzmann's $S = k \ln W$ to yield entropy through the uncertainty principle), energy and mass (a logical equivalence, not a mutual exclusion)—the list is long.

The pseudosciences, which compete in the public eye with established science, are usually constructed by selecting confirming evidence and ignoring disconfirming evidence, an improper process that can "prove" any hypothesis (and "justify" any behavior). Furthermore, pseudoscience is almost always missing elements of the current understanding of the relevlant scientific principles.

In the conduct of science, elements of knowledge about human perception, information processing, decision making, action on the world and meeting of needs are almost always missing. Nevertheless science—its discovery, subsequent learning and its use—*is* human and a part of that biologically evolved complementary set of elements. Scientific concepts derive from human minds. Human minds are coordinated systems of very many evolved perceptions and other information processes—which are somewhat different for different individuals. Science is not an "alternative" (mutually exclusive) way of knowing. It is a way of knowing that treats multiple elements somewhat more adequately than does its competitors. Many of its discoveries were obvious yet remained unobserved until some human extended his or her perceptions into the realms of abstract, multielement ornateness.

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