The Saying of Science

The conduct of science often leads not so much from answer to specific answer as it does along converging successions of questions—a matter of the often subtle but sometimes critical distinction between fact and hypothesis. Yet despite all the constraints of the scientific method, that fragile awareness sometimes has a way of evolving into what has been called "canonical wisdom" — assumptions, in other words, that are occasionally found masquerading as established fact.

Around the turn of the century, when Percival Lowell was asserting that features he "observed" on the surface of Mars represented artificially constructed canals, some astronomy students expressed confidence that they, too, would be able to see the canals when they became sufficiently competent observers. In the case of another planet, with essentially nothing to go on but the telescopic appearance of impenetrable clouds, chemistry Nobel laureate Svante Arrhenius asserted flatly in 1918 that "everything on Venus is dripping wet."

It is not that such conclusions were necessarily wrong; more to the point is that one could not know them to be correct. The problem arises when taking them for granted results in overlooking a different line of inquiry that might have led in a more meaningful direction. If you are determined enough to "confirm" the existence of a "fact" such as the presence of Martian canals, who can say what interpretations you might overlook—or reject out of hand—when phenomena seemingly inconsistent with that "reality" present themselves to view? The situation here is somewhat analogous to that raised by physicians who are concerned not that a person may be trying an unproven "cure" for some illness, but rather that the sufferer may therefore be ignoring more established therapies that offer at least some medical benefit.

One of the more dramatic findings in the quarter-century of spacecraft studies of Venus was the 1981 determination (from a 1978 probe that had been part of the Pioneer Venus mission) of the ratio between the deuterium and hydrogen (D:H) in the water of Venus's atmosphere. It was dramatic because it seemed promptly to resolve one of the leading questions about the history of that cloud-shrouded world: Did such a dry place once have an earth-like ocean of water?

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Deuterium is an isotope of hydrogen that is twice as heavy as the more familiar kind (each molecule has an extra neutron), and which makes up a minor portion of the universe's total hydrogen abundance. The idea is that if Venus formed with a given quantity of water, some of the hydrogen in that water would have been deuterium. As ultraviolet sunlight and/or other factors then dissociated the water into atoms of oxygen and hydrogen, most of the hydrogen would have escaped into space, but most or all of the part that was deuterium would have stayed behind, "enriching" the deuterium fraction, or D:H ratio, in the bit of water remaining. The amount of the enrichment, it is reasoned, would indicate the amount of water that was there at the planet's beginnings.

So was there an ocean? The measured ratio, about 0.016, has seemed, in the view of many, to indicate that the answer is "yes." And that may indeed be the case. David Grinspoon of the University of Arizona in Tucson does not say that it is "no" (though he does have a point of view) — he merely reports, in the Dec. 18 SCIENCE, that the provocative data do not prove the point.

Countless other scientific questions remain similarly unresolved, but among the many in planetary research, this is a particularly significant one. Of all the planets in the solar system, Venus is most like the earth in terms of its size, mass and distance from the sun. Yet the temperature at the surface would melt zinc. The atmosphere there presses in like the water more than half a mile below the waves of a terrestrial ocean, and the clouds of earth's so-called "twin" are rich in sulfuric acid as concentrated as the stuff in the battery of a car. In fact, it was a droplet of "Venus acid" — ignored by researchers for nearly three years because it was known primarily for having clogged one of the atmosphere probe's instruments — that was eventually recognized as a possible source of enough "Venus water" to yield a D:H ratio.

Did worlds now so different formerly resemble each other in such a fundamental way as the existence of watery seas, thus far identified on no planet but our own? The University of Michigan's Thomas M. Donahue, one of the scientists who first noted the exciting measurement (SN: 12/12/81, p.372), described the issue at the time as "a major question, and perhaps *the* major question,

regarding the formation of Venus."

Six years have passed, during which several other spacecraft have been that way (all of them Soviet), and numerous other studies of the planet have been published. By now, notes Grinspoon, the Venus D:H ratio "has been accepted as proof" of a "wetter, more earth-like past on that planet."

For example, in the second edition of *Theory of Planetary Atmospheres: An Introduction to Their Physics and Chemistry* by Joseph W. Chamberlain and Donald M. Hunten, Academic Press, 1987 (the first edition predated the D:H measurement), the respected scientists who are its authors write that the finding "means that Venus has outgassed (and subsequently lost through escape) a large amount of H_2O – perhaps as much as the earth outgassed." Not that it "suggests," or "apparently means," or "indicates," or even that it "means, if the measurement is correct" (though no one seems yet to have disagreed with that part).

Hunten notes that the book does not categorically state how much water "a large amount" is, though there are estimates that various researchers feel to be consistent with the available evidence. Some planetary scientists occasionally find fault with one of their most well-known colleagues for saying that a given scientific finding is "not inconsistent with" some provocative interpretation. Fair enough, if one is finding fault with what is perceived as sheer sensationalism; but it can be another matter if the consequence is the rejection of a potentially fruitful inquiry.

There have certainly been other shadings. In a book called *The Planets* (Byron Preiss, Ed.; Bantam Press, 1985), the Pioneer Venus mission's project scientist, Lawrence Colin of NASA, wrote only that "overwhelming evidence suggests" the early Venus to have had much more water than it does today. On the other hand, when Donahue and colleagues first published their D:H measurement in a scientific journal (the May 7, 1982 SCIENCE), they unambiguously titled the piece "Venus was wet."

But unraveling the real story may be more complicated than that. Venus is closer than the earth to the heat of the sun, and some researchers maintain that it would thus have had far less water available during its formation – in other words, that Venus was essentially "born dry." On the other hand, there is another and probably larger body of opinion to the effect that the tiny "planetesimals" of raw material thought to have coalesced into Venus, earth and Mars would have become sufficiently mixed in the process that all three planets began with significant quantities of water.

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Furthermore, if Venus was in fact born dry, how can there be a D:H ratio that indicates it to be at least somewhat "wet" now? According to Grinspoon, for example, the calculated amount of water in the present Venus atmosphere could be gone in 100 million years – a mere fraction of the solar system's generally agreed-upon age of nearly 5 billion. If that is true, he concludes, some source must be supplying Venus with enough water, or at least its hydrogen, to compensate for the rate of the hydrogen's escape. Together with the University of Arizona's John Lewis (who has favored the idea of a "dry" early Venus for at least a decade and a half), Grinspoon proposes that a likely source could be the icy nuclei of comets. In fact, the two researchers note, in a paper soon to be published in ICARUS, "the water now observed on Venus is quite possibly more than 99 percent of cometary origin."

That little phrase, "quite possibly," is important. Without some such caveat, the words of even the most careful and qualified of scientists can sometimes have a misleading effect, particularly when they are the vital tools of communication with students, or even professional colleagues.

I recall a discussion I had several years ago with Baerbel Lucchitta of the U.S. Geological Survey in Flagstaff, Ariz., on the subject of permafrost on Mars. Permafrost, despite its name, does not necessarily imply the presence of ice; technically, it refers only to permanently frozen ground. But the term, Lucchitta noted, is not always used with such precision. Even among scientists, the "-frost" part sometimes evokes the impression of water-ice – an impression that can be misleading if one is being swept along by a sense of the general opinion of some part of the scientific community.

Mars, for example, is a parched and arid planet that somehow preserves sinuous channels, possible braided silt patterns and other such apparently fluid-formed features. Indeed, although journalists, too, are sometimes condemned for trampling on the lines separating proof, likelihood and mere speculation, Lucchitta's point at the time was that even qualified scientists reading their journals and going to meetings could be – and occasionally were – swayed by what they took to be numerous evocations of water-ice on Mars, when some of the cited authors meant nothing more than ever-frozen terrain. (More recently, she says, scientists seem to have become much more careful about one another's uses of the term "permafrost," although in the case of Mars, she admits, "I, too, subscribe to the idea that there is ice in the permafrost zone.")

Martian canals are not the point here, any more than are oceans or volcanoes on Venus, the possibility of asteroids with their own moons, the existence of planets orbiting other stars or any of the other intriguing topics that enrich planetary science. The role of the scientist sometimes is, and should be, similar to that of the lawyer, the conduct of whose profession often stands or falls on the preservation of subtle distinctions in communication. In the awesomely exciting matter of whether there may turn out to be intelligent extraterrestrial lifeforms, for example, the issue is simply too important for its reality to rest on matters of hunch, "belief" or other such toothless methodologies. There is just too much at stake. – *Jonathan Eberhart*