which began to operate — the first outside the USA — a month after the War came to an end.

Joliot led a double life during the occupation. He kept his Paris laboratory going, but subtly sabotaged any research which Germany tried to conduct there; and he worked in the Resistance and came to admire the communists for their courage, idealism and competence. When France was liberated he was tireless in reviving fission research, amidst political strife and a ruined economy. Equipment was requisitioned or home-made; young people, attracted by the glamour of nuclear energy, were trained. Before Christmas 1948 the first reactor in France began to operate a heavy-water reactor, again built by Kowarski.

After that, the power of the scientists began to decline as the engineers, administrators and politicians took over. The declaration that France would never build nuclear weapons was gradually forgotten. Joliot's communist stance caused increasing problems, and after a rally in April 1950 when he declared that France would never make war on the Soviet Union he was removed from his post as head of the Commissariat à l'Energie Atomique. Large reactors were built, optimised for the production of plutonium, and the first French Bomb was exploded over the Sahara in 1960.

Joliot is clearly the hero of the book, a scientist who combined hard logic with lively imagination, and a persuasive personality with considerable skill as organiser. In his bid for nuclear power he was up against Fermi, probably the greatest all-round physicist of our time, as experimenter and theoretician alike, while France was short on theory. But Fermi was cautious and a foreigner in the USA while Joliot was full of fire and had the support of his country and his government. The author quotes Lord Blackett for saying "had the war not intervened, the world's first self-sustaining reaction would have been achieved in France".

This is a very well researched book, with its 12 pages of bibliography, 35 of footnotes, and a good index. But in spite of that scholarship the book is eminently readable and contains deft pen portraits of its many characters. It is written with a quiet dignity that yet does justice to the dramatic events with which it deals. Spencer Weart focusses on the French story but gives fair attention to efforts made elsewhere. Scientific explanations are kept fairly brief; much more space is given to the delicate interplay of social, economic and political forces; of great families and great schools; of scientists and administrators. Whichever way you look at it, this is a valuable and fascinating book. □

Otto R. Frisch was Professor Emeritus at Trinity College, Cambridge, UK. In Copenhagen he had contributed to the discovery of nuclear fission early in 1939. Professor Frisch died on 22 September, 1979.

Curiosity of a scientist

Hermann Bondi

Disturbing the Universe. By Freeman Dyson. Pp. 283. (Harper and Row: New York and London, 1979.) \$12.95; £6.50.

OCCASIONALLY I feel unkind towards my many friends and colleagues in the education industry by pointing out that every small child makes a nuisance of itself by constantly asking "Why?", that society has developed a marvellous defence mechanism called education, and that this is so effective that it stops almost everyone from keeping on with this questioning. The few failures of this cure are, I claim, called scientists.

Curiosity must indeed be the mainspring of scientific endeavour. The constant nagging feeling of *wanting* to know something or other that is well hidden is indeed a powerful drive. To find out what a particular problem really is like and has as its solution, to worry the problem like a dog worries a bone, to gain insight by following to their end innumerable false turns, to see the whole confusing jumble eventually form a surprising and unexplored pattern, that is the real compulsive urge and joy of a scientist's labours.

To an extent that varies markedly between individuals there is associated with this an urge to communicate, an urge to teach, an urge to show to others the lovely pattern one has seen (whether one has found them or made them is a moot point) in one's own sandbox. Thus, research and teaching are naturally linked, but the link may take many different forms. To interest suitably qualified colleagues or research students in one's own researches is natural enough, but to watch a research student learn by making his own mistakes, perhaps messing up a lovely corner of one's sandbox is more of an acquired taste needing much self-discipline, but with its own rich satisfaction when one's pupil finally soars off under his own power. Undergraduate teaching is often seen as a chore, but only by those who have not got the urge to get across the beauty one sees in the structure of one's subject, the pleasure of conveying the personal pattern that one has seen (or made) in a well known part of the field.

Thus, there is substance to the notion of the normal academic career where one's researches (the value of which can be judged reasonably well) lead to posts in which teaching (the quality of which it is much harder for a university to assess) forms a major part of one's duties, along with continuation of one's research.

However, justification for the curious habit of academic tenure (other than the mental comfort of the holder) can surely only be found if it enables the incumbent to follow daringly different unconventional and potentially fruitful pursuits on which he would otherwise not have embarked. Unhappily it is only a minute minority who so use their freedom. The vast majority of tenured academics, even of full professors who have nowhere further to rise, turn their academic positions or chairs, not so much into comfortable beds, as into narrow grooves of dried-up specialism often made most uncomfortable by making an 80 hour week out of administrative tasks that would take a competent bureaucrat half of an afternoon. Rare indeed is the person who really uses the freedom given by academic tenure to enrich the world and to enjoy himself by working hard and effectively at each in turn of the wide variety of pursuits he finds intriguing. Pre-eminently one such is Freeman Dyson, and his book is an exciting journey through the broad landscape of his experiences and thoughts.

Perhaps this is the point at which I should interpose the story of my period of friendship with the author which illustrates some of the bits he so oddly left out of the book. He does not mention his extraordinary brilliance at school at Winchester and as undergraduate at Trinity College, Cambridge, in the bumper class that had in it James Lighthill and Freeman Dyson, a record pair not equalled before or since. After the painful interlude of Bomber Command (fully described in the volume) he returned to Trinity as a young Fellow a few years my junior. An inveterate talker like myself (I recall his interrupting me at High Table dinner with "Not another word now. We are still on the soup while the other are finishing their desserts") he clearly had a most enjoyable year, but found that Cambridge, with its then rigid barrier between Physics and Mathematics was not a good place to learn and work in the lively field of theoretical quantum physics he wished to pursue. Hence his move to Cornell and Hans Bethe, where his book restarts. Why this odd omission of Cambridge?

He relates how he learned, travelled, and did brilliantly, none of which surprised me. But I was astonished and a little worried when he accepted a permanent position at the Institute of Advanced Studies in Princeton. That such an able and enterprising young man should take a post from which there was no escape upwards in academic life, a post that would hang round his neck for nearly 40 years, that would prevent him from teaching anyone but a few highly selected graduate students, that would isolate him in a closed esoteric community, all this saddened me greatly. How wrong I was to worry is so beautifully shown in his book. To him the Institute post was simply a springboard for pursuing

his foibles, and for one such as Dyson each foible is both what would be the adventure of a lifetime for others and a notable contribution to mankind's storehouse of knowledge and experience.

Two of his particular characteristics are to be totally fascinated by space, and to be deeply interested in nuclear power. He describes with such evident joy his cooperation with a brilliant group of people to design the 'inherently safe' Triga nuclear research reactor. In very little time the endeavour was most successful, and dozens of these reactors were sold. Not long afterwards Dyson was involved with the splendidly conceived Orion project which aimed to use nuclear power to make space travel cheap and fast. In the end, this

mankind's future in space as he sees it. I happen to be more of a doubter in this field, but I too was carried along by the sweep and logic of his vision, by his imaginative application of knowledge, by his sheer enthusiasm. I tend to think that the solution of our problems on the Earth must be found on the Earth, but his comparison with older efforts of settling new lands is certainly intriguing and well argued, his view of the need for adventure is stimulating, and the whole section is not just very readable, but truly exciting and thought provoking.

I am less enthusiastic about the pieces of Dyson's personal history in the book. They certainly are well chosen fragments, but they are only fragments. One's personal

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endeavour was doomed through external developments. He describes his involvement with molecular biology more sketchily but the depth of his understanding is evident. Politics fascinated him, not the strident shouting of electioneering that is so liable to expand minor differences of judgment on non-central issues into great philosophical divisions, but the patient work of exploring how the most deeply held and widely differing convictions can be reconciled in modest and valuable programmes of action. His work in the Arms Control and Disarmament Agency and his efforts in the Princeton Citizen's Committee to advise on whether recombinant DNA researches should be permitted are all lovingly related in a most human and readable manner. Much earlier, in the Oppenheimer tragedy, he seems to have been only a spectator, naturally an immensely concerned spectator, but one with much understanding of how some actors came to what he regards as utterly wrong choices. This was his bleeding in politics, and if it left him wounded, he was keen to point out the total absence of scars.

But perhaps the most thrilling part of the book deals with his deep speculations on

life is a continuous chain of experiences and impressions, each section being properly intelligible only in the light of its predecessors. His episodes, though, make excellent reading matter. He is also curiously reticent about his scientific work since his appointment to the Institute.

But to come back to the mainstream of his book, I was especially intrigued by his fascination with engineering, a fascination I, as another theoretical physicist, share with him, though he came to it earlier in life than I did. But where he and I differ is in our attitudes to bureaucracy. It is natural for a scientist to feel antipathetic to big organisations. The brilliant ideas, the outstanding contributions we most admire and indeed venerate, are necessarily the product of one person's mind, or very occasionally of two or three closely collaborating minds. Ten thousand mediocrities working for ten thousand years could not have duplicated Einstein's ideas or those of Charles Darwin. Exceptional quality of mind is needed in our fields and cannot be replaced by quantity. But great engineering projects like Apollo, or the Forth Bridge, or Concorde, are created, and can only be created, by vast impersonal organisations responding only slowly and gently to any

ELLIS HORWOOD

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CELL POPULATIONS

Editor: **E. Reid**, Director, Wolfson Bioanalytical Centre, University of Surrey

This desk guide to new and established methods of isolating cell populations from tissues or other heterogeneous biological sources surveys techniques for obtaining homogeneous samples of healthy cells from mammalian tissues, and from protozoan and other free-living cells. It also offers guidance on the choice of the most suitable methods. The range of techniques covered includes sedimentation, isopycnic banding, elutriation, partition between two aqueous phases, and free-flow electrophoresis. It will serve as a research and laboratory reference book, or as a teaching aid, providing also adequate background knowledge for non-specialists. It is an authoritative coverage of the field by an international team of experts, first presented at a Subcellular Methodology Forum held at the University of Surrey in 1978. There is no such wide-ranging survey of its size known to be available.

Contributors include: W.S. Bont, N. Crawford, M.J. Crumpton, W.H. Evans, R.J. Hay, H.G. Heidrich, G. Johansson, D.L. Knook, H.A. Krebs, S.M. Lanham, J.P. Luzio, H. Pertoft, G. Raydt, I. Schulz, P.O. Seglen, and Th. J.C. van Berkel.

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PLANT ORGANELLES

Editor: **E. Reid**, Director, Wolfson Bioanalytical Centre, University of Surrey

This comprehensive and critical survey of known methods of the isolation of organelles and membrane material from plant tissue also emphasizes the advances in the field.

The book first considers methods for isolating bioenergetic organelles, and then presents current views on vacuoles and microbodies. There is consideration of membranous components and nuclei, and of constituents such as glucan synthetases and phytochrome, with attention to lectins, auxin binding and glycosyl transferases. The critical collation of current thinking on markers for characterizing subcellular fractions concludes this outcome of a Subcellular Methodology Forum held at the University of Surrey in 1978.

Contributors include: H. Beevers, D. J. Bowles, R. Douce, J. L. Hall, R. Hertel, C. Larsson, R. A. Leigh, J. M. Lord, G. MacLachlan, A. E. C. MacRobbie, D. Marmé, D. J. Morré, C. A. Price, P. H. Quail, P. M. Ray, S. P. Robinson and E. L. Vigil.

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change in direction, whether the command comes from a genius or from a mediocrity. They can be accelerated slightly be leaders of great drive, and lose momentum without leadership. But invariably they grind on remorselessly, very inefficiently, but necessarily successfully, for only mass murder could stop them in their tracks.

It needs a certain type of sophistication to derive job satisfaction from the awareness that, without one's sustained efforts over a year, the organisation would be moving in a slightly different direction, and would not have got quite so far. Such a form of sophistication Dyson does not have. To him only work in a small group is

fun. This attitude separates him from much modern engineering and from much that is involved in the public service. He is thus a supporter of small bands of pioneers rather than of large project management teams. It is a great loss that our necessarily large bureaucracies are unable to attract such talent.

I am sure I have said enough to make it clear that I thoroughly enjoyed reading this book, that it gave me a lot to think about, and that I can recommend it heartily to all. □

Sir Hermann Bondi is Chief Scientist at Her Majesty's Government's Department of Energy.

A man who thinks otherwise

Eric Ashby

The Medusa and the Snail: More Notes of a Biology Watcher. By Lewis Thomas. Pp. 175. (Viking: New York, 1979.) \$8.95. (A UK edition will be published after May next year by Allen Lane (London).)

IN far off days, when the academic profession was a revered élite, the Germans defined a professor as "a man who thinks otherwise". In these days, when knowledge is fragmented and the academic profession unionised, otherwise-thinking is rare, even among professors. Hence the significance of this little book of essays, for Lewis Thomas is a virtuoso in thinking otherwise.

At first glance the book seems to be lightweight, no more than a capricious assortment of fancies about ponds in Manhattan, cloning of human beings, committees, punctuation, disease, death, warts; all gently mischievous, witty, conversational in style, the work of a latter day Montaigne or Lamb. Those who have read Thomas' other essays (*The Lives of a Cell: Notes of a Biology Watcher*; Viking: New York; Garnstone: Petworth, UK; for review, see *Nature*, 258, 24; 1975), know how misleading such a first glance would be. In common with another Lewis, Lewis Carroll, he has an extraordinary intellectual exuberance. I have not read any of his papers on pathology (Thomas is a distinguished pathologist) but I guess they are as unlike *The Medusa and the Snail* as Lewis Carroll's *Euclid and his Modern Rivals*, published just 100 years ago, is unlike *The Hunting of the Snark*.

Carroll wrote for children. Thomas writes for grown-ups who still retain a child's capacity for wonder. Apart from his

mastery of prose, which makes me green with envy, he has a rare talent for picking up something familiar and suddenly, with a flash of imagination, giving it a fresh meaning. It's done deftly, like a conjuring trick. It's the technique of a poet. Edith Sitwell used it effectively; she described it once to me as a "leakage of thought" from one compartment of the mind to another. Thomas himself describes it: "finding the marks of remote similarity, points of distant relationship, tiny irregularities that indicate that this one is really the same as that one over there only more important". And in an essay on thinking about thinking he tries to describe the process. The human head, he writes, "is filled alive with molecules of thought called notions. . . flowing at random from place to place, bumping against each other. . . like the paths of Brownian movement". The mind is heated a little, the movement speeds up, there are more encounters, some of the notions dock and lock (notice the imagery of space-travel), aggregates are formed, they act like "purposeful organisms, hunting for new things to fit with. . . turning things over, catching at everything" — and a harmonious idea is generated, with the elegant geometry of a Brandenburg concerto. At that point Thomas' mind takes another leap: why not begin with music "and see what this can tell us about the sensation of thinking".

So far so good: the book is delightful entertainment. Is it more than that? I believe it is. It is a piece of intellectual autobiography. Its theme is the impact of Nature on Lewis Thomas. By what I believe is a valid extrapolation, it speaks for thousands of other less articulate biologists and naturalists; and this is why it is more than entertainment. Thomas visits the Tucson Zoo and watches beavers and otters at play in glass-walled pools. For a few minutes he sheds his professional reductionist shell and becomes, as he puts it, "transfixed. . . there was only one sensation in my head: pure elation mixed with amazement at such perfection". The beavers and otters had done something to

him. "I learned nothing new about them. Only about me, and I suspect also about you, maybe about human beings at large: we are endowed with genes which code out our reaction to beavers and otters, *maybe [my italics] our reaction to each other as well*".

Speculation, bordering on the turbulent territory of sociobiology? Perhaps it is, but there is no dogmatic assertion in Thomas' reflections. He offers you a subjective experience, take it or leave it. I would be surprised if many biologists reject the *credo* which is the main motif in these essays. The *credo* rests on wonder at two principles Thomas finds all around him. One is uniqueness; the other is symbiosis. Here are a few examples of the impact they make on him.

To say that the DNA molecule is the greatest single achievement of Nature is a commonplace opening for an essay. But then Thomas goes on to wonder whether molecular biologists could have achieved this, if they had been flown from another planet to start life off on Earth. Suddenly comes the refreshing insight: "We would have made one fatal mistake: our molecule would have been perfect. Given enough time, we would have figured out how to do this, nucleotides, enzymes, and all, to make flawless, exact, copies, but it would never have occurred to us, thinking as we do, that the thing had to be able to make errors. The capacity to blunder slightly is the real marvel of DNA. Without this special attribute, we would still be anaerobic bacteria and there would be no music. . . it is no accident at all that mutations occur; the molecule of DNA was ordained from the beginning to make small mistakes".

This is the source of the uniqueness of living things, of the idea of selfhood. In the *Testament of Beauty* Robert Bridges came to a similar conclusion along a different path. Thomas takes the scientist's path. He cites the self-labels of beans — the glycoproteins which may negotiate the intimate concordat between bean and nitrogen-fixing bacteria; he cites the capacity of fish and mice to tell each other apart as individuals by a sense of smell; and he concludes that nucleated cells detached from the parent organism seem to be the only living units without a "sense of privacy". It is no wonder he has deep reservations about cloning human beings. Of course, like any other professional biologist, he doesn't think it is likely to happen; but suppose it did: think what this would do to filial affection and paternal care; think of the terrifying prospect of raising from infancy and teaching language and discipline to a creature whose genetic constitution is exactly the same as your own. In any case, as Thomas explains, it couldn't happen because the selfhood of human beings depends not only on their genes but also on their environment, including their personal relations with other human beings, and it would be