production on carbohydrate wastes there would be increased local production of yeast from locally available material. Thus the only paper from India, where there is much unused molasses, is devoted entirely to hydrocarbons.

Enthusiasm for algal foods seems to be waning, but belated interest is now being shown in the blue-green alga, *Spirulina*, which is a traditional food in several regions. One paper deals with the use of algae for photosynthetic recycling in space stations. The conclusion is essentially that come to at an Institute of Biology symposium in 1960: there will be no advantage in recycling carbon dioxide unless the station is being occupied for several months, and the practice of trying to feed astronauts on unfractionated algae is misguided. The paper by Oswald and Golueke is of more mundane interest. They rely on bacteria to break down the organic matter in sewage and make carbon dioxide; the photosynthetic algae use this and at the same time supply the oxygen that the bacteria need. The mixture of algae and bacteria is used as fodder. This is excellent. In sunny regions algae will grow in nutrient-rich water in any event, and it is much better to have them growing in a tank from which they can be collected, and from which purified water can be drawn off for re-use, rather than having them fouling the waterways as they now do. The paper is marred by some false comparisons between carefully tended algae in California and the yields got by average farming in regions with a harsh winter. N. W. Pirie

POP DNA

DNA: at the Core of Life Itself

By Lawrence Lessing and the Editors of *Fortune*. Pp. 85. (Macmillan: New York; Collier-Macmillan: London, March 1969.) 22*s* 6*d*.

The awe-inspiring discoveries of the past few decades in molecular biology have, rightly, begun to hit the popular press. Lots of books, in different sizes and shades, are cramming the booksellers' windows. *The Double Helix*, with its racy style, is now joined by this slim, glossy, pop book peering at the core of life itself—DNA. Just as *The Double Helix* presented us with a new set of standards in scientific research, so now the editors of *Fortune* magazine, led by Mr Lawrence Lessing, have provided a new language for the arena in which the mysteries of the versatile DNA molecule have been pierced.

Mr Lessing starts on a well paved—and well trodden—road, "the Master Key to Life". After a series of big "waves of discovery", including a dig at the Russians, we arrive at a "model in scrap tin" of DNA with its "5,000,000,000 'bits' of DNA = Man". Racing along in top gear, Crick, Nirenberg and Khorana solved the genetic code, Rich worked out how a protein is manufactured, Holley worked out "the exact positions of the 2,500 or more atoms" in transfer RNA, and then we slow down for "the traffic directors". During this panoramic trip we see how "life puts on individual tissue and integument, flesh and blood". At "the traffic directors", we find that "the varieties of proteins are almost as infinite in number as stars in the sky". A little "genetic engineering", and someone is "reported to be grooming" a virus for the "risky experiment" of correcting mutations in man. Already, we gather that scientists at Columbia–Presbyterian Medical Center in New York have joined with Avco Corp. in the first stages of computer scanning of human chromosomes.

Having learnt how the engine works, we then come to the controls. The first glimmer of how a "computer-operated chemical plant" is controlled comes from "the rebels at the Pasteur Institute", "ex-Free French and Resistance Fighters throughout World War II". After France's first scientific Nobel prize for thirty years, we see "Monod seizing the occasion to launch a blistering attack on a rigid, minister-dominated educational system, laid down by Napoleon, which . . . was experiencing no improvement under another rigid military man, de Gaulle". Leaving the General behind, we discover "Seeing-eye-dog RNA" around the corner, an RNA tag which Bonner thinks might draw its chain of histones to shut off a structural gene on the "gelatinous strands". Moving on, with "hands on the genetic throttle", we fly past hormones and "how a plant decides to flower", to "creative federalism in the cell" and "molecular medicine". After antibodies in the shape of "lock and key in the body's defenses", we come round the corner again to intervene in human heredity and "I would like to have four hands" by Bonner.

Mr Lessing's book, which received the Albert Lasker Medical Journalism Award, can only hope to get faint-hearted approval from scientists.

The scientific content, though not particularly inaccurate, is very limited in its scope. Not even a table of the genetic code is included. But it may be asking too much of a reader who is really interested in understanding recent developments in molecular biology to find the message hidden in this book, overburdened as it is with a style which is too sensational and a political slant which is not scientific. M. S. Bretscher

CANCER AND AGEING

Biological Aspects of Cancer and Aging

Studies in Pure Line Mice. By L. C. Strong. (International Series of Monographs in Pure and Applied Biology, Vol. 31.) Pp. xv + 221. (Pergamon: Oxford, London and New York, December 1968.) 75*s*.

Strong seeks to discuss the contributions of predisposing genes and somatic mutations to ageing and carcinogenesis in mice. Attitudes towards genetic factors in disease—especially in man—do not always derive exclusively from the evidence. The following quotation from Gutierrez and Williams[1] illuminates this point: "In an era when 'environmental determinism' (as Aldous Huxley called it) prevails in people's thinking, the medical profession has been loath to consider the role that inborn traits can play in disease. For many years it was contrary to the policy of leaders in the American Cancer Society, for example, to let the public know that some individuals are innately vulnerable and others are not. It was feared, we presume, that members of the public, thinking heredity to be vastly simpler than it is, might draw erroneous and damaging conclusions with respect to themselves".

During this century, many oncologists have been preoccupied with extrinsic carcinogens including ultraviolet and ionizing radiations, chemical carcinogens and co-carcinogens, and oncogenic viruses. By contrast, intrinsic factors have been relatively neglected, although the recent resurgence of interest in the immunology of cancer is an important move in the biological direction. An up to date and comprehensive treatise on the biology of cancer is therefore overdue, and it could help to establish a balanced outlook. In spite of the promise of its title, the book under review does not fulfil this need.

Mastery of language, and the ability to organize his material, cannot be included among Strong's accomplishments. An author, I imagine, generally lavishes extra care on the first paragraph of his foreword. Strong begins characteristically: "*Biological Aspects of Cancer and Aging* considers the two problems enumerated in relation to Genetics. There is no attempt to consider other aspects of Biology. The analysis of the several biological characteristics has only been discussed in the text by reference to the aging process (Gerontology)". Many passages in the text achieve complete opacity, and repetitiveness arises because five of the seven chapters are reprints of occasional lectures. Extensive editing could halve the length and clarify the meaning.

Much of the book describes the effects of inbreeding, and different selection régimes, on the incidence of lung and mammary gland cancers, and on longevity. Selection was often based on the age of the mother at first litter. Equilibrium with respect to cancer incidence or longevity was attained much more quickly when offspring were selected from mothers whose age at first litter fell in the intermediate range of 201 to 300 days. When the maternal age at first litter was under 100 days, the percentage incidence of mammary cancers was still rising after forty-five generations of brother–sister inbreeding. In another experiment, selection was based on resistance towards chemically induced tumours and eventually a strain was obtained that showed complete resistance to a large dose of 20-methylcholanthrene.

I found the connexion between developmental abnormalities and cancer incidence interesting. Numerous and complicated pleiotropic effects are connected with the *LST* gene, including polydactylia, early age at first litter, a high cancer incidence and average life span. Nevertheless, even after fifty-five generations of inbreeding from parents both of whom had polydactylia, the penetrance of this abnormality in the offspring stays at about 80 per cent.

The other principal topic concerns the effects of certain liver extracts on the growth rate of spontaneous tumours in the C3H/St strain of mouse. Some striking reductions in the rate of growth of tumours have been obtained, up to and including complete arrest. Strong makes out a case for the further investigation and characterization of these cancerostatic extracts.

The final chapter touches on the connexions between somatic mutations, histocompatibility and tissue-specific antigens, and tumour transplantability. This area is ripe for illuminating discussion, but it suffers the fate of other topics in this book and fades off into incomprehensibility. Reading this book has been an agonizing experience.

P. R. J. BURCH

[1] Gutierrez, R. M., and Williams, R. W., *Proc. US Nat. Acad. Sci.*, **59**, 938 (1968).

CYBERNETICS IN MATURITY

Neurological Control Systems

Studies in Bioengineering. By Lawrence Stark. Pp. xx+428. (Plenum Press: New York, 1968.) n.p.

THE term bioengineering may bear various nuances, but it is increasingly accepted that engineering retains two characteristic aspects when applied to biology and medicine. The first aspect, that of providing instrumentation, has been readily accepted, but the second, that of applying engineering theory to the study of biological systems, is only now beginning to find similar recognition. Professor Stark has made resort to both aspects of engineering in his work, but the feature that acts as a unifying focus for the book is the application of engineering control and information theory to neurological control systems. This, according to Weiner's original definition of 1948, identifies the work as cybernetics.

The promise of Weiner's ideas was evident at the outset, but it was soon realized that, because of the awesome complexity of biological systems, the subject of cybernetics was far easier to formulate than fulfil. Contrary to the dictates of ease, and fortunate for the scientific survival of cybernetics, a few workers refused the easy path of speculation and persevered with more realistic mathematical and experimental approaches. The author was stimulated to join the ranks of these workers in pursuit of a quantitative explanation for disorders of motor coordination, but he soon realized the efficacy of concurrent interest in other neurological systems, the lesser complexity of which made them more amenable to the techniques available. Considerable persistence over a period of many years is required to accumulate an amount of original work worthy of publication as an entire volume, and it seems particularly fitting that, in the year cybernetics reaches its majority, the occasion is heralded by the present evidence that the subject has survived an adolescence that has not been without frivolity and has acquired a substantive maturity.

The style of presentation adopted throughout the book reflects that it is in reality the author's self-edited collected works. The book makes little deviation towards that of a formal didactic text, but the order in which the material is presented does invoke a progression from relatively simple towards more complex systems. This progression is revealed in the five sections into which the book is divided: the crayfish, the pupil, the lens, the eye and the hand.

The first section illustrates some basic cybernetic ideas with reference to the "random walk" system of the crayfish. This system allows the animal to pursue a suitably dark environment on a trial-and-error basis and makes use of an illumination sensor situated towards the tail. After determining the transfer function of this sensor, other aspects of the system, such as the walking response to light stimulation, are discussed and followed by a description of conventional neurophysiological procedures which provide data for a discussion of the nerve impulse code by which information is transferred between system elements.

Stark is perhaps most widely known for his studies on the pupillary servomechanism using elegant optical and electronic techniques to effectively open and otherwise modify the control loop operation. In the second section on the pupil, these techniques are described and their application is illustrated in a number of situations which include an investigation of the noise arising in the pupillary system. Based on the results obtained, a heuristic model of the pupillary system is proposed that includes both noise generation and the gross system non-linearities that are observed. These non-linearities are invoked as an illustration of the mathematical approaches that may be made to non-linear systems in general and includes an interesting example of the use of Weiner G-functions.

Control of the refractive power of the eye lens involves a more complex system than that controlling the pupil, as witnessed by the voluntary control that may be exercised over its operation. In the section on the lens, the author returns to the question of system non-linearity and from elegantly obtained experimental data establishes a model for the lens control system that includes both linear and non-linear elements. The system has a particular interest in the apparent absence of means by which the sign of the error signal (retinal blur) may be determined, and the section includes the author's experiments which strongly suggest that the absence of sign information is normally compensated by the participation of higher nervous centres.

In passing to the section on the eye, the involvement of higher centres in eye positioning necessitates discrimination between predictive and non-predictive responses. The difference between these two situations is investigated in some depth, together with the two types of evoked eye movement, that is, the saccadic jump and the smooth pursuit movement. These investigations provide evidence for discrete data sampling within the system, and the author proposes a model of the system, a simplified and linearized version of which is compared with experimental data. Finally, the system is re-examined by including an adjustable transfer function in the experimental loop and the results obtained are presented as further support for the model which is nevertheless, as the author admits, a much simplified representation of the real system.

The voluntary control of skeletal muscles obviously invokes systems of considerably greater complexity than