novel point of view. Unfortunately, *Drug Discovery* does neither. The author's statements are always left open to question because no references are given in the text, so leaving the reader to search the rather poor and imprecise chapter bibliography at the end of the book. Interestingly, this sacrifice was made so that the text, which was written to convey "drama and excitement", should not be disrupted. However without references to contemporary information, the book has lost much scientific credibility.

Perhaps more annoying, there seems to be no benefit of hindsight. The ethical issues that have emerged so forcefully over the past 30 years and now engulf medicine seem to have left no impression. For its easy pace and the stories it relates I would expect the book to have its devotees; but as a serious historical account it falls short of what should be expected. □

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Marking the path

Peter Laing

The Biotechnology Business: A Strategic Analysis. By Peter Daly. *Frances Pinter, London/Rowman & Allanheld, Totowa, New Jersey: 1985. Pp. 155. £16.50, $25.*

THE emergence of an international industry based on molecular biology and immunology is a striking example of the potential economic benefits of government funding of basic research. Equally, however, the commercialization of biotechnology well-illustrates the familiar pattern of technological innovation being avidly and rapidly exploited in the United States and only belatedly in Europe.

In the United States, the availability of venture capital and an entrepreneurial business climate have led to the formation of numerous specialist biotechnology companies. These have been able to attract many of the brightest academic scientists (who would not normally have considered an industrial career) and concentrate upon the problems of developing marketable products. The large, established American companies, aware of the many studies that have shown that technical innovation most often stems from small, flexible and highly-specialized firms, have generally encouraged this process by the provision of research contracts (and even equity finance) for start-up companies, obtaining in exchange the commercial rights to future products.

By contrast, in Europe the start-up company as an engine of technological change has until very recently been a rarity. The brunt of commercialization of new technology has been borne largely by the established industrial companies, in which new ideas have a depressing tendency to be stifled or restrained by corporate inertia and the "Not Invented Here" syndrome. This situation has been compounded by a general lack of contact between industry and academia, particularly in the biological sciences, with the result that the more enterprising scientists have either remained in universities or left for North America.

In Japan, a strong sense of national purpose and a cultural preference for consensus solutions have engendered active cooperation between Government, industry and academia with the aim of establishing national priorities for the exploitation of new ideas and identifying the means of bringing them about. Even so, the vehicle for commercialization in Japan has invariably been the established company — indeed, companies in moribund or declining industries have often been selected for revitalization by the injection of funds for biotechnology projects.

The Biotechnology Business is a comprehensive and readable guidebook to the commercial side of the biotechnology industry. As acknowledged by the author, it leans heavily on the excellent Office of Technology Assessment report *Commercial Biotechnology*, published in 1984, but is less nationalistic in its approach (and also weighs only a quarter of the OTA report's daunting 1.2kg).

Daly's emphasis on strategic analysis, made explicit in his sub-title, has resulted in many interesting case studies. Among them is a timely comment on the American company Genex, warning of the dangers of the company's heavy reliance on a single manufacturing contract for L-phenylalanine with G.D. Searle. This contract was terminated a few weeks after the book was published, plunging Genex into a financial crisis.

The source material for the book appears to have been culled largely from articles in specialist biotechnology magazines. These have tended to concentrate on the newsworthy start-up companies, and there is in consequence an under-representation of the strategies which are being adopted by the large chemical and pharmaceutical firms; now that the basic technology is more widely disseminated, such companies are beginning to make real inroads into the market. The likely impact of these moves on the start-up companies suggests not only a volatile employment market for the scientists involved, but, as Peter Daly points out, the development of an even more fruitful area for strategic analysis than the biotechnology industry has provided to date. □

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A stir in the primeval soup

Jacques Ninio

Seven Clues to the Origin of Life: A Scientific Detective Story. By A.G. Cairns-Smith. *Cambridge University Press: 1985. Pp. 123. £9.95, $17.95.*

WE ALL admire the high technology feats that the simplest cells achieve in duplicating chromosomes, translating genes into proteins and adjusting their enzyme activities to their immediate needs. All such pathways are interdependent, each relying on all the others, as in an arch that would collapse if any one of its stones were missing. How did the first cells arise, if life requires, at a minimum, a translation apparatus to make proteins to replicate DNA?

The usual answer is that some 4×10^9yr ago the Earth was a gigantic organic reactor producing masses of small molecules, amongst which were amino acids, sugars and nucleotides. Spontaneous polymerizations occurred, leading to nucleic acids that could replicate without the help of enzymes. Some of these "naked genes" acquired control over their environment. The coupling between nucleic acid replication and peptide synthesis became tighter and tighter until it became a strict coding relationship.

Cairns-Smith objects to this view; he believes that primitive organic reactors were more likely to produce tars and sludges than fine biochemical products, and that nucleotides are complex molecules that require sophisticated mechanisms for their production. Also, if a low-technology machine is to work, it must avoid the mutual dependency of its parts that is characteristic of more complicated machines. But, he says, the very existence of a primitive life-form made the synthesis of well-defined organic molecules possible. Amongst these, fancy polysaccharides, with no genetic use, might initially have been precursors of DNA or RNA. According to Cairns-Smith, new genes and the machineries they controlled gradually took over from the older forms of life: "None of the fibres in a rope has to stretch from one end to the other . . . new 'gene fibres' may be added and others subtracted without breaking the overall continuity".

These ideas are well known among scientists in general but are rarely discussed openly. In the origins-of-life research community, people seek a comfortable corner where they are least likely to interact with competitors. Yet, consider the fundamental issue: is nucleic acid replication conceivable in a prebiotic world? We are flooded with so-called theoretical treatments which generate models of the evolution of prebiotic self-replicating nuc-

leic acid populations as though the very existence of such reactions were not the primary theoretical issue. With highly-skilled organic syntheses, the beginnings of something like non-enzymatic DNA or RNA replication are observed. But now, as Schwartz and Orgel have said (*Science* **228**, 585–587; 1985), we need to "design reactions that proceed efficiently with more plausibly prebiotic substrate mixtures". Sooner or later, organic polymers, able to replicate in the laboratory and having simpler backbones than DNA or RNA, will be synthesized. Then the idea of "takeover", as Cairns-Smith has called it, will become inevitable.

Cairns-Smith, however, is far more radical than this, in that he rejects the concept of any primitive *organic* gene. Instead, he thinks in terms of clay particles, made of successive layers, each new layer added on top reproducing the defect structure of the previous layer; or of clays made of a succession of various kinds of uniform layers, that grow sideways. If such particles break across the layers, then the one-dimensional information contained in the particular succession of layers is conserved. Ways in which clays might influence organic reactions and use them for their growth are discussed in this book. Thus clay particles are suitable substrates for natural selection. Will field studies be conducted on the population structure of clay particles in given ecological niches? Or will some courageous young scientist design a clay-chemostat where the growth of clay crystals will be studied under various selective pressures?

Cairns-Smith's ideas deserve to be assimilated and discussed. In *Seven Clues to the Origins of Life*, a layman's version of his earlier book *Genetic Takeover*, all his essential theses are presented in a clear, precise and condensed manner. The choice of a deductive form of presentation for his arguments (clays are introduced only three chapters from the end), buttressed by references to Sherlock Holmes, lends much rigour to the plot, and leaves no escape exit. How can low-technology life be designed, and how can it evolve towards the high-technology form? I know of no other book that succeeds as well as this one in maintaining this central question in focus throughout. It is a summary of the best evolutionary thinking as applied to the origins of life in which the important issues are addressed pertinently, economically and with a happy recourse to creative analogies.

The concept of "takeover" is an important evolutionary one, and may apply to a wide variety of situations. I regret in this respect that the author did not attempt to analyse concrete biological examples (such as the origin of split genes, RNA catalysts and ribosomes, or the design of the immune system) in the light of this idea. Inevitably, I think, schemes in which things acquire complexity of detail without a change in their organization will have to compete with "takeover" schemes. The time has now come for those scientists working on the subject of the origin of life to cease dealing with such ideas obliquely. □

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Appeal to the laity

John Rae

The Flamingo's Smile: Reflections in Natural History. By Stephen Jay Gould. *W.W. Norton: 1985. Pp.476. $17.95. To be published in Britain in February 1986, £12.95.*

It is 20 years since C.P. Snow described the gulf fixed between scientists and non-scientists in academia. Not much has changed. The two communities continue to go about their business like a couple of Englishmen travelling in a foreign land: they are on the same journey but have nothing to say to one another because they have never been introduced. The non-scientist complains that the scientist cannot communicate what he is doing in a language that the layman can understand. The scientist complains that the non-scientist defines language in narrowly non-scientific terms — why should a biologist have to explain what he means by morphology any more than a grammarian has to explain what he means by tautology? No doubt it is the education systems that are to blame; meanwhile the dialogue of the deaf continues.

Stephen Jay Gould overcomes this problem, not by laicizing the language, but by using it in the context of intellectual enquiries that any intelligent person can understand and by a technique of cross-referencing that relates the scientific enquiry to comparable problems in other disciplines. It might be argued that as a palaeontologist and evolutionary biologist he has an easier task than say, the nuclear physicist. But easy or not he succeeds brilliantly. This collection of essays, the fourth to be based on his monthly column in the *Natural History Magazine*, communicates both the fascination and the universality of scientific study in a way that can hardly fail to intrigue scientist and non-scientist alike.

Take, for example, Kinsey and the wasps. Kinsey's reports on sexual behaviour were not the product of his desire to promote sexual enlightenment. He drifted into sex research by accident and applied to the question his experience as America's leading taxonomist of wasps. His study of wasps persuaded him — in his own words — "of the uniqueness of individuals and of the wide range of variation that may occur in any population of individuals". He transferred this anti-essentialism from entomology to human behaviour. Human sexual behaviour cannot be pigeon-holed; just as the world of wasps was a continuum in each and every one of its aspects, so too the male population cannot be divided into two discrete groups, heterosexual and homosexual.

The enigmatic smile of a swan — or an upside-down flamingo?

Gould teases out the wider implications of a particular scientific enquiry, from the taxonomy of wasps to a more accurate — and tolerant — understanding of what is regarded as sexual deviation. The scientific, moral and political (Kinsey had the misfortune to coincide with Senator McCarthy) implications are shown to interact.

The essays range widely from speculation about the reason for the extinction of the dinosaurs to the bizarre and unhappy cases of the Hottentot Venus and of Ritta-Christina, the celebrated siamese twin sisters. The style is relaxed but not flip; the content all the better for being disciplined by the limits of the monthly column. If there is a weakness it is Gould's rather too obvious wish to hook his reader with a startling opening paragraph. An essay on continuity and quirkiness in evolution leads off with Michelangelo and one on the flamingo's eating habits with Buffalo Bill. It is good journalism but unnecessary: in all these essays the subject matter is compelling enough in itself.

Scientists who communicate their enthusiasm to a wider audience are regarded by some of their professional colleagues as vulgar; if it can be explained to a layman it cannot be serious. Gould brushes aside that mixture of arrogance and insecurity. His essays popularize science in the same sense that Macaulay popularized history — by making it interesting and entertaining to read. Roll on volume five. Meanwhile I shall be looking for copies of volumes one to three. □

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