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Breakthroughs 1998

Floyd E. Bloom

Science readers follow some fields more closely than others, asking large questions and smaller ones. However, relatively few scientists elect to take on the really big questions of science: how did the universe begin, is it expanding or collapsing, how did life on Earth begin, is there life elsewhere? Such questions seem scientifically unapproachable for all but the theorists and operate on time scales that dwarf human life-spans. Rarely could we expect a dramatic breakthrough in one of these grand, fundamental questions. Yet this year, early but hard evidence has shown that the universe is flying apart at ever-greater rates. These findings have begun to challenge scientists' assumptions about the universe's physical characteristics, and they have striking implications about the forces that permeate "space." These achievements and others are recognized as *Science*'s Breakthroughs of the Year.

Science reaffirms the importance of recognizing such major achievements.

Selection of the accelerating universe as our major Breakthrough of the Year offers unique insights into the strategies and theories of descriptive physical sciences and how great thinkers can make sense of new data no matter how bizarre they may appear. Albert Einstein followed up on his general theory of relativity by trying to determine what it could add to our limited understanding of the universe. In order to find a theoretical solution for an isotropic, homogeneous, and static universe, Einstein added a "fudge factor" λ (termed the cosmological constant; see http://super.colorado.edu/~michaele/lambda.html). In order to maintain a constant-sized universe, a term of repulsive energy was required to counteract gravity and to prevent the universe from collapsing. Later, Einstein became convinced by data from the astronomers de Sitter and Hubble that in fact the universe was expanding, not static, and he dropped the constant from his equations. In doing so however, he also recognized that this simplification created a new problem: if one calculated the reciprocal of the apparent rate of expansion back to its origins, the universe would not be as old as some of the galaxies. Today, newer data from far distant galaxies confirm these discrepancies and resurrect the idea of a repulsive energy driving the galaxies further apart at accelerating rates. Einstein would no doubt have embraced these recalculations based on the direct evidence of the physical phenomena.

This is the 10th year-end recognition by *Science* of the top developments in scientific research, assessed by our editors for their effects on society and the advancement of science (see the special section coordinated by Deputy News Editor Elizabeth Culotta, beginning on p. 2156). Without question, the discovery of the accelerating universe and the resurrection of the cosmological constant fulfill our definition of a breakthrough [*Science* **274**, 1987 (1996)] as a rare discovery that profoundly changes the practice or interpretation of science or its implications for society. The continuing bounty of experimental results produced over the past year includes many far less abstract breakthroughs. Our 1998 runners-up encompass still more detailed workings of what last year we called the "quiet ticking of cellular clocks," offering relief to those whose circadian rhythms are desynchronized by travel or illness. We also recognize new approaches to determining the causes of cancers and their possible treatments, new ways to automate the evaluation of massive sets of DNA sequences, the first physical characterization of the membrane protein responsible for the selective movement of K^+ into and out of cells, and new evidence that neutrinos have mass. *Science* reaffirms the importance of recognizing such major achievements as provisionally established advances, knowing full well that more data will be required to convince many and that some new data may well surprise all.

As in previous years, we have again attempted to look into the near future to anticipate which streams of today's research are likely to become fast rivers in 1999. We score ourselves on last year's predictions and end up doing no better than chance. Perhaps the only conclusion we should draw from our past retrospectives would be to heed Einstein's assertion that he never thought of the future because it comes soon enough.