BOOK REVIEWS


In a small town in the heart of rural America, in a relatively small laboratory, a micro organism is at work. In a first of its kind successful experiment, a scientist has just observed the reproduction of bone cells around a small piece of bio-degradable material which to the trained eye looks like a human arm. Cells are rapidly multiplying and within a few days, the actual bone will appear around the bio-degradable piece. The scientist goes to his computer and neuro cells in his brain move his fingers on the keyboard as he types words, announcing the news of his successful experiment. Within seconds, his words travel across the continent and beyond, via an invisible path which criss-crosses hundreds of channels and millions of megabytes of electronic data.

Artificial human organs, gigabytes of electronic data on the go, internet chat and innumerable other phenomena are transforming images of a brave new world, ushering us into the 21st century. Whatever else the new century may bring for the human race, it is bound to produce a new global culture in which the defining factor will be speed.

Now imagine: If you were the editor of a prestigious science magazine with inside knowledge of what was happening in various cutting-edge scientific disciplines around the world, would you not be tempted to foretell what would be discovered next? Perhaps the thought would not cross your mind until your son asks you: "If you're the editor of *Nature*, why can't you say what will be discovered next"?

Once the question has been asked, the process takes its natural course and one ends up with a fascinating book: *What Remains to be Discovered: Mapping the Secrets of the Universe, the Origins of Life, and the Future of the Human Race*. Those who had known Maddox through his previous four books, *The Spread of Nuclear Weapons* (1962), *Revolution in Biology* (1963), *The Doomsday Syndrome* (1972) and *Beyond the Energy Crisis* (1974) would be pleasantly surprised with this synthetic narrative which fully brings forth the enormous range of his interests, twenty-three years of experience as the editor-in-chief of *Nature* and by his self-restraint which
is obvious from the very first chapter of the book, "Introduction: The River of Discovery" and is carried throughout the book:

This century has been so rich in discovery and so packed with technical innovation that it is tempting to believe that there can never be another like it. That conceit betrays the poverty of our collective imagination (p. 1).

Had it not been for certain broad statements which have totally ignored the achievements of "non-Western" sciences, the book would have been truly a remarkable achievement of the first order. But as it is, one wonders at the oversight of the rich and well-documented accounts of the achievements of the non-Western scientific traditions. Like many historians of science in the West, Maddox has also fallen in the same trap which devours all marvels of discovery between the resurgence of Greek science at Alexandria in the second century and the appearance of modern science. The cursory acknowledgement of the "contributions of the ancient Chinese, the extinct civilization of the Indus Valley, the Babylonians and the Greeks" hardly does justice to the rich and intricate achievements of the centuries before the modern era.

But, be it as it may, seen from the perspective of modern science and disregarding the issue of the legacy of "non-Western" sciences, one finds here a fascinating account of the achievements of the last three hundred years, leading to the twentieth century. Charting out the progress of science from the time of Copernicus, Maddox rightly points out that there would have been the same sense of wonder at the end of each of the three preceding centuries (p. 2). Looking back at the seventeenth century, an historian of science would be justified in boasting that there had never been a century like it since the resurgence of Greek science at Alexandria in the second century: Seventeenth Century — a century in which Francis Bacon brought his forceful argument in favour of experimentation; William Harvey dissected animals and people for "almost" the first time since Galen 1,200 years earlier, discovering the function of the heart, the arteries and the blood. A century in which René Descartes produced the legacy of the system of geometry in the language of algebra — the Cartesian Geometry — and a century which saw the crowning achievements of Isaac Newton in the 1680s which showed "that the orbits of the planet were the result of an attractive force between the Sun and its planets" and ended up in the discovery of the Newton's law of gravitation which explained such diverse phenomenon as the attraction between Earth and the falling apple as well as the roughly spherical shape of Earth, the Moon, the planets and the Sun and stars. Newton's genius redefined our concept of the world; in his fascinating book now simply known as Principia, which first appeared in 1687, he summoned up the speculations of the previous two centuries and
produced agenda for science for the next two centuries.

The next century was likewise full of discoveries. Newton had to devise a new mathematical technique, differential calculus, for calculating the orbits of planets and other trajectories. It was a clumsy technique but useful enough to engross a team of brilliant German and French mathematicians in its refinement. But while this was happening, a fascinating new area of science had opened up revolutionary vistas: Electricity and Magnetism. The discoveries of this century changed, once again, our view of the world and its composition. We learned about the positive and negative charges, about the nature of lightning, forces of attraction and repulsion between charges and about the steady flow of electricity through metal wires. As if this was not enough, the eighteenth century also produced a series of technological advances which sent salesmen trudging across western Europe with their wonderful steam engines as replacements for traditional water wheels.

But it was the nineteenth century which could truly claim to be the century of wonders. Within the first two decades of this century of discovery, John Dalton, a teacher in the north of England, had firmly established that all matter is made of indivisible atoms, that there are only a few fundamental substances, which he called elements and that each different kind of atom has a different weight: hydrogen atoms are the lightest and carbon atoms are roughly twelve times heavier than the hydrogen atoms.

By 1851, James Prescott Joule had proven the doctrine that energy is conserved. Then came the revolutionary idea of Entropy, introduced by German Rudolf Clausius and the laws of thermodynamics. But perhaps, as the author says, the crowning "achievement" of the century was Charles Darwin's theory of the evolution of species by natural selection, published in 1858. Perhaps equally important was the conceptual difficulty raised by the wonderful Wave Theory of James Clerk Maxwell which explained all kinds of properties of light and other radiations: How could a ray of light, or some other kind of radiation, keep on travelling long after its source had vanished? In other words, what "filled the empty space"? This problem took almost a quarter of a century to reach at the notion of vacuum and our understanding of this wonderful void is still imperfect.

But nineteenth century could also boast of having produced Louis Pasteur who demonstrated the nature of bacteria and postulated his germ theory of infectious disease. Above all, the revolutionary discoveries of the last two decades of the century were unprecedented: Generation of invisible Maxwell waves in the radio-frequency range by Heinrich Hertz in the 1880s which would herald the era of global communication when Guglielmo Marconi spanned the Atlantic with these waves two decades later; the
discovery of X-rays by Rontgen (1895); the discovery of radioactive elements by Antoine Bequerel (1896) and the discovery of electrons by J. J. Thompson (1897).

The century thus ended on a triumphant note. Not only had fundamental physics been reduced to a series of problems in mathematics that would in due course be solved, but the closing decades of the century were made prosperous by technology resting on science that was itself the product of the same century. The dyestuffs industry and the chemical industry more generally were the products of the atomic theory and what followed from it. The electrical industry (harbinger of the communication industry) had already begun to change the world. For science and technology, the nineteenth century was certainly the best there had yet been. Only now do we know that it was merely a beginning (p. 9).

And it was true, for in these closing years of the twentieth century, we can look back and wonder: what would be the nature of our understanding of the world had there been no Max Planck, Albert Einstein, Niels Bohr, Louis de Broglie, Erwin Schrodinger and Werner Heisenberg who would take science out of its self-satisfied citadel of certainty and open up a whole new arena of uncertainties which would eventually leave us scurrying for the "fundamental truths" which science had already seemingly solved?

From an historic perspective, perhaps the most revolutionary discovery of the twentieth century is DNA, that almost uniform and apparently featureless molecule that generates such a variety of living beings. "The structure of DNA ranks with Copernicus' successful advocacy of the heliocentric hypothesis in importance", writes Maddox. "In 1900, a few brave spirits may have hoped that an understanding of life would be won during the century just beginning, but there cannot have been many of them" (p. 20).

After this fascinating broad sweep, we are left with the three main parts of the book, "Matter, Life and Our World", each dealing with specific fields. Part one is a rich account of the theories about the origins of the universe and of matters; part two deals with the sciences related to the origin of life, and part three with the neuroscience and mathematics. The book concludes with a futuristic account, appropriately entitled,"What Lies Ahead".

Three chapters which make up the first part of the book ("Matter") narrate the gripping tale of the emergence of various theories about the origin of universe. How did the scientists arrive at theories like the Big Bang and Theory of Every Thing (TOE)? How were smaller and smaller particles discovered and what were the implications of these discoveries? What lies ahead for cosmologists? These and related topics form the core
of this part but one thing is missing: Maddox makes no reference to the return of the scientists to the religious worldviews and many attempts which have been made and are being made to correlate the scientific data with the religious texts. He is not interested in a "religious cosmology", his subject is merely the "scientific cosmology" devoid of metaphysical considerations. He concludes this section with predictions:

By extension, the idea that the universe began in a single event, the big bang, will be found false. For most of the five centuries since Galileo first saw the moons of the Jupiter through a telescope, observers of the heavens have been like kidnap victims seeking to learn where they are from the chinks of light that reach them through imperfect blindfolds; half a century from now, cosmologists will have a much better idea of what kind of universe they are expected to explain. The once-and-for-all universe of Genesis, or of Guth's equivalent, is an improbable outcome (p. 122).

"Life", the second part of the book, is more directly concerned with the questions on the borderline of science and religion but does not deal with the issues which arise from this interface. Tracing the origin of modern biology, Maddox outlines the broad contours of our understanding of life, as it emerged through the work of Darwin, Louis Pasteur, Friedrich Wohler and A. I. Oparin. He narrates the interesting set of events which led to our understanding of the Organic and Inorganic matter and, step by step, constructs the grand picture of Human Genome Project.

This part is also where one comes to the humbling realization of the limitations of science. What we know is so little compared to what we do not. Genetics has produced a rich harvest of understanding during the last twenty years: We now know that Down's Syndrome is caused by the presence in the embryo of three rather than two copies of human chromosome 21 but what do we do with this knowledge? Use it to terminate pregnancy? Know in advance that the baby will be born with Down's Syndrome and be ready for the civilizational influence that comes with caring for disadvantaged children? A whole range of ethical and even religious questions have been raised by these discoveries, though Maddox does not deal with them (for they are outside the scope of the present book).

Recent advances in genetics have raised more questions than they have solved: How are groups of related genes regulated in concert? What exactly are the influences that prevent the activity of some genes? Maddox ends chapter six of this part with an appropriate warning: "But there is an important lesson that molecular geneticists should learn: in a field that engenders great public sensitivity and triumphalism, the idea that everything is determined by genes is their Achilles' heel. Most people, including those whose health may be powerfully improved with the help of new genetic knowledge, know that there is more to life than genomes" (p.
"Our World", the third part of the book, deals with three important subjects in as many chapters. "Thinking Machines", the first of the three chapters, is a wonderful account of the emergence of neuroscience as one of the key sciences of the twentieth century. The transition from focus on the nervous system to the brain has been slow but once the scientific community came to realize the lack of data about the functioning of "mind" — the imprecise label sometimes used to denote a combination of heart, brain and nervous system and sometimes other combinations (including the soul) — there has been steady progress in the field and neuroscience has gained tremendous prestige and respect. Maddox traces the relatively short history of major discoveries in this field and leads us to the connection neuroscience has made with the study of genes:

Fortunately, there is now a prospect that the understanding of all these processes will be illuminated not merely by further studies of the anatomy of the brain, but by the study of the genes that guide the development of the nervous system (p. 286).

This important connection has been made in a series of remarkable discoveries which produced the metaphor of mind as a computer. In 1954, Frank Rosenblatt, a US engineer, devised a machine called "The Perceptron", intended as a device for recognizing printed characters. It failed but the idea that networks of simple electronic elements can simulate some functions of the brain was not forgotten and twenty years later, John Hopfield of the California Institute of Technology published his persuasive account of how such a network could indeed be built so as to store "memories" of several different patterns of inputs and then tell to which of them an unknown stimulus most closely corresponds. This important suggestion is leading to cutting-edge technological innovation, including the speech recognition and NETtalk. But the crucial question remains unanswered: What is Consciousness? And how does it work? And this is the question for neuroscience of the twenty-first century.

But what really lies ahead for science? The book concludes with a map of things to come. Maddox briefly revisits his earlier chapters and leads us to the road that lies ahead for physics and life sciences. He concludes the book by saying that years ahead are full of exciting possibilities for the entire human race.

Muzaffar Iqbal*

---

*Muzaffar Iqbal, Research Associate, International Institute of Islamic Thought, Islamabad.