"more interesting than any novel". Next, Max Planck's volumes on theoretical physics, reaching his hand by chance, conveyed the essentials of the subject to him in a clear and direct way, despite their being in German. His first awareness that physics was on the move at last, came from a lecture given by Professor Nagaoka in a visit to Kyoto during Yukawa's first year as a university student and Schrödinger's papers on quantum mechanics became the young Yukawa's bible in the following year; wisely, he read only from the original papers and came to know them through and through.

Yet, even so, Yukawa felt that he came into theoretical physics, not through conscious choice, but by the exclusion of other possibilities where his personality and intuition gave him no advantage, until theoretical physics was the door most readily open to him. His first postgraduate years were spent as an unpaid research associate in the Tamaki research room at Kyoto University. In 1929, when Heisenberg and Pauli made their famous trip around the world, they came to Kyoto and their lectures were an immense stimulus to the young Yukawa. S. Tomonaga was a fellow student through this period, "an outstanding companion . . . encouraging and challenging . . . the type of person who is aware of limitations and yet comes up with the clever ideas".

In 1932, the discovery of the neutron, the positron and nuclear disintegration directed Yukawa's attention to the nucleus and the forces which held it together. Psychologically the time was ripe for him. Nishina had come to Kyoto about 1930, after a long stay with Niels Bohr at Copenhagen, and in his presence "my solitary mind began to open". Around this time he married Sumi Yukawa, whose photograph had attracted him instantly when a go-between came to his father (Ogawa) proposing marriage. This moved him outside his family circle and the young couple set up house in Osaka, a neighbouring city, as open and lively a city as Kyoto was closed, private and quiet. He was then appointed to a lectureship at Kyoto; Sakata and Kobayashi were students at his first lectures and Taketani came soon after, and they, together with Tomonaga (by then in Tokyo), became his close friends. Next, a university was established at Osaka and he became a lecturer in Professor Yagi's department there; a happy situation, since he felt great admiration for Yagi.

Through this period, Yukawa's work with the nuclear force problem went on almost subconsciously. Already in 1932, he had reached the conviction that there must be some new force field involved but, as he said, "the path thereafter was not straight: I had to take the wrong path first, before I could arrive at my destination". Then, one

night in October 1934, the crucial point occurred to him that the range of nuclear forces must be connected with the mass of the new particle he was seeking. Next morning he calculated its mass to be about 100 MeV. The particle had not been seen experimentally since such high energies were not available in the laboratory. He quickly became confident and predicted that such particles should be found in cosmic rays, in Wilson cloud-chamber experiments. He presented his new theory to the Physico-Mathematical Society of Japan, but his wife kept urging "please

disreputable in those days; physicists were conservative and progress in physics was not to be made in that way. Evidence of a particle was needed first; then we could talk about its properties and purpose! Even in 1954, John Wheeler gave "a sermon" to the American Physical Society with the text from St John: "Believe in those things which are good", urging us to explore thoroughly the established theories of electromagnetism and gravitation, before invoking new physical interactions to account for the elementary particles then being discovered. The resulting work led to

many unexpected and important results, although it achieved little towards our understanding of these particles. Today, a theoretician feels no embarrassment in proposing a new theory involving several dozen unknown particles, nor in proposing some different theory in the following month. This was not Yukawa's style.

Yukawa's autobiography, written in his fiftieth year, is not concerned with his later work, and this helps to focus our attention on the importance of quiet reflection and subconscious

thought on basic problems. We may quote a poem Yukawa once wrote:

In Kamakura,

*here in a deep and quiet valley,
a man walks deep in thought.*

He had in mind a particular professor of philosophy, who impressed him greatly, but we may take it as Yukawa's epitaph. □

R.H. Dalitz is Royal Society Research Professor at the University of Oxford.

IMAGE UNAVAILABLE FOR COPYRIGHT REASONS

write the English paper and show it to the world"; so, an English-language paper was quickly sent to the Society for publication.

Young physicists today find it difficult to understand the mental attitudes of physicists even 30 years ago. They wonder why it took so long for physicists of Yukawa's time to propose a new particle to solve this problem. The fact is that to hypothesize unobserved particles to account for new phenomena was

Man and machine

Brian Gaines and Mildred Shaw

Micro Man: Living and Growing with Computers.

By Gordon Pask and Susan Curran.
Century, 76 Old Compton St, London:
1982. Pp.222. £8.95.

TO LIVE a life unaffected by computers is becoming increasingly difficult. Soon it may be impossible. Whether the prospect excites or appalls you could well be shaped by reading this book. The medium of print has been used to present the message vividly with pictures and graphics on every page, many in colour. An erudite text has been transformed through brilliant layout and illustration into an everyman's guide to computers. Not only are the techniques here — you can use the book as a guide to chips and bytes, Apples and COBOLs — but also the intuitive feel for the culture.

Gordon Pask should need little introduction. He is an authentic genius, a visionary yet an immensely practical man, whose cybernetic theories have influenced

many in engineering, psychology, education and the arts. Pask built personal computers before the name was coined. Some were intended to interact with people and others to be people. During a quarter-century of intellectual innovation he has used the technology of the day to create models of, and tools for investigating, a range of theories that encompass questions going to the roots of life itself. If anyone can speak for both humanity and computers it is Pask.

Susan Curran brings to the collaboration professional experience of presenting advances in electronic, computer and office technology to businessmen and others concerned with their economic and social impact. Her partnership with Pask has resulted in a lucid book that illuminates the often obfuscated issues of computers and their impact on us, our societies and ourselves.

This is a book of questions rather than answers — it probes and it speculates and it wonders. Many of the questions are profoundly disturbing, not only because we do not know the answers, but also because many of those that we dimly perceive are unacceptable and frightening. Modern

technology has reified science fiction and brought fantasy into our everyday lives. The computer is a tool of the mind allowing us to explore our wildest imaginations; it is also a tool too close to ourselves for comfort, perhaps replacing us in activities that we have been taught are our purpose for existence, such as work.

How can we encapsulate the complexities of computing technology and see it in terms that we already know? One view that has already proved very useful is to regard the computer as providing us with a new communications medium supporting interaction and conversation. Books are remarkable in allowing voices from the past to communicate with us and influence our emotions, values, knowledge and actions. But books are one-way. An author may come alive to us, as may his characters and his concepts, but we cannot answer back or ask questions.

Computers provide a medium analogous to a book that supports two-way communication. The programmer may simulate himself, the personalities of others, and the phenomena of complete worlds of objects and of people that may, or may not, have ever existed. Adventure games on the personal computer in the home allow us to become a character in an electronic "novel". We learn to live in an alien environment, gain friends and resources, and use them to achieve our goals. Expert systems on larger computers allow the recorded mind of an expert, or the composite "mind" of many, to guide others less skilled in complex tasks. In using them you are discussing with a "colleague" problems of medical diagnosis or oil exploration, or the inventive processes of mathematical discovery. You tell them your problem and the information you have. You discuss it with them, query their judgement and ultimately come to a decision based on a collaboration with someone who may be long dead.

Computer technology affects the core of our being because conversation is at the heart of human civilization. We are a species remarkable for our adaptive and learning capabilities, the effect of which is immensely amplified by our capability for conversation. Only one person need learn from experience. Others can be told and media allow the telling to transcend space and time. New media *do* change our world and the computer provides the first one for encoding not just a conversation but the capability to converse itself, not just a picture but the capability to be in the world portrayed. Pask and Curran have made superb use of an existing medium to give an exquisite portrayal of that which is to come. □

Brian Gaines is Professor in the Department of Industrial Engineering at the University of Toronto, and Mildred Shaw Associate Professor in the Department of Computer Science at York University, Ontario, Canada.

Futuristic futures

Margaret A. Boden

The Super-intelligent Machine: An Electronic Odyssey.

By Adrian Berry.

Cape: 1983. Pp.180. £7.95.

The Intimate Machine: Close Encounters with the New Computers.

By Neil Frude.

Century, 76 Old Compton St, London: 1982. Pp.190. Hbk £8.95; pbk £4.95.

THE Duchess assured Alice that "Every thing's got a moral, if only you can find it". The moral of these two books is not hard to find. They both offer a taste (a soupçon) of what has already been achieved by artificial intelligence, but their main message in each case is: "You ain't seen nothing yet". The specific "nothings" the authors have in mind, however, differ.

Berry caps a highly superficial account of some current programs with the forecast that super-intelligent machines will inevitably surpass and replace us. They will outlast all conceivable biological species, which are limited by thermodynamics: long after the Universe is too cold for life-forms to persist or to be formed, intelligent computerized systems could continue to evolve. They could even forestall their own annihilation, by devising a "technological fix" on a literally cosmic scale to prevent the otherwise inevitable collapse of the galaxies into one infinitely massive point.

Berry admits that this is stranger than the strangest science fiction, but his readers' respect for Wells and Asimov may not suffice to settle their doubts. What I found no less difficult to accept is the vulgarity of style and superficiality of argument throughout the book. The question "Will time end, or will it go on for ever?" is given short shrift: the Big Bang theory is cited as showing definitively that time had a beginning, and then our question is answered for us, since "What had a beginning may surely have an end". Again, instead of discussing Abelson's pioneering "Goldwater Machine" (to which he merely refers), Berry tells us that he himself wrote a "Wedgwood Benn Machine", whose quoted conversation provides an easy crack at his *bete noire*, but which casts no light on the way in which computer models of belief systems actually function. An author who is science editor of the *Daily Telegraph* could surely have served his readers better.

Frude's book, which is the more original and interesting, extrapolates from those current programs which embody some sort of "friendliness" and/or "personal" characteristics. These include simulations of political or paranoid belief systems, systems capable of automatic speech-recognition and speech-production (the latter with increasingly realistic vocal timbre and intonation), and computer models

of patterns of social interaction and of distinct personality-types.

The author is a social psychologist, interested in the forms of interaction that may develop between human beings and computers. He argues that — irrespective of whether a programmed system could in principle be *really* friendly — appropriately-programmed computers will increasingly *appear* to be personal beings, and will be so taken by their human users, who will experience interaction with them as a form of intimate relationship. He reminds us that even today's crude beginnings are viewed personally by many people, and that users often adopt an inappropriately anthropomorphic stance towards computer systems. His main point is that this is due not merely to a lack of computer literacy, but to a universal human tendency toward animism, and that this response is more likely to wax than to wane. With increasingly human-like performance on the part of programmed systems, our natural animistic tendencies will often swamp our scientific understanding (which for many users may be minimal in any case).

It is a rare adult who has never smiled back at a smiling teddy-bear, or winced when it was punched on the nose by an unfeeling (*sic*) person. But these sorts of dolls are mere child's play. The novels of Tom Sharpe, if not our own experience, have alerted us to the existence of less innocent sorts of doll: rubber inflatables sold by sex-shops for unprintable purposes. Frude sees it as a commercial inevitability that, among the many friendly and convivial programs to be developed in the future, some will be embodied in "soft machines", sexually seductive or merely cuddly depending on the market concerned. Young monkeys spend more time clinging to a non-feeding monkey-doll that is covered with soft towelling than to the wire-frame "mother" which provides them with milk. Our comparable preference for softness and warmth, combined with our animism, could lead us to have significant emotional engagements with the dolls of the future — whether suited to sex-shops or not.

Past achievements in puppetry, impressive as they are, will be as nothing to the programmed versions. Already in 1970, a soft robot was exhibited in Japan that had 30 distinct "facial muscles" to generate expressions. A wide range of emotions were attributed to this creature by its human audience. Slight changes of speed or muscle-combinations often led to significant

Fresh yeast

Cold Spring Harbor Laboratory have published the companion volume to *The Molecular Biology of the Yeast Saccharomyces: Life Cycle and Inheritance* (reviewed in *Nature* 299, 92; 1982). The second volume, Monograph 11B, is subtitled *Metabolism and Gene Expression* and costs \$75 in the United States, \$90 elsewhere.