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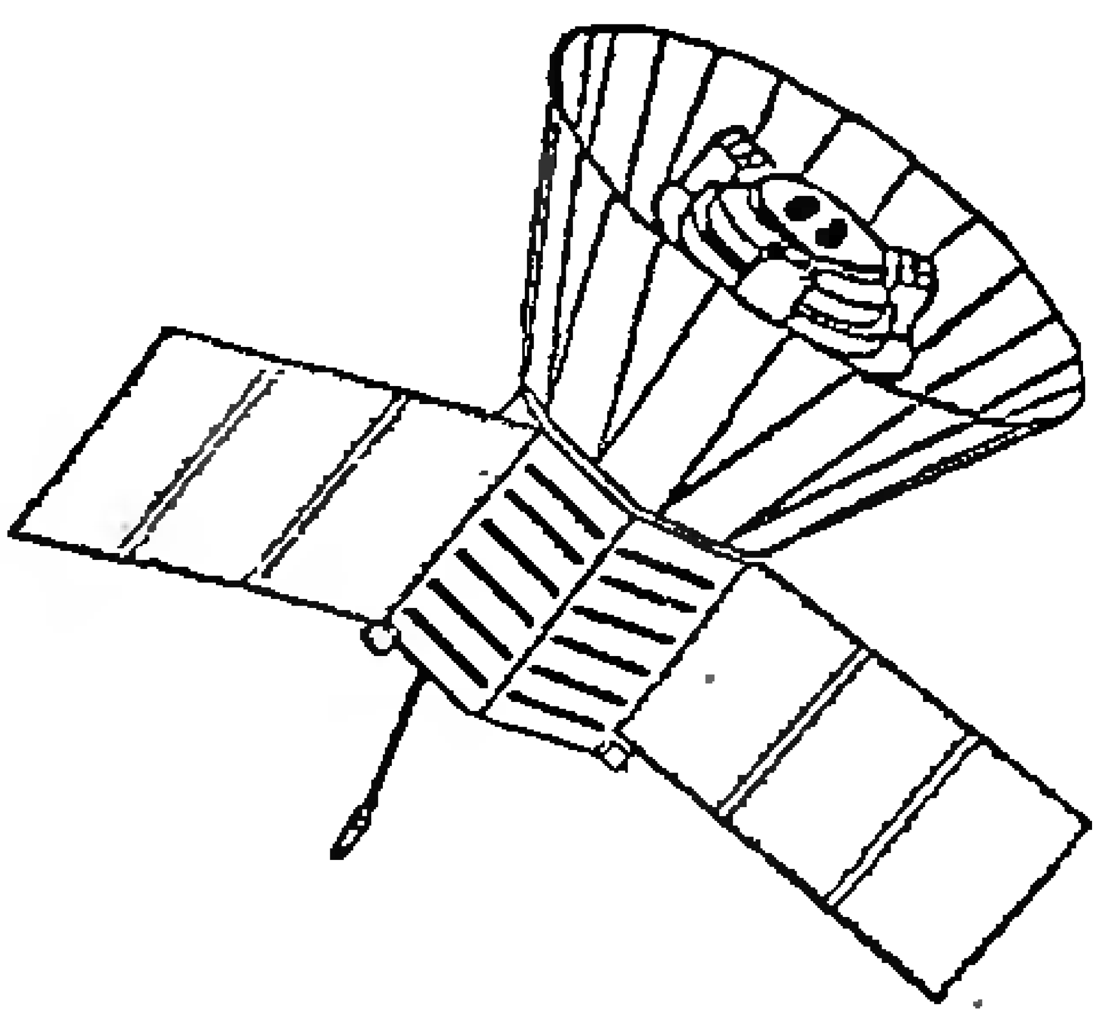
## The big bang

Drama is the only word to describe every aspect of the recent discovery of the weak large-scale fluctuations of the microwave background radiation (MBR) by the satellite Cosmic Background Explorer (COBE). The subject itself, as to how the universe began; the announcement of the results early in the morning to a packed audience at the Washington meeting of the American Physical Society; the euphoric comments of scientists, 'If you are religious it is like seeing God'; the reaction of newspapers and the lay public; the problems faced in launching COBE; and even the manner in which the news reached India. We publish on page 655 an invited article by T. Padmanabhan on the implications of the discovery.

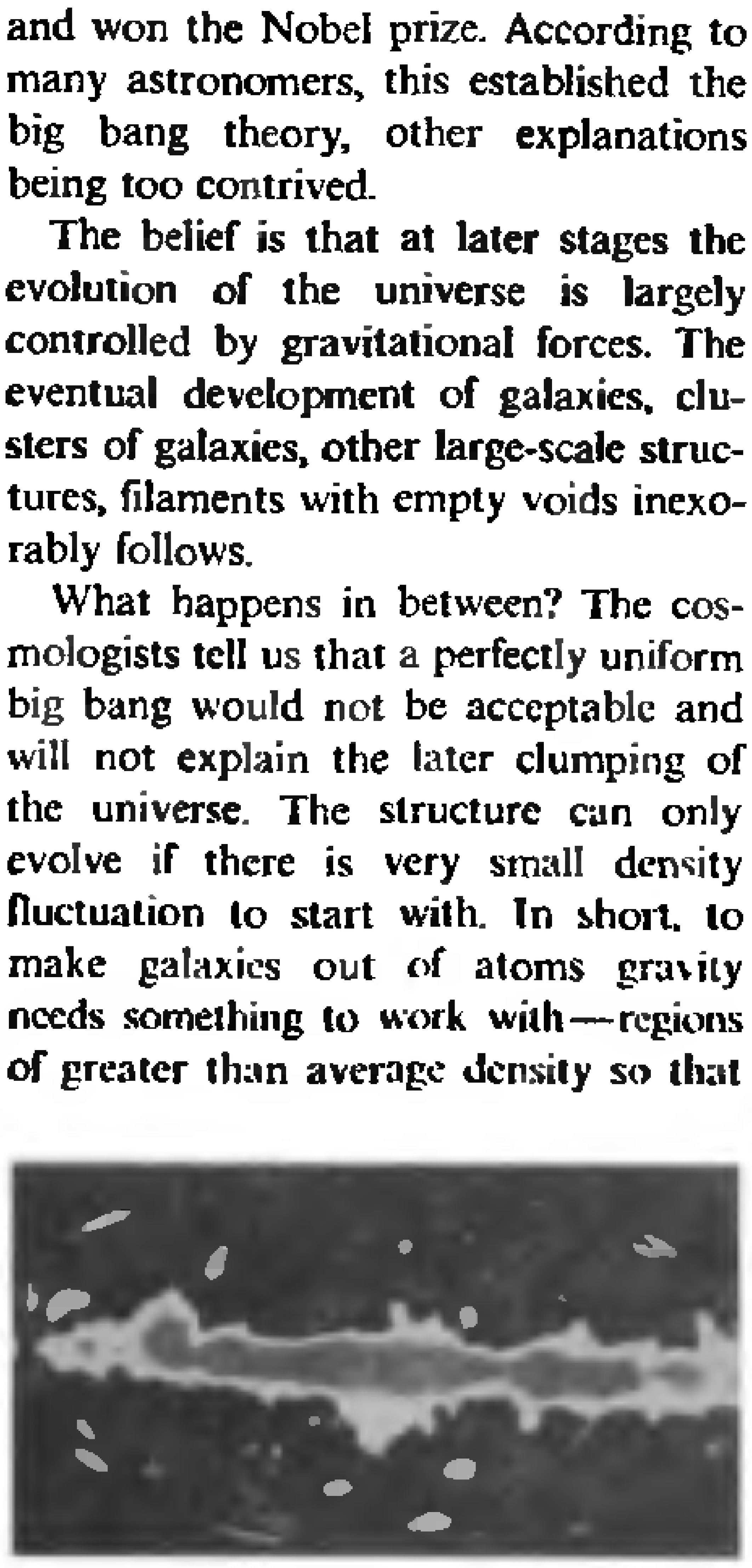


Every child of today 'knows' that the universe is expanding. Extrapolation backwards suggested that all matter should have been at one point at a single instant of time, 10 to 20 billion years ago. The gospel of the big bang was born and it goes as follows:

The universe was created by an explosion from 'zero volume' at 'zero time'. Since then space has been expanding uniformly. Immediately after the explosion the universe consisted only of radiation and ionised plasma. The electrically charged particles of the plasma scatter/interact with the radiation easily, and hence the radiation and matter are in intimate thermal contact. The plasma is opaque and so the radiation does not travel very far. The universe continues to expand and, in this process, cools (cosmologists expect various particles to exist in the plasma-electrons, quarks, neutrinos, other dark matter (sometimes called 'WIMPs', for weakly interacting massive particles). They also introduce concepts like inflation—which is 'the phase of exponential expansion'—none of which have direct experimental support so far). When the universe was 300,000 years old the temperature drops to about 3000 K, the particles form atoms, which do not absorb the radiation. So to a large extent scattering of radiation ceases and the radiation travels freely and unhindered. The expanding space stretches the wavelength of the radiation, making it appear as though it comes from a cooler body. As Gamov, Alpher and Herman proposed in the fifties, these photons must be observable even today and should correspond to those from a black body. Penzias and Wilson in 1964 (accidentally) discovered this radiation at a temperature of 3 K, and won the Nobel prize. According to many astronomers, this established the big bang theory, other explanations being too contrived.

The belief is that at later stages the evolution of the universe is largely controlled by gravitational forces. The eventual development of galaxies, clusters of galaxies, other large-scale structures, filaments with empty voids inexorably follows.

What happens in between? The cosmologists tell us that a perfectly uniform big bang would not be acceptable and will not explain the later clumping of the universe. The structure can only evolve if there is very small density fluctuation to start with. In short, to make galaxies out of atoms gravity needs something to work with—regions of greater than average density so that they could draw surrounding atoms in. When matter and radiation decide to go their separate ways, the last scattering from the early universe must imprint itself in the background radiation and must be visible in the Cosmic Microwave Background (CMB) maps made in the present era as large-scale fluctuations. Despite assiduous search for over a quarter of a century from the ground, no anisotropy in CMB was detected.



Since ground-based astronomy has many inherent problems a satellite COBE (3 meters across, 5 tonnes weight) was conceived of, designed and fabricated. When shuttle launches were delayed after the Challenger tragedy, a Delta launch vehicle was resorted to, and the painful process of reducing the weight, redesigning the satellite was gone through. The satellite was delivered into orbit in November 1989 and 'everything worked perfectly'.

The satellite had five differential microwave radiometers, and two independent pairs each for the wavelengths of 5.7 mm and 3.3 mm and one at 9.5 mm. The enormous information received over a year was cleaned up and analysed into three terms: the monopole isotropic radiation, the dipole radiation (to allow for our galaxy moving through space which results in one half of the sky being brighter than the other) and, finally, the quadrupole and higher multipoles (which shows the real asymmetry and the fluctuations one is looking for). 'The precision of the data is a testament to the power of modern instrumentation. The data gathered have been subjected to the most rigorous checking and consistency—the number can be believed', says an expert.

Almost imperceptible (10 parts in a million) warm and cool patches in the CMB radiation have been recorded. The variations are of the order of 16.2 ± 0.4 millionth of a degree Kelvin or $\Delta T/T = 5(\pm 0.5) \times 10^{-6}$. Even these apparently minute fluctuations are enough to keep the big bang theory alive and, in fact, have been hailed as the missing link which removes the biggest remaining objection.

Finally, the manner in which the scientific information came into the Indian astronomical community is also an indication of the sociology of how science operates today. One of the American scientists who attended a seminar in the US sent an E. Mail addressed to 'Dear All' giving as much of the information he could. Our astrophysicists T. Padmanabhan and D. Narasimha at TIFR could arrive at some conclusions based on these data which they incorporated into a pre-existing paper in a matter of days!

The smallest patches observed by COBE are by far the largest area ever surveyed—they dwarf even 'the great wall of galaxies' discovered in 1990. COBE has been designed to see such structures but astronomers would like to see smaller structures. How would the small hot spots look? Would the models used to fit the new COBE results fit smaller phenomena like galaxies. Some models do not, conclude the Indian scientists. Preliminary indications are that the popular cold dark matter models will have difficulties in accounting for the observations at COBE and galaxy scales simultaneously. No doubt much ingenuity will be applied to the physics of galaxy formation to try and bridge the gap.

## Diabetes

It is important that blood glucose levels be maintained in the physiological range. This is accomplished by an intricate hormonal system in the pancreas, the best known component of which is the polypeptide hormone insulin. In type I diabetes, the capacity to synthesize insulin is lost, and the patient requires regular insulin injections for survival. In type II diabetes, injections of insulin do not cure the symptoms. This is therefore called a non-insulin dependent diabetes. Both type I and type II diabetes can probably be caused by defects, environmentally induced or genetic, in one of several physiological steps. Sarma and Rajeswara Rao (**page 679**) review the role of amylin, a small peptide that could affect blood glucose levels, in part, by interacting with and affecting the function of insulin, thus causing a form of type II diabetes. While the role of amylin is indicative, there have been some recent exciting results on a form of type II diabetes that affects the young. This disease is called maturity-onset diabetes of the young (MODY) and is an inherited autosomal dominant disorder. A recent paper in *Nature* (Vionnet *et al.*, 1992, **356**, 721) shows that the locus responsible for this disease encodes the structural gene for a well-known enzyme glucokinase. The mechanism by which a single mutant copy can cause the disease has not been deciphered. Recent methods allow the rapid analysis of whether a particular locus is responsible for a human disease. The genetic basis of the various forms of diabetes is an area of extensive experiment and should result in clarifying the role of amylin in this disease.

## Chromosome damage

There have been remarkable recent advances in our ability to detect chromosomal aberrations in cells. Commercial kits are now available that allow the 'painting' of entire chromosomes with a chromosome specific label and the examination of this under the fluorescence microscope. Typically, this method will show a neatly painted chromosome pair and all the other chromosomes will not show the signal. If a translocation of a piece of DNA from the 'painted' chromosome to another chromosome has taken place, then a signal will be detected from the chromosome where the translocation has occurred, something which does not happen in normal cells. Fluorescence in situ hybridzation (FISH) and standard metaphase chromosome analysis are very informative techniques which require careful training in execution and analysis. Another method that complements these is that of micronuclei analysis. Cells with gross chromosome defects following irradiation or exposure to other damaging agents can be examined by the micronuclei technique. Micronuclei are caused by fragments of chromosomes or entire chromosomes being excluded from daughter nuclei. The analysis of micronuclei frequency can give a rapid assessment of the extent of chromosomal damage. Uma Devi and Streffer (**page 691**) combine micronuclei analysis after treatment with a cell-division blocking agent to improve the sensitivity of the method. Their experiments standardize a test that could be used for assaying chromosomal damage in dividing cells.