SCIENCE AND SOCIETY

Cosmology and 21st-Century Culture

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We like to think of our generation in this Information Age as the smartest and most knowledgeable that has ever lived. Yet most people in modern Western culture have no idea what our universe looks like or how to begin to think about the way we humans may fit into the cosmos. Every traditional culture known to anthropology has had a cosmology—a story of how the world began and continues, how humans came to exist, and what the gods expect of us. Cosmology made sense of the ordinary world by defining a larger context and grounding people's sense of reality, their identity, and their codes of behavior in that grand scheme. Like modern science it embedded everydayness in an invisible reality: modern science explains by means of countless molecules; African cosmologies explain by means of countless spirits. Ordinary people in traditional societies accepted responsibility for maintaining the cosmos itself by ritually reenacting the creation stories for every generation. This is how they knew who they were. The absence of a cosmology was as inconceivable as the absence of language. Their pictures of the universe were not what anyone today would consider scientifically accurate, but they were true by the standards of their culture.

Science undermined all traditional pictures of the universe in the Renaissance, centuries before it was in a position to create one of its own. A cosmology can only be taken seriously if it is believable, and after the scientific revolution our standards of believability were forever changed. For four centuries scientific cosmology was not taken seriously because the ratio of theory to data was almost infinite. However, science now appears to be closing in on an origin story that may *actually be true*—one that can withstand the most rigorous tests and will still be accepted hundreds of years from now, as Newton's theory remains valid for the solar system (within known limitations). This is the highest grade of truth possible in modern science[*]

Modern cosmology is in the midst of a scientific revolution. New instruments are producing the first detailed data about the distant universe. Since light travels at a finite speed, looking out in space is the same as looking back in time. We can now observe every bright galaxy in the visible universe, and even look back to the cosmic dark ages before galaxies had formed. In the patterns of the subtle temperature differences in the cosmic background radiation in different directions we are learning to read the Genesis story of the expanding universe.

The resulting origin story will be the first ever based on scientific evidence and created by a collaboration of people from different religions and races all around the world, all of whose contributions are subjected to the same standards of verifiability. The new picture of reality excludes no one and treats all humans as equal. The revolution in scientific cosmology today may open the door to a believable picture of the larger reality in which our world, our lives, and all our cultures are embedded.

Religion and Cosmology

In Biblical times when people looked up at a blue sky, they understood the blue to be water, held up by a hard, transparent dome that covered the entire flat Earth. In the King James translation, the dome was named the "firmament." According to the first creation story at the beginning of Genesis, by creating this dome on the second day, God divided the waters "above" from the waters "below" and held open the space for dry land and air.

At about the same time as the Genesis story took the form in which we know it, Greek philosophers were living in a different universe in which the Earth was not flat and domed but a round celestial object. By the Middle Ages the Greek image of concentric spheres, and not the Bible's flat domed Earth, had become the unquestioned universe for Jews, Moslems, and Christians alike.

Thus, on a clear night in Medieval Europe, a person looking up into the sky would have seen hard, transparent spheres nested inside each other, encircling the center of the universe, the Earth. Each sphere carried a planet, the moon, or the sun. Heaven itself was immediately outside the most distant sphere, which carried the "fixed stars." The hierarchies of church, nobility, and family mirrored this cosmic hierarchy. Every thing and every

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creature in the universe tended toward its proper place for love of God.

The stable center was torn out of the Medieval universe at the beginning of the 17th century, when Galileo's telescope observations showed that the Ptolemaic Earth-centered picture was wrong.[†] Galileo ridiculed the prevailing cosmology in his *Dialogue Concerning the Two Chief World Systems* (1632), but the Catholic Church forced him to recant and held him under house arrest for the rest of his life. This was a frightening and sobering event for scientists all over Europe. Eventually, following the lead of Bacon and Descartes, science protected itself by entering into a de facto pact of noninterference with religion: Science would restrict its authority to the material world, and religion would hold unchallenged authority over spiritual issues. By the time Isaac Newton was born in 1642, the spoils of reality had been divided. The physical world and the world of human meaning were now separate realms.

The new picture portrayed the universe as endless empty space with stars scattered randomly in it. It never fully replaced the Medieval universe in people's hearts, partly because it felt so incomplete. There was no particular place for humans, no place for God, and no explanation of the universe's origin. In the mid-17th century, Blaise Pascal [*Pensees* (1670)] expressed a sentiment unheard of in the Middle Ages: "engulfed in the infinite immensity of spaces whereof I know nothing, and which know nothing of me, I am terrified…The eternal silence of these infinite spaces alarms me." Newtonian cosmology was the first that had nothing to say about humans, and believers in science could no longer even conceptualize the ancient ideal of humans living in harmony with the universe.

Why should an origin story matter today? “The universe” is irrelevant to most people in the West, except as a fantasy outlet. The universe plays no part in mainstream religions, except perhaps to demonstrate the glory of a creator. How many people recognize the possibility of a sacred relationship between the way the expanding universe operates and the way human beings ought to behave? What religion teaches that this could be a source of harmony among humans?

Instead, most educated people in the 21st century live in a cosmology defined by a 17th-century picture of cold, still, empty space, along with fragments of traditional stories and doubts about what is real. Many have not fully absorbed the discovery nearly a century ago of the great age and size of the universe; indeed, controversies between science and religion often center on conflicting origin stories. The current cosmological revolution may provide the first chance in 400 years to develop a shared cosmology. There is, however, a moral responsibility involved in tampering with the underpinnings of reality, as scientific cosmology is now doing. How well the emerging cosmology is interpreted in language meaningful to ordinary people may influence how well its elemental concepts are understood, which may in turn affect how positive its consequences for society turn out to be. Will the new scientific story fuel a renaissance of creativity and hope in the emerging global culture—or will it be appropriated by the powerful and used to oppress the ignorant, as the Medieval hierarchical universe was used to justify rigid social hierarchies? Will news of new discoveries about the universe just be entertainment for an educated minority but, like science fiction or metaphysics, have little to do with the “real world”?

All possibilities are still open because the meaning of this new cosmology is not implicit in the science. Scientific cosmology, unlike traditional cosmologies, makes no attempt to link the story of the cosmos to how human beings should behave. It is the job of scholars, artists, and other creative people to try to understand the scientific picture and to perceive and express human meanings in it.[‡] A living cosmology for 21st-century culture will emerge when the scientific nature of the universe becomes enlightening for human beings.

This will not happen easily. The result of centuries of separation between science and religion is that each is suspicious of the other infringing on its turf. In 1999 the AAAS Program of Dialogue on Science, Ethics, and Religion sponsored a 3-day public conference§ that asked: Did the universe have a beginning? Was the universe designed? Are we alone? Not surprisingly, no consensus was reached on any of these questions. Although the goal was “constructive dialogue” between science and religion, some of the participants complained that the dialogue went one way—science always demanding that religion adapt to new discoveries. Naturally, science is not about to change its methods to accommodate religious concerns. But a cosmology that does not account for human beings or enlighten us about the role we may play in the universe will never satisfy the demand for a *functional cosmology* that religions have been trying to satisfy for millennia .

There is space in this article for only one of many possible examples of how the emerging scientific cosmology could provide a basis for a living, functional cosmology for the 21st century that, like ancient cosmologies, can help guide humanity.||

The Transition from Cosmic Inflation to Expansion as a Model for Earth

Standard Big Bang theory explains the creation of the light elements in the first 3 minutes, but it does not explain what preceded or what has followed. Gravity alone could not have created the complex, large-scale structures and flows of galaxies that are observed to exist. If matter were absolutely evenly distributed coming out of the Big Bang, gravity could have done nothing but affect the rate of the overall expansion. Consequently, either some causal phenomenon such as “cosmic strings” acting after the Big Bang formed the giant structures we observe today—which looks increasingly dubious because such theories conflict with the new observations of the cosmic background radiation—or else gravity must have had some differences in density to work with from the beginning. Cosmic Inflation could have caused such primordial differences.

The theory of Cosmic Inflation was proposed two decades ago by Alan Guth, Andrei Linde, and others. It is the only explanation we have today for the initial conditions that led to the Big Bang.# It says that for an extremely small fraction of a second at the beginning of the Big Bang, the universe expanded exponentially, inflating countless random quantum events in the process, and leaving the newly created spacetime faintly wrinkled on all size scales. All galaxies and larger structures in the universe grew from these quantum fluctuations, enormously inflated in scale.

Inflation is also the controlling metaphor of our culture in the present epoch. Not only is the human population inflating; so too are the average technological power and the resource use of each individual. The human race is addicted to exponential growth, but this obviously cannot continue at the present rate. In a finite environment, inflation must end, however cleverly we may postpone or disguise the inevitable.

The single most important question for the present generation may be how global civilization can make the transition gracefully from inflating consumption to a sustainable level. But the cosmic transition from inflation to the slow and steady expansion that followed the Big Bang shows that ending inflation does not mean that all growth must stop, even though many people trying to save the planet assume so. Inflation transformed to expansion can go on for billions of years. Processing information, which occupies more and more of the world’s population, does not need to be environmentally costly. Human life can continue to be enhanced as long as our creativity in restoring the Earth stays ahead of our material growth.

References and Notes:

*N. E. Abrams, J. R. Primack, *Philos. Sci.* **9**, 75 (2001).

†T. S. Kuhn, *The Copernican Revolution* (Vintage Books, New York, 1959), esp. pp. 222-224.

‡N. Abrams, *Alien Wisdom* (a CD of her original music exploring themes of this article; for more information see www.expandinguniverse.org).

§ *Cosmic Questions*, J. B. Miller, ed., *Ann. N. Y. Acad. Sci.* (Dec. 2001). The entire text plus video excerpts from the meeting and interviews with speakers will be included on a CD-ROM; for further information see www.aaas.org/spp/dser/ .

||Another example: J. R. Primack, N. E. Abrams, *Tikkun* **16**, 59 (2001).

#For a more detailed explanation of current thinking about the initial conditions for the Big Bang, see, e.g., A. H. Guth *The Inflationary Universe: The Quest for a New Theory of Cosmic Origins* (Addison-Wesley, Reading, MA, 1997); M. Rees, *Before the Beginning: Our Universe and Others* (Addison-Wesley, Reading, MA, 1997).