Leaves **of Truth**

Objectivity ranks as one of the highest ideals in research, but that wasn't always the case. It wasn't until the 19th century that it began to vie with the centuries-old principle of natural truth. Even today, the two concepts still come into conflict. As the author explains, some scientific controversies are more easily understood through a closer look at the history of science.

TEXT **LORRAINE DASTON**

Why does society need the history of science? And why does science, in particular, need the history of science? In the fast-moving, pressurized world of present-day research, scientists often wish for something that the history of science can't deliver: they want to know where and when the next breakthrough is coming, and which research program will fulfill its promises and more besides. These things can't be prophesied – fortunately. Science that relies on its past to extrapolate its future would lack creativity.

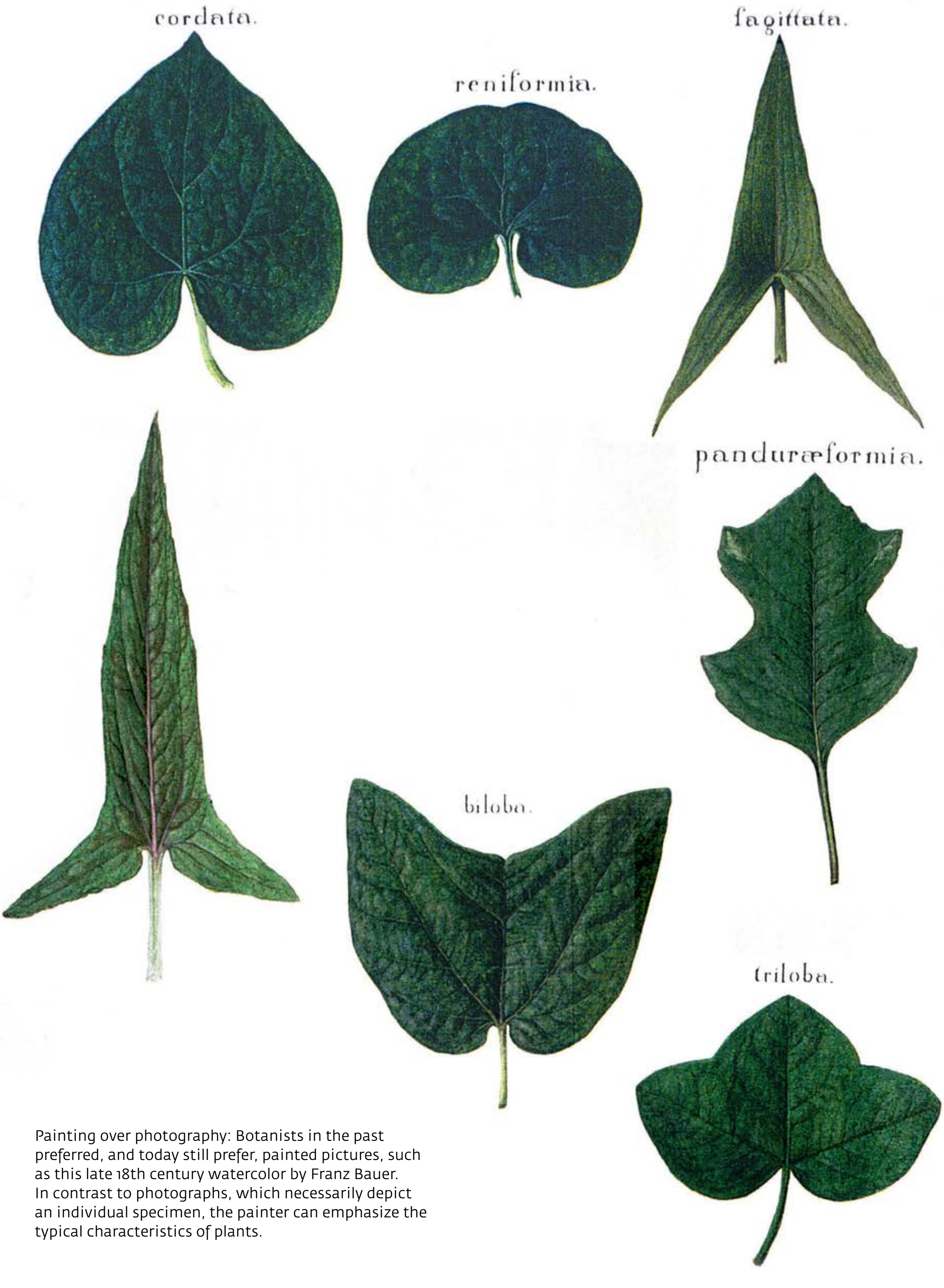
Science has different time scales, each with its own tempo

What the history of science can provide is an explanation of why present-day research is devoted to certain issues (and not to others); why certain methods (and not others) have become indispensable; why some discoveries are hailed immediately while others languish in obscurity for decades, or even centuries; why one discipline flourishes while another is neglected; why a scientific career follows certain stages (and not others); and ultimately why scientific careers exist – something that, from a historical perspective, is anything but self-evident.

Above all, the history of science provides an explanation of the varying time scales of science, each with a tempo of its own – and each with transformative potential.

There are three clocks that measure the pace of science. Empirical discoveries move at the fastest pace – the research results that appear in the next issue of SCIENCE, NATURE and other journals. This clock is calibrated in weeks and months; it ticks *allegro*.

The tempo of the climate for empirical research, on the other hand, is *andante*. By climate, I mean the synthetic theories – the different questions embodied within a theory – but also the material con-



Painting over photography: Botanists in the past preferred, and today still prefer, painted pictures, such as this late 18th century watercolor by Franz Bauer. In contrast to photographs, which necessarily depict an individual specimen, the painter can emphasize the typical characteristics of plants.

ditions for science: the invention of new instruments, the level of social support and appreciation of research, the ability to attract the finest minds to this career rather than any other. This clock ticks slower, in units of years and decades.

The third clock is *legato*, advancing in units of centuries or even millennia. It measures the pace of the fundamental epistemic virtues of science, the particular characteristics that define the science of a specific era as science (as opposed to knowledge, opinion or belief): certainty, truth, precision, objectivity. It is this third clock, the history of the seemingly self-evident in science, that I focus on in my research.

Only experienced observers are capable of distinguishing signal from noise

Given that these categories develop so slowly and are anchored so deeply in the identity of science, they appear to have no history. But let us take an example – certainty: For almost 2,000 years, from antiquity until the end of the 17th century, this was the sine qua non of science. *Episteme* in ancient Greek, *scientia* in Latin, the concept was defined as certain knowledge that not only accorded with the facts, but could be proven by *axiomata*, in the same way as a syllogism in logic or a mathematical proof.

Even Isaac Newton still clung to this vision: he described his laws of motion as *axiomata sive leges motus*. Redefining the concept of science as probable and even revisable knowledge was a slow but revolutionary transformation.

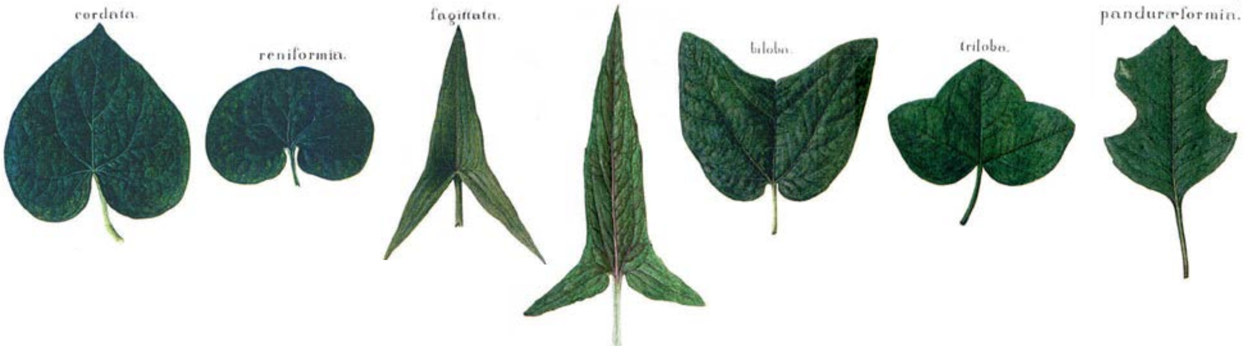
Certainty, truth, precision, objectivity – they all sound so abstract. In reality, however, these goals are tangibly expressed in scientific practice. Error bars for measurements, Monte Carlo simulations, idealized graph curves and techniques of illustration are all examples of how the abstract-sounding categories take on concrete form in everyday scientific practice.

The three time scales of science – *allegro, andante, legato* – are interwoven like a triple fugue. Taking one of these concrete forms, imaging, I would like to flesh out two of these epistemic virtues – natural truth and objectivity – and the resulting potential for conflict. Let us consider two illustrations of leaves, one a watercolor dating from the late 18th century and the other a so-called nature print from the mid-19th century. Both were created for botanical purposes.

The leaves in the watercolor were depicted very naturalistically by a master of botanical art named Franz Bauer. However, the painting doesn't depict real leaves, but rather idealized leaf types: *cordate* (heart-shaped), *trilobate* (having three lobes) and *sagittate* (arrow-shaped).

The leaf in the nature print, in contrast, is an imprint of an individual oak leaf, pressed between copper and lead plates until it made an impression in the soft lead. Although this process was lauded by its originator as the third great moment in cultural history – following the invention of writing and Gutenberg's movable type – botanists remained unconvinced. Neither the meticulously accurate reproduction of details nor the immediacy of the method impressed them. Photography also found little use in tomes devoted to plants. Botanists preferred, and still prefer, natural truth over accuracy and objectivity.

What, exactly, is natural truth? Under which circumstances is this epistemic virtue better suited to scientific purposes than any other? Particularly in the sciences given to classification – botany, zoology, anatomy, crystallography – natural truth aims to capture the typical: not this or that human skeleton with all its idiosyncrasies, but *the* human skeleton – or *the* gladiolus, *the* elliptical galaxy or *the* isometric crystal.



Natural truth fights not only against natural variability, but also against the spread of all kinds of data. Astronomers, physicists or psychologists, suddenly confronted with a data point that refuses to fit the pattern, must decide whether or not it is meaningful to include it in their calculations. If an astronomer, for example, is trying to determine the orbit of a comet, and all of his observations bar one single exception point to a parabola, does it make sense, is it right and proper, to ignore this aberration?

Natural truth would say "yes," whereas objectivity would say "no." Natural truth recognizes symmetries and regularities among a seething mass of variability, thus opening the way for classification and mathematical models. Even though natural truth is inclined to idealize, it promotes the highest empirical efforts.

Only the most experienced observers are capable of distinguishing the typical from the atypical – the signal from the noise. This ability requires mature powers of judgment. And assertive intervention in images and data.

Natural truth is an age-old epistemic virtue and is still regarded as an ideal any time scientists in a wide variety of disciplines attempt to recognize symmetries, regularities and types (such as the genera of organisms) under conditions of variability, data spread, and noise of all kinds.

However, it was probably from the mid-16th to the mid-19th century that natural truth experienced a golden age, in the era of Vesalius' Canon of the Human Body and Linnaeus' "plant archetypes." From the early to mid-19th century, natural truth came into increasingly frequent conflict with a new epistemic virtue: objectivity.

At first glance, it seems surprising that objectivity, perhaps the central epistemic virtue of modern science, should be so late in making an appearance.

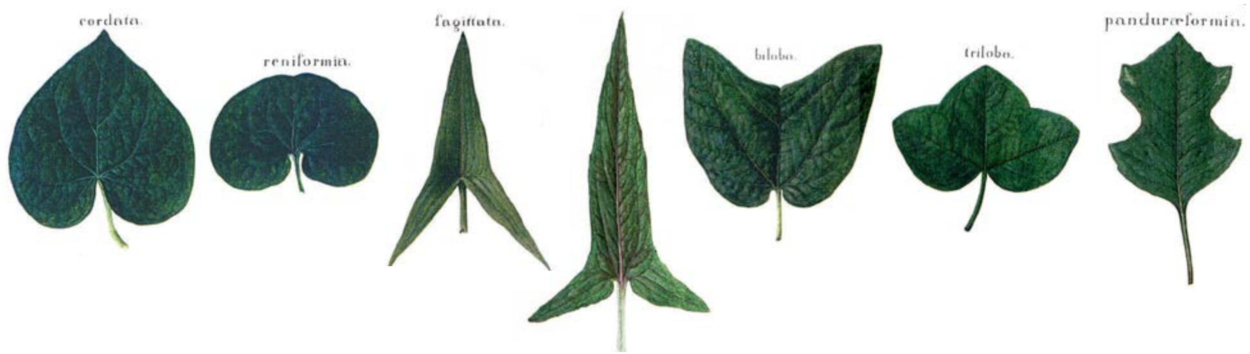
The word objectivity is indeed much older, deriving from the late scholastic Latin term *objectivus*, frequently paired with *subjectivus*. These familiar-sounding terms, however, signify the precise opposite of what we understand the words to mean today: "objective" referred to things as they appear to the conscious mind, whereas "subjective" referred to things themselves.

But it wasn't just the meaning of the words that turned 180 degrees around the year 1840. Objectivity and subjectivity, once of purely philosophical interest, became increasingly relevant for the empirical sciences in some very specific cases. From the middle of the century, scientists in a wide variety of disciplines – physiology, astronomy, chemistry, physics, bacteriology and even philology – were becoming concerned about a new obstacle on the path to knowledge: the obstacle that they themselves presented.

> An objective researcher must resist the temptation to embellish nature

The researchers feared that their subjective self was inclined to embellish, idealize and, in the worst case, regularize observations in order to make them fit theoretical expectations – to see what it hoped to see. For the adherents of the new epistemic virtue of objectivity, the interventions by the proponents of natural truth were scandalous – they were the subjective projections of the researchers themselves.

What form did the difference between natural truth and objectivity take? Often it was a contrast between drawing and photography, as in the case of British physicist Arthur Worthington, who, after 20 years studying the splashes of drops, was forced to admit that his earlier drawings were too fine, too symmetrical – a projection, he felt, of his expectation that he would indeed find nature to be perfect. It was only with the introduction of photographic



methods that Worthington recognized that his ideal, the “autosplash of his mind’s eye,” didn’t exist.

Photography, however, can serve both natural truth and objectivity. There are, for instance, some microphotographs of snowflakes dating from the end of the 19th century that are quite revealing in this regard. They were taken in Vermont around 1885 by Wilson Bentley, who edited the pictures to eliminate any irregularities. Richard Neuhaus also published images of snowflakes in Berlin in 1893, but his show asymmetries, broken or missing arms, and other deviations from geometric perfection.

While scientists since Kepler had regarded snowflakes as proof of the mathematical structure of nature and very openly removed “damaged” or “abnormal” examples as being atypical, Neuhaus criticized Bentley’s embellishment of his photos as “entirely gratuitous.” The objective researcher had to exercise self-discipline and resist the temptation to portray nature as more beautiful, more symmetrical or more regular than it actually was.

There is no mistaking the moral overtones of the accusations Neuhaus leveled at Bentley. Objectivity wasn’t only a methodological dictate, but also a moral one. Almost all epistemic virtues have a similarly moral tone. How could it be otherwise? This is determined not only by practical considerations – whether, for example, an aberration may be discarded or not – but also by a professional ethos that must be internalized. The ethos of natural truth doesn’t always coincide with that of objectivity: all scientists serve the cause of truth, but they have differing assessments of the obstacles.

Where is the risk of misjudging the truth greater: in the variability of nature or in the subjectivity of the scientist? Given that differing epistemic virtues such as natural truth and objectivity also have different histories, it’s no surprise that these histories sometimes collide. But precisely because the differences in the course of history aren’t apparent to scientists, such collisions are frequently interpreted as scientific misconduct, even to this day.

The consequences can be devastating. Let me cite just one example from the US – without mentioning any names, although biologists will probably immediately recognize the case. A young postdoctoral student was working with an experienced scientist in the laboratory of a Nobel laureate. The student was unable to replicate the scientist’s results despite adhering meticulously to the textbook methods; she also noticed that the published measurements didn’t always coincide with those recorded in the scientist’s lab diary.

Misconduct proves to be a case of colliding epistemic virtues

The student became a whistleblower and accused her colleague of falsifying data. Because the research was being funded by the National Institutes of Health, this episode became a national scandal, with hearings in congress, secret service investigations and ruined careers. After more than ten years of investigation, the scientist was exonerated by the Office of Research Integrity.

Other experienced scientists were ultimately able to replicate her results: precisely because they were experienced, they were willing – as the accused researcher had been – to sometimes refrain from including aberrant data in their published analyses. What the press and congress had interpreted as a case of scientific misconduct appears in retrospect to have been an example of colliding epistemic virtues: the objectivity of the postdoc who followed the methods precisely and wanted to include all of her measurements in her analysis, versus the natural truth of the scientist who modified her methods on an ad hoc basis and ignored implausible data.

SUB Göttingen, Gr 2 Cod Ms. H NAT 94

Please don't misunderstand me: genuine cases of data falsification and scientific misconduct do, unfortunately, exist. But there are also genuine collisions between epistemic virtues – just as ethical virtues sometimes collide. Justice and mercy aren't always reconcilable, any more than honesty and courtesy.

The initial reaction on both sides is frequently an outburst of moral indignation directed at the other party, as if virtue were to be found on one side only. But the historic perspective shows that both parties have virtue on their side – albeit different virtues, with different histories. Because the third clock that measures scientific development ticks so slowly, these histories remain invisible for most scientists.

This is where the history of science can facilitate a completely different discussion that doesn't focus on who is right and who is wrong, but instead asks: which goals do we wish to pursue in this specific case, and where does the greatest risk of failure lie? ◂

THE AUTHOR

Lorraine Daston (born in 1951) is a Director at the Max Planck Institute for the History of Science in Berlin, a visiting professor on the Committee on Social Thought at the University of Chicago, and an honorary professor of the history of science at Humboldt University in Berlin. She was born in the US, where she was awarded a doctorate at Harvard University in 1979 and taught at Harvard, Princeton and Göttingen Universities, among others. The main focus of Professor Daston's research is on the ideals and practices of rationality. She has also published papers on numerous topics relating to the history of science, such as the history of probability and statistics, wonders in early modern science, and the history of scientific objectivity.

Photo: Skúli Sigurdsson