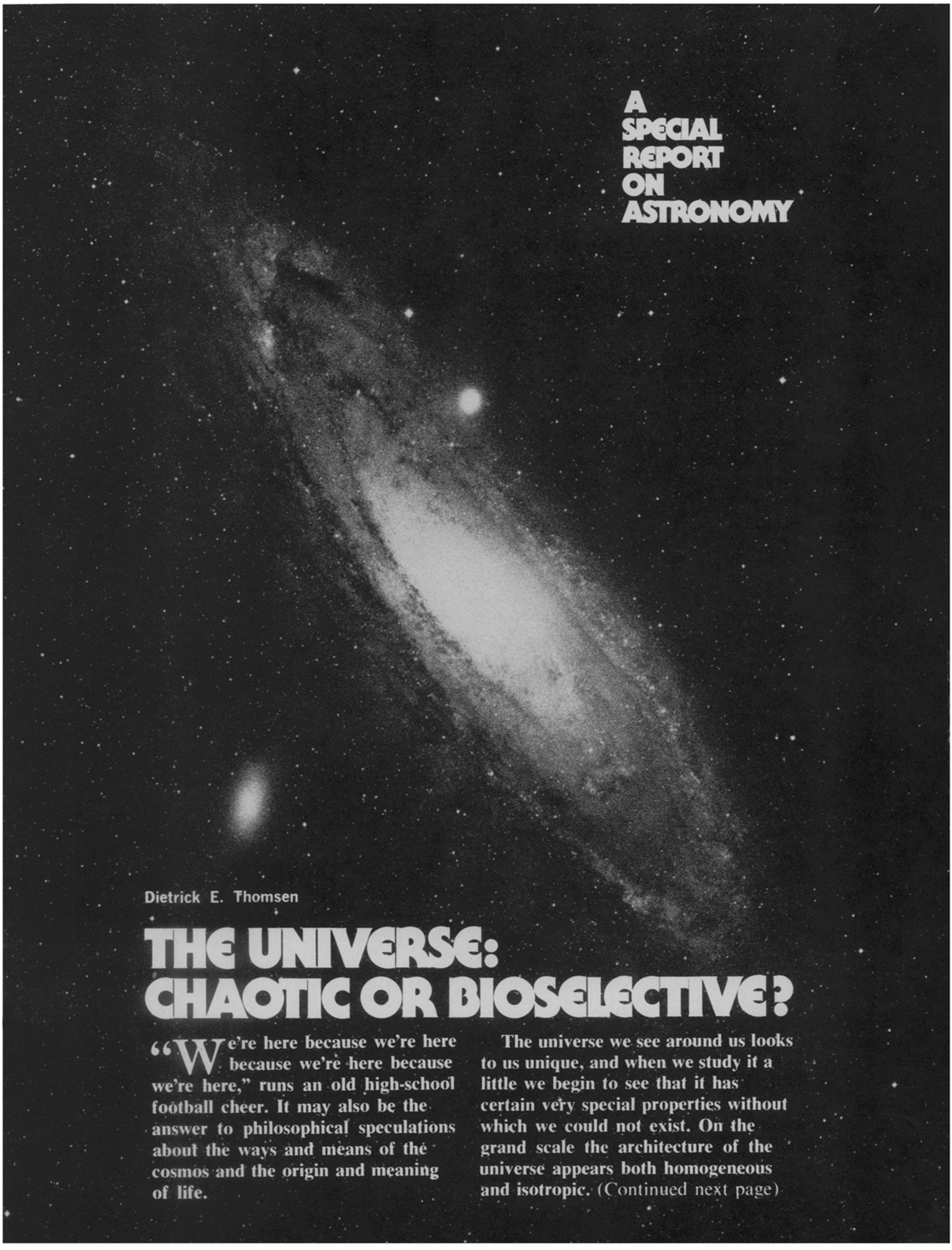

A SPECIAL REPORT ON ASTRONOMY

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THE UNIVERSE: CHAOTIC OR BIOSELECTIVE?

"We're here because we're here because we're here because we're here," runs an old high-school football cheer. It may also be the answer to philosophical speculations about the ways and means of the cosmos and the origin and meaning of life.

The universe we see around us looks to us unique, and when we study it a little we begin to see that it has certain very special properties without which we could not exist. On the grand scale the architecture of the universe appears both homogeneous and isotropic. (Continued next page)

(Isotropic means the same in all directions; homogeneous, on the grand scale not lumpy.) These are two qualities that give fits to students of cosmic evolution because they seem to require very special initial conditions.

The laws of physics that operate in our universe seem very special too. In an article in SCIENTIFIC AMERICAN in September 1971 Freeman J. Dyson reviewed what he calls the physical "hangups" that prevented uniform gravitational collapse of the cosmos and permit such things as galaxies, stars, planets and living beings to exist. His first hangup is a size hangup: The universe is simply so large that the day of ultimate gravitational self-immolation of the clusters of galaxies is postponed to a very far future; it takes aeons and aeons for them to fall together. Dyson's last hangup is the surface-tension effect that prevents naturally fissionable atomic nuclei from fissioning too fast, thus preserving them and their energy for our use. Dyson sums up: "As we look out into the universe and identify the many accidents of physics and astronomy that have worked together to our benefit, it almost seems as if the universe must in some sense have known that we were coming."

A prominent physicist has remarked that God made the fine-structure constant to be 1/137 so that we would arise to worship Him. The fine-structure constant measures the strength of electromagnetic forces relative to other kinds of natural forces. If it had been different, chemistry would have been different. Specifically the large carbon-based molecules on which life depends would not form.

Contemplation of these things disturbs cosmologists because it seems as if such particular and precise conditions could hardly have arisen at random. One way to deal with the question is to say the whole thing was contrived and lay it on Divine Providence. This neatly removes the question from the realm of cosmology and gives it to theodicy, the branch of theology that studies how to justify the ways of God to the minds of humans.

But most cosmologists are not willing to take the cop-out route. They hanker to play with the question scientifically. Writing in the May 17 NATURE, P. C. W. Davies says: "It is truly remarkable that modern theoretical physics can make a contribution to this philosophical question."

The debate at the moment concerns the origins of the universe. Is it possible that the present isotropic and homogeneous conditions could have developed out of a large number of possible initial states, or do those qualities require a particular kind of beginning? The discussion simmers along in a dialectic way with first one side then the other making a point.

The special side is argued by C. B. Collins and S. W. Hawking of Cambridge University in the March 1, 1973, ASTROPHYSICAL JOURNAL. They study the class of spatially homogeneous universes that evolve toward isotropy and find, to use the mathematical terminology, that the set of such universes is of measure zero in the space of all homogeneous models. In other words, the original conditions must have been very special indeed. There must be strict adherence to qualities of isotropy and homogeneity. Chaos, that is, an arbitrary set of initial conditions, is ruled out.

NGC 2237 nebula in Monoceros

This makes the chance of our universe's actually having begun rather precarious. Collins and Hawking avoid being gored by the horn of the dilemma by invoking a modern cosmological suggestion usually attributed to R. F. Dicke of Princeton University and B. D. Carter of Cambridge: There is an infinite number of universes "with all possible different initial conditions." Among these would be some that fit the specifications and are expanding with just the escape velocity, that is, just enough speed so that each part of the universe escapes the collective gravitational field of the rest. These are the only ones in which galaxies can exist. (Those with less than the escape velocity would collapse back too soon for galaxies to form; those with more than the escape velocity don't tend to isotropy.) For life, it seems, galaxies are necessary. "Thus there will be life only in those universes which tend toward isotropy at large times. The fact that we have observed the universe to be isotropic is therefore only a consequence of our own existence."

Davies calls this philosophy "bio-selection." We're here because we're here because we couldn't be in any other kind of universe. We have to have the one we have and no other.

The opposite view, that our universe could have come from chaos, from any arbitrary beginning, was first argued by Charles W. Misner of the University of Maryland in 1968. Its proponents would like to show that our universe is not special at all. It is the logical outcome of any kind of beginning. We're here because—well—there really was no other way for things to come out. All anisotropies and inhomogeneities would have been damped out in the process of expansion. The latest blow for this side is struck in MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY (Vol. 167, p. 55) by W. B. Bonnor of Queen Elizabeth College of the University of London.

Bonnor answers Collins and Hawking, pointing out that they did not consider possible inhomogeneous initial states. Indeed, they explicitly rejected them saying: ". . . one would expect inhomogeneities to produce anisotropy rather than isotropy."

Bonnor, however, proceeds to argue that there are classes of inhomogeneous beginnings that can evolve toward homogeneous and isotropic conditions. In those of his models that have just the escape velocity, every one approaches such a case. For those that have more than the escape velocity there are some restrictions on the initial conditions.

If Bonnor is correct, it means that a wide, if not infinite, variety of beginnings could have brought us about. But there's one hitch in his argument, and it's a serious one. His models violate what is called the cosmological principle, the axiom that there are no privileged points in space. Bonnor's models are spherically symmetric, and the centers of symmetry become privileged points. Bonnor admits the defect and says it needs working on.

So the debate continues: Is the universe the way it is because we couldn't exist in any other, or do we have nothing to do with it, the present state of the universe being the only possible outcome of cosmic evolution. The last word has not been said, not by a long way. Some ramifications of the question are hinted at by a suggestion of Dyson's. "Life may succeed against all the odds in molding the universe to its purpose. And the design of the inanimate universe may not be as detached from the potentialities of life and intelligence as scientists of the 20th century have tended to suppose." □