Objective Visions

Historians track the rise and times of scientific objectivity

By BRUCE BOWER

In an influential 1749 atlas of the human skeleton and muscles, Dutch anatomist Bernhard Albinus describes his meticulous methods for bringing a particular specimen to the printed page. Albinus carefully cleans, reassembles, and props up a complete male skeleton; he checks the position of each bone in comparison with observations of an extremely skinny man hired to stand naked next to the skeleton; he calculates the exact spot at which an artist must sit to view the skeleton's proportions accurately; and he covers engraving plates with cross-hatched grids so that images can be drawn square-by-square and thus be reproduced more reliably.

The modern reader of Albinus' work then gets a shock. After all that excruciating attention to detail, the eminent anatomist announces that his atlas portrays not a real skeleton, but an idealized version. Albinus has dictated alterations to the artist. The scrupulously assembled model is only a springboard for insights into a more "perfect" representation of the human skeleton, visible only to someone with Albinus' anatomical acumen.

It seemed perfectly reasonable for 18th-century knowledge seekers to defer to the informed imaginations of acknowledged geniuses such as Albinus. Objectivity was not an issue. That term did not acquire its current cachet in science until the 19th century. Then, many scientists decided it was best to find ways to let nature speak for itself rather than through the mouths of designated geniuses, says science historian Peter L. Galison of Harvard University. Only recently, in historical terms, has science aspired to be based on impartial treatment of physical objects, as opposed to subjective impressions.

Ever since science's embrace of objectivity, according to Galison and other historians, the conceptual ground beneath the idea has shifted enough to give pause to anyone who views it as a fixed vantage point from which successive scientific generations gaze upon reality.

Historical analyses conducted in the past decade conclude that scientists' working notions of objectivity and its usefulness have changed in significant and revealing ways. External reality has remained a constant focus of inquiry, the historians emphasize, but investigators frequently grapple with the daunting task of deciding which of its myriad features merits special attention.

Hooker, The Rhododendrons of Sikkim-Himalaya

In 1849, just before the flowering of scientific objectivity, botanist Joseph Hooker directed the drawing of this plant, based on observations of several blossoms. He chose to present what he saw as Rhododendron argentum*'s characteristic features.*

Enter objectivity. Historians view objective standards as a flexible framework for reasoning about the world and communicating with large networks of peers in a chosen field. Science's success and growth, combined with outside pressures to solve societal problems and to justify research funding, have helped shape and transform this framework.

The historians' efforts to study objectivity have great significance for what are called the science wars. They revolve around clashing beliefs over what scientists can know about the world. Combatants in that intellectual slugfest tend either not to know about work on the history of objectivity or to view it with ambivalence, remarks Ian Hacking, a philosopher of science at the University of Toronto. Hacking is familiar both with the historical analyses and the ongoing bitter debate over the nature of science.

On one side of the battle stand scholars, including sociologists and philosophers, who portray objective methods in science as products of a social consensus among practitioners based on their shared assumptions about the nature of reality. Objectivity then is a tool that scientists use to tell stories about how the world works and to boost their power and prestige, according to advocates of this perspective.

Critics of this view respond that conventions of objectivity allow researchers to chip away at chunks of reality that, with perseverance, yield basic laws of nature. Cultural and personal philosophies may organize scientific approaches to a problem, but theories grounded in real-world evidence eventually yield culturefree knowledge, in this view.

Science historians express frustration with what they see as a tendency of both sides in this battle to treat objectivity as something locked in place, an indentured servant either of personal and social interests or of external reality.

"The great debate about the desirability of objectivity in science is highly confused," says Lorraine Daston, director of the Max Planck Institute for the History of Science in Berlin. "Objectivity has had and continues to have different meanings." Its modern meanings include empirical reliability, procedural correctness, emotional detachment, and absolute truth, she notes.

Adds Theodore M. Porter of the University of California, Los Angeles, "We need to examine more closely the historical development of objectivity without making the exercise an attack on science."

A good place to begin untangling the roots of objectivity is the scientific atlases that proliferated from about 1830 to 1920, holds Galison. At that time, atlas makers embraced a form of objectivity in which cameras and a host of other machines were seen as stages on which nature could speak for itself without human prompting, he maintains. Atlases in this tradition of "mechanical objectivity" covered a vast array of phenomena—fossils, clouds, stars, elementary particles, bones, wounds, embryos, and plants, to name a few.

Inspiration for the new wave of atlases derived partly from growing unease with the earlier scientific practice of Albinus and other supposedly inspired geniuses to fish out "true forms" from beneath nature's surface. For instance, turn-of-the-century paleontologists began to question their convention of drawing ideal versions of partial or misshapen fossils, which were then used as centerpieces for evolutionary theories.

Around the same time, an increasing number of established scientific theories came under attack or were discarded. Investigators started to doubt whether they possessed a stable core of knowledge. Particularly stinging was the replacement of the Newtonian theory of light with the wave theory championed by French physicist Augustin Fresnel.

Scientists of the 19th century rapidly adopted a new generation of devices that rendered images in an automatic fashion. For instance, the boxy contraption known as the camera obscura projected images of a specimen, such as a bone or a plant, onto a surface where a researcher could trace its form onto a piece of paper. Photography soon took over and further diminished human involvement in image-making. In a joint article published in the Fall 1992 REPRESENTATIONS, Galison and Daston documented the rise of mechanical objectivity in scientific atlases.

Researchers explicitly equated the mechanical registration of items in the natural world with a moral code of self-restraint, Galison and Daston hold. A blurry photograph of a star or ragged edges on a slide of tumor tissue were deemed preferable to tidy, idealized portraits.

A saintly struggle against the temptations of interpreting and improving what one observed was a kind of purifying ritual for scientists, readying them to receive natural truths, the two historians suggest.

Astronomer Percival Lowell's effort at the start of the 20th century to establish the reality of canals on Mars starkly illustrates this point, according to Galison. Lowell took great care in sketching his initial telescopic discoveries. After observing more features of the Martian landscape, Lowell described in his journal how he refused to add these characteristics to earlier drawings because he wanted to ensure scientific objectivity and guard against unintentional "artistic delineations."

Lowell also agreed with book editors to refrain from a judicious retouching of his blurry, gray photographs of the Red Planet, which would have made Mars' canals visible in published reproductions. Such embellishments would invite claims that "the results were from the brain of the retoucher," Lowell's editors wrote to him in 1905. So, readers of his book were left to squint at a hazy version of the scientist's hard-won images.

Daston and Galison each emphasize different implications for science in the rise of mechanical objectivity. In the Winter 1998 DAEDALUS, Daston contends that this brand of objectivity accompanied broader cultural changes in Europe that polarized artists and scientists. Her article's title describes what she sees as the result: "Fear and Loathing of the Imagination in Science."

In the 18th century, imagination was viewed as essential to philosophy and science as well as to the arts, Daston says. Moreover, facts were assumed to arise out of particular observations or experiments and were subject to later revisions.

Romantic poets, writers, and artists of the 19th century claimed imagination as their inner muse, calling it an unexplainable creative impulse residing within the individual. Scientists, on the other hand, broadened their pursuit of objectivity beyond its basic mechanical form, in Daston's opinion.

Researchers began to standardize their instruments, clarify basic concepts, and write in an impersonal style so that their peers in other countries and even in future centuries could understand them.

Enlightenment-influenced scholars thus came to regard facts no longer as malleable observations but as unbreakable nuggets of reality. Imagination represented a dangerous, wild force that substituted personal fantasies for a sober, objective grasp of nature.

Scientists then and now acknowledge the presence of imagination in their work, particularly in devising groundbreaking theories and experiments, Daston notes. She suspects, however, that mainstream researchers experience a complex mix of admiration, envy, and disdain for the relatively few creative pioneers in their midst.

Galison, however, says that by around 1920, mechanical objectivity gave way to an emphasis on a kind of trained imagination in medical and natural sciences. Many atlas makers in these fields chose images that, in their opinion, brought into relief crucial elements that would help the observant reader learn how to interpret such displays with an expert eye, he suggests in *Picturing Science, Producing Art* (1998, Caroline A. Jones and P.L. Galison, eds., Routledge).

In this approach, subjective impressions got a reprieve. However, they were assumed to work in favor of all experienced practitioners and researchers rather than simply a few geniuses.

A 1941 atlas of electroencephalograph, or brain-wave, readings provides an example of how informed judgment replaced mechanical objectivity, Galison asserts. The authors wrote that they used their many years of experience to select EEG waveforms that would best help novices notice key patterns and train themselves to reach accurate diagnoses at a glance, such as distinguishing between the wave output of a person with epilepsy and one without epilepsy.

Nonetheless, scientists of all stripes still find much of value in a facet of mechanical objectivity that emphasizes the impartial application of standard mathematical methods, says Porter. Quantitative rigor proves most alluring to troubled scientific communities, which are buffeted by internal divisions and outside criticisms, he argues. Objective standards attempt to heal the distrust among researchers who are largely strangers to one another by making their specialized knowledge public and impersonal.

In contrast, and perhaps somewhat surprisingly, disciplines that enjoy a more secure status operate largely on the basis of informal, shared conventions rather than rigidly applied objective methods.

Porter explored several examples of this pattern in his book *Trust In Numbers* (1995, Princeton University Press). For instance, mathematically precise cost-benefit analyses were developed in the early 20th century by the U.S. Army Corps of Engineers. In the face of intense political pressure, the corps had been plagued by "utter disunity and savage infighting," Porter says. At the same time, powerful congressmen opposed the corps' efforts to plan and carry out major public works projects.

Analysis of congressional testimony, internal corps documents, and other sources indicates that strict cost-benefit formulas expressed in mathematically objective terms, such as those in the 1936 Flood Control Act, were developed by the corps to unite warring engineers and to overcome legislators' concerns about its competence to carry out complex tasks.

Yet, at the same time, the French government's engineering corps successfully resolved controversies over the location and costs of various public works without conducting a single cost-benefit analysis. Unlike their U.S. counterparts, the French engineers reached consensus on thorny issues through informal discussions informed by their past professional experiences. French politicians left the engineers alone, regarding them as elite and eminently trustworthy products of the national educational system.

Members of France's engineering corps showed no interest in cost-benefit rules until after World War II, when U.S. influence expanded in Europe, Porter contends.

Today, the small community of experimental high-energy physicists operates much in the tradition of France's prewar engineers, in his view. These scientists—a select few who survive a long process of formal training and research apprenticeships—have access to only a few particle accelerators and constantly adjust or even completely rebuild their own detectors for new experiments. Independent replication of experimental results proves extremely difficult when the equipment constantly changes from one researcher to another. Instead, influential physicists assess the skill and trustworthiness of experimenters and reach agreement as to whether a particular set of findings merits acceptance.

In contrast, experimental psychology, which faces stark internal divisions and considerable political pressures, clings to rigid statistical formulas of objectivity (SN: 6/7/97, p. 356), the UCLA researcher holds.

Historical work like Porter's challenges the widespread tendency to treat objectivity as "a given" that never changes, comments Hacking.

"Scientists employ techniques and ways of thinking which are powerful and effective, but which are often hard to articulate," Porter says. "In science, as in political and administrative affairs, objectivity has more to do with the exclusion of personal judgment and the struggle against subjectivity than with truth to nature." ☐

Astronomy

Star motions yield four more planets

The hunt for planets outside our solar system continues to show results. The latest findings include a nearby, sunlike star that may have two companions: a planet and a heavier object, known as a brown dwarf. Studies also suggest that three other nearby stars have closely orbiting planets, bringing to 16 the number of extrasolar planets that astronomers have indirectly detected around sunlike stars. As recently as August, only 10 such planets had been identified (SN: 8/8/98, p. 88).

The main search strategy has stayed the same since the first extrasolar planet was discovered in 1992. By tracking the back-and-forth motion of nearby stars toward and away from Earth, astronomers infer the gravitational tug of planets too faint to be detected directly. This technique favors the detection of massive, closely orbiting planets, since these bodies induce the largest wobbles in their parent stars.

Researchers have identified two planets among a sample of 82 stars they had begun monitoring recently at Lick Observatory on Mt. Hamilton in California. The team had already been studying 107 stars at Lick for several years. One of the newly found planets, which orbits the sunlike star HD195019, is at least 3.51 times as massive as Jupiter and whips around the star in just 18.27 days.

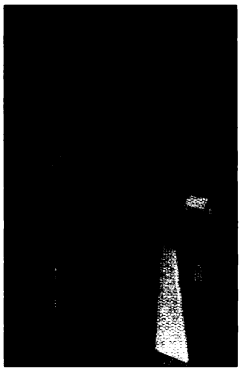
The other planet found at Lick Observatory circles the sunlike star HD217107 once every 7.12 days and is at least 1.27 times as massive as Jupiter. Geoffrey W. Marcy of San Francisco State University and the University of California, Berkeley and his colleagues, including R. Paul Butler of the Anglo-Australian Observatory in Epping, Australia, will report both Lick findings in the January 1999 PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC.

A third discovery, which Marcy announced Dec. 2, during a talk at Marymount College in Palos Verdes, Calif., concerns a star whose motion was tracked at the W.M. Keck Observatory atop Hawaii's Mauna Kea. The wobble of the star HD168443 suggests that it has a planet, which is at least 4.96 times as massive as Jupiter, in a highly elongated orbit.

The tug of a single object can't fully explain the star's motion, however. Marcy proposes that the star has another companion—either a tiny star or a brown dwarf, an object heavier than a planet but too lightweight to shine continuously as stars do.

The fourth find comes from a Swiss team working at the European Southern Observatory's La Silla Observatory in La Serena, Chile. Using a new telescope and spectrograph devoted to tracking stellar wobbles, the team found evidence of a planet circling Gliese 86, a dwarf star with a mass 0.79 times that of the sun. About 35 light-years from Earth, this is the second-closest star known to harbor a planet.

Gliese 86 has another distinction: It possesses an unseen stellar partner. The separation between the two stars is probably more than 100 times larger than the distance between the newly discovered planet and the star it orbits, the Swiss team reports. The planet circles the star once every 15.83 days and is at least 4.9 times as massive as Jupiter. It is separated from its parent by just over one-tenth the distance between the sun and Earth. Didier Queloz of the Geneva Observatory and NASA's Jet Propulsion Laboratory in Pasadena, Calif., and his colleagues announced the finding on Nov. 24. —*R.C.*



Queloz *et al.*/ESO

The new Leonard Euler Telescope at La Silla Observatory.