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Series on articles on the greatest ideas of the Millenium

Best Idea; Eyes Wide Open

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When an obscure Arab scientist solved the riddle of light, the universe no longer belonged to God.

By any human measure, a millennium is a considerable chunk of time. It is the longest fixed unit of time with a distinct name in common usage. At the beginning of our spent millennium and at frequent intervals throughout it, vexed to nightmare by the calendar, believers have awaited Christ's imminent return to rule over a new heaven and earth in a kingdom that was to run for the unthinkable span of a thousand years. Near the millennium's end, the Nazis, refiners of another one of the period's most persistent concepts, predicted their own third kingdom would last for a thousand years. They were off by 988.

At the start of this millennium, nothing resembling an accurate map of any continent existed. Now a hand-held Global Positioning System satellite receiver can pinpoint its owner's location anywhere on the face of the globe. Trade and enterprise have expanded beyond all reckoning. More volumes are printed each year than existed in the year 1000. The last 10 centuries have also seen global deforestation, a steep falling off in spoken languages and mass extinction on a scale beyond anything since the Cretaceous.

Any search for the millennium's most important concept already dooms itself to myopia. Consider the candidates that spring to mind: parliamentary democracy, the nation-state, free markets, due process, the limited liability corporation, insurance, the university, mandatory formal education, abolition, socialism, the emancipation of women, universal suffrage, universal human rights. The scope of the upheaval in social institutions suggests some corresponding revolution in underlying thought almost too large to isolate.

Line up the usual intellectual suspects: the theory of evolution, relativity, the mapping of the unconscious. As cataclysmic as each has been for our own era, they are 11^{th}-hour arrivals, the latter-day consequences of ideas much larger and longer in motion. Push backward to Boyle's Law, Newton's F=ma or the Copernican Revolution, and you begin to close in on that fundamental leap in human conception.

The notion of progress, the invention of the future, might itself be a leading candidate for the most influential idea of the millennium. But the belief in transformation and advancement, in a constantly increasing control over the material world, is still just a symptom of a wider conceptual revolution that lies at the heart of what has happened to the world in these last 1,000 years: the rise of the experimental method.

Say, then, that the most important idea of this millennium was set in motion by a man named Abu Ali al-Hasan Ibn al-Haytham, born around the year 965 in Basra, in what is now Iraq. Even by his Western name, Alhazen, he remains a little-known figure in the history of thought. But the idea that Ibn al-Haytham championed is so ingrained in us that we don’t even think of it as an innovation, let alone one that has appeared so late in the human day.

Ibn al-Haytham resolved a scientific dispute that had remained deadlocked for more than 800 years. Two inimical theories vied to explain the mystery of vision. Euclid, Ptolemy and other mathematicians demonstrated that light necessarily traveled from the eye to the observed object. Aristotle and the atomists assumed the reverse. Both theories were complete and internally consistent, with no way to arbitrate between them.

Then Ibn al-Haytham made several remarkable observations. His most remarkable was also the simplest. He invited observers to stare at the sun, which proved the point: when you looked at a sufficiently bright object, it burned the eye. He made no appeal to geometry or theoretical necessity. Instead, he demolished a whole mountain of systematic theory with a single appeal to data. Light started outside the eye and reflected into it. No other explanation was consistent with the evidence.

Ptolemy had appealed to math and reason; Aristotle’s position had been mere conjecture. The world, however, answered to neither reason nor conjecture. What argument required was something more than theory, something that would hold up in the court of controlled looking. This empirical insistence lay at the heart of Ibn al-Haytham’s real revolution, and while he did not upend the world single-handedly, his influence has spread without limits.

The shift from authority to observation seems small, self-evident, almost inevitable. In reality, it is none of these. Over the course of 1,000 years, the conceptual shift would grow catastrophic, and its consequences would transform every aspect of existence.

Ibn al-Haytham made numerous other experimental contributions to optics and physics, part of a surge of Arab science at a time when Europe possessed little science to speak of. His contemporaries, investigators like Ibn Ahmad al-Biruni, Ibn Rushd (Averroes) and Ibn Sina (Avicenna), revived and extended Greek thought, unhindered by Augustine’s insistence that the world was an inscrutable riddle invented by God to lead us toward contemplation of a universe beyond this one. While none of these men can be called an experimental scientist in the modern sense, each helped to open up the possibility that the world can be known through its particulars and that direct observation was the best way to know it.

When the Arab cities in southern Spain began to fall in the late 11^{th} century, the contents of their great libraries flooded into Christian Europe. Ibn al-Haytham’s works on optics were at last translated into Latin late in the 12^{th} century, enlightening the proto-empiricist Roger Bacon (c. 1220-1292).

Bacon—Dr. Mirabilis, as he came to be known—was a bizarre mixture of old and new mind. Both a philosophical Franciscan and an antiphilosophical experimentalist, he fought to introduce science into university curriculums and became the first European to write down the recipe for gunpowder. He proposed ideas for airplanes, power-driven ships and automobiles. Ibn al-Haytham’s optics, which included the invention of a primitive camera obscura, led Bacon to many optical insights.

But optics formed just the visible surface of what Bacon took away from Ibn al-Haytham.

"Argument," he asserted in his "Opus Majus" (1267), ". . . does not remove doubt, so that the mind
may rest in the sure knowledge of the truth, unless it finds it by the method of experiment. . . . For
if any man who never saw fire proved by satisfactory arguments that fire burns . . . his hearer's
mind would never be satisfied, nor would he avoid the fire until he put his hand in it . . . that he
might learn by experiment what argument taught."
The world was not a vaporous trap but a collection of things with heft and substance, worth the closest scrutiny and palpation. Aristotle failed to see the value of controlled experiment, believing that nature could only be understood whole. With Bacon, through Ibn al-Haytham, there arises the idea of testing for truth through isolated particulars. Bacon's was also the moment in Western sculpture when Mary stops holding her child out in front of her like a pillar of stone and starts to straddle her grasping boy over one load-bearing, sensual hip.

Another three centuries passed before science emerged from its roots in natural philosophy. But the idea of looking had begun to shake the foundations of authority at the base of thought.

Light did not come from the eye, but rather fell into it. The world could be grasped in its particulars.

William of Ockham (c. 1285-c. 1347) bolstered empiricism with his own Law of Parsimony, or Ockham's Razor: when multiple ways exist to explain a datum, go with the one that requires the fewest theoretical assumptions. Jan van Eyck (c. 1395-c. 1441) took the zeal for nominal reality to such heights that his Ghent altarpiece depicts more than 40 identifiable plant species. Ibn al-Haytham's empirical optics traveled down yet another path to trouble the medieval mind into early modernism. If light entered the eye from the outside, then the eye sat at the tip of a visual cone, where the perpendicular ray dominated over all oblique ones. This implied a geometry of seeing, described by Ibn al-Haytham and elaborated on by Witelo (d. after 1281), a Pole connected with the papal court. Through Witelo, the idea of visual perspective spread in Italy.

The new depth of seeing worked its spell on Giotto (c. 1267-1337). The solid spaces hinted at in his frescoes were said to reduce viewers to alarm and ecstasy. The eye of Europe turned itself inside out. Ibn al-Haytham's camera obscura, improved upon by Bacon, set painters loose on the pursuit of light and its reflection off real surfaces.

But only when Brunelleschi, Masaccio and Uccello got wind of the new optical mathematics through their compatriot, the geographer-mathematician Paolo Toscanelli (b. 1397), did Western Europe achieve full liftoff into rectilinear reality. Using the techniques of deep perspective, with its ability to measure the relative size of objects at any distance, Toscanelli assembled a chart that wound up leading Columbus to the New World. The deep spaces of the new painting opened up even deeper spaces on the map, terra incognita that the Age of Exploration rushed to fill in.

Ibn al-Haytham's inexorable idea derives its power from a radical overthrow of what constitutes acceptable demonstration. Nothing, finally, can gainsay the data. Wholeness, harmony and radiance must give way to verifiability and repeatability. With the invention of printing, experimental data could proliferate without limit. Fueled by and fueling the Protestant Reformation, with its universal priesthood of man, skepticism's challenge to received wisdom spread into all quarters.

So did Ibn al-Haytham's optics. His work on refraction and lenses led to the development of the telescope and microscope. Once these devices threw open their portals onto the invisible, there was no looking back. Van Leeuwenhoek's (1632-1723) "tiny animalcules" revealed the living world to be stranger than any natural philosopher could have guessed.

The Lutheran Kepler (1571-1630), in his "Supplement to Witelo," solved the problem of atmospheric refraction and built Ibn al-Haytham's foundation into a full account of vision. Freed up to cast his glance into the heavens, Kepler explained magnification and laid out the laws of planetary motion. And Galileo, the true prototype of the modern skeptical empiricist, looking at the light that fell into his telescope tube and reporting what he saw, defying all theory and common sense, moved the world against the world's wishes. Rising to his feet after recanting to the authorities, as legend has it, he muttered the words that would form the credo of triumphant science: "But it does move." In short order, measurement laid out the calculus behind its every wobble.

"And new philosophy calls all in doubt," John Donne wrote in his poem "An Anatomy of the World: the First Anniversary" (1611). And doubt itself became the engine of the new creation.

Francis Bacon (1561-1626) wrote the user's manual for the new scientific instrument of thought. He banished the "idols of the mind," those habits of reason that blinded you to the evidence.

Knowledge depended on suspending belief in anything except the most indifferent measurement. In
"The Advancement of Learning" (1605), he wrote, "If a man will begin with certainties, he shall end
in doubts, but if he will be content to begin with doubts, he shall end in certainties." With the Baconian method, knowledge did not stop at the curation and annotation of bygone ideas. Bacon was right: the revolution unleashed in Western Europe in the 17th century represents the sharpest break with the past in history. In the 300 years since the break commenced, modern science and its handmaid, technology, have altered the globe beyond recognition or recall, revising the terms of material existence, not to mention the geopolitical ones. For politics, too, is born in experiment. The rise of a technological Europe produced an era of imperialism from which the continents have yet to recover.

"It is not what the man of science believes that distinguishes him," Bertrand Russell said, "but how and why he believes it. His beliefs are tentative, not dogmatic; they are based on evidence, not on authority or intuition." Out of that tentativeness have flowed the airplane, air pump, anesthesia, aniline dye, antiseptic surgery, aspirin, atomic energy, automobiles and on, ad infinitum.

The most adventurous mind from the year 1000 -- even Ibn al-Haytham himself—faced with the runaway results of the experimental method, would have no available mental response short of schizophrenia. Ibn al-Haytham's doubt of existing optical theory has led to the certainties of electron microscopy, retinal surgery and robotic vision. Millennial expectation has shifted away from the thousand-year reign of Christ toward the thousand-megahertz personal computer. The universe has progressed from an enigmatic metaphysical emblem to the accidental byproduct of superstrings. An orbiting telescope now extends the cone of vision out to the very edges of creation.

There is something paradoxical in claiming, as the greatest concept of the last millennium, the skeptical rejection of concept in favor of evidence. But there is something paradoxical in the idea of radical empiricism itself. At its purest, science strives to be neither logical nor reasonable, merely suspicious. It claims to begin in the abeyance of theory, but strives to produce a deeper, wider explanation of observable event. It pursues a relentless reductionism in order to erect a single, consistent material theory of everything from the unified cosmological force to the evolution of consciousness, a vastly more comprehensive blueprint than any City of God, yet still a theory, always tentative, and refutable at best.

In fact, in the most fundamental sense, skeptical empiricism may be a contradiction in terms. It has come under attack in recent years by a number of thinkers—from Ludwig Wittgenstein to Thomas Kuhn and beyond—who have no qualms about applying the same skepticism toward the scientific method that Francis Bacon advocated applying to any body of accepted lore. Their objections are many and varied: that fact and artifact may be closer than most empiricists are comfortable accepting. That even pure observation has an agenda. That great empiricists have rejected initial data on hunches, until their observations produced more acceptable numbers. That scientists need pre-existing theory and supposition even to ask the questions that will lead to data. That the shape of a question produces the data that answer it.

A new generation of cultural constructionists similarly maintains that Western science, whatever its technological triumphs, is the product of a certain cultural moment and represents no transcultural truths. But that notion, too, may beg the question of just which forces construct culture. You may well wonder whether any but a culture of high technology could have produced the theories of cultural construction.

Still, it lies beyond all reasonable doubt that no single idea has had a more profound or ubiquitous impact on what the human race has become, or what it has worked upon the face of the planet, than the vesting of authority in experiment. Anyone who looks can arrive at no other conclusion. More urgent, at this moment, is the question of what the greatest idea of the next thousand years will have to be if we are to survive the power unleashed by the last.

Many have noted, here at millennium's end, that our vast increase in technical ability has not been accompanied by a commensurate increase in our social or ethical maturity. A soul in the year 1000, from any region of the globe, knew more about its place in the grand scheme than a body in the year 2000 does. Francis Bacon was right: the program that began in doubt has produced certainties beyond a medieval mind's wildest dreams. But what was once a certainty now drifts in a gulf of doubt wider than the millennium itself.

The greatest idea of the last 1,000 years has granted us ascendance over matter by asking not how things ought to be but how things are. We have given ourselves to finding out not what we should do with the world, but what we can make the world do. The greatest idea of the next thousand years must make up the difference, returning subtlety and richness and morals and lightness of spirit to the long human experiment, if any part of it is to survive. Light falls into the eye, reflected from the object under observation. But something else, too, must go out from the eye to the things we observe.

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