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The Nobel Prize winners — Ziegler (left) and Natta listen as Professor Fredga makes the presentation speech, Stockholm, 1963.

them on propylene instead of on ethylene and, of course, obtained polypropylene. Considering that, at that time, no high polymers of propylene were known, this was an important contribution to polymer technology. It was dwarfed, however, by Natta's discovery that the use of Ziegler catalysts permitted the preparation of several species of polypropylene and other vinylpolymers differing from each other only by the steric arrangement of the substituents. Until that time stereospecific catalytic power had only been observed with natural enzymes: it is understandable, therefore, that the discovery of the existence of dozens of stereo-regulated polymers and their precise identification added to this commercial success a major scientific sensation.

Dr Frank McMillan, as a contemporary of all these events, was manager of a large industrial research laboratory and has, therefore, acquired a special feeling for the intricate relationship between fundamental research and practical application.

Needless to say, the alluring commercial features of the new catalysts and their novel applications attracted, with increasing intensity, the interest of many large companies. As a result of their permanent and strong participation, there came the day when the predominant question was formulated: "What belongs to whom?" — a question which has been debated for the last 25 years. Understandably, the litigations have led to several confrontations, and in this domain the author is a true master of ceremonies, distributing fame and blame with restraint and distinction. All this makes excellent reading: entertaining, instructive and sometimes even philosophical. In several instances he offers specific warnings to avoid certain mistakes in research and development and even in the recording of results. The clarity of his exposition should certainly convince readers to avoid such mistakes in future. But, very probably, in doing so, they will make others. □

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Jean Baptiste Rousseau revisited

Gunther S. Stent

The Double-Edged Helix: Science in the Real World. By Liebe F. Cavalieri. Pp.196. ISBN 0-231-05306-1. (Columbia University Press: 1981.) $14.95, £10.80.

THE latter-day metamorphosis of molecular biology from the esoteric speciality of a small band of *aficionados* into an academic juggernaut and billion-dollar industry, and its technical and moral implications, have not been slow to draw the attention of sociologists and ethicists of contemporary science. Indeed, the writing of books about the banishment of molecular biology from the Garden of Eden has become a minor cottage industry. *The Double-Edged Helix* by Liebe F. Cavalieri, a biochemist working at the New York Sloan-Kettering Institute for Cancer Research, is another contribution to this literature. Subtitled *Science in the Real World*, Cavalieri's book addresses the politics of the recent controversy surrounding the development of recombinant DNA technology. One of his chapters is entitled "Rousseau Revisited", and since Cavalieri makes no allusion to Jean Jacques, the philosopher, he appears to be revisiting Jean Baptiste, the poet, who was prosecuted and exiled from France in 1712 for libelling his colleagues.

As presented by Cavalieri, the situation is as follows. There are some people who believe that genetic engineering by recombinant DNA methods is dangerous and should be closely controlled. They are "thoughtful", "unusually frank" and "valiant"; they "have a conscience", "question neatly" and "testify" before government bodies "in the public interest". Other people, by contrast, believe that there is little or no danger in this enterprise and oppose strict controls on recombinant DNA research. They are "simplistic", "self-serving" and make "crusades"; they have "myopic vision" and form part of the "power structure", "smack of scientific elitism" and "lobby" before government bodies, "snowing" them with "massive campaigns" to satisfy "spurious" and "inane" needs.

Moreover, many of these opponents of strict controls happen to be holders of the Nobel Prize, "an exceedingly dangerous device" that gives each of them "virtual limitless power . . . within his institution and among his colleagues"; others are merely members of the National Academy of Sciences, that "tends to favor special interests", "does not represent the bulk of the national science effort" and has a president, or "high priest", who "muddies the water" and "breaches . . . canons of scientific propriety". I think there is little chance that many readers of *Nature* will find merit in this book. But it may be useful all the same to dissect and review briefly Cavalieri's main propositions.

1. Molecular-genetic engineering is morally wrong because "the natural gene pool of the earth [is] an inalienable birthright". Moreover, we must not cross the "natural genetic barrier between species which protects the integrity of the species", as is generally done in recombinant DNA experiments. This is not a political argument, as Cavalieri thinks it is, but a theological, non-utilitarian one that has meaning only within the Judeo–Christian tradition. Since God has obviously permitted the natural gene pool of the Earth to change over evolutionary time and allowed man to change it since Neolithic times, this proposition, if true, would present us with another paradox of theodicy. In any case, what it is we are and are not allowed to do genetically hinges on the hermeneutics of Genesis 1:26 versus Genesis 2:7 and the sense in which God gave man dominion over the animals. Hence the discussion must focus on whether or not our divine grant of "dominion" includes permission to alter the natural gene pool and cross species barriers. Genesis 9:1 is relevant here, in that the passengers of Noah's Ark provide the exegetically pertinent explication of "species". And as regards species crossing, Cavalieri's proposition is supported by Leviticus 19:19: "Thou shalt not let thy cattle gender with diverse kind; thou shalt not sow thy field with mingled seed". I believe it is possible to produce a rational argument according to which a devout Jew, Christian or Muslim should not undertake recombinant DNA experiments. In a secular context, however, the gene pool and species-crossing proposition is irrational.

2. Molecular-genetic engineering is potentially very dangerous, and hence should not be carried out, or, at least, should be closely controlled. This utilitarian argument is the centrepiece of the *The Double-Edged Helix* and, although it can be simply stated, it is actually quite complex. First, as far as the dangers themselves are concerned, they can be subdivided into short term — "immediate biohazards that could result from a laboratory accident" — and the long term — "irreversibility of the organisms themselves and the irreversible socioeconomic entrenchment that will result from the successful use of recombinant organisms, regardless of their side effects". As for the immediate biohazards, there seems to be no disagreement regarding the possibility that such hazards *may* exist. What is under dispute is who, if anyone, is competent to assess these hazards and decide whether there is or is not a reasonable chance of averting them.

According to Cavalieri, the molecular biologists who are actually engaged in genetic engineering cannot be trusted to make this assessment, because their self-interest causes them — Nobel Laureates, Academy members and just plain bench workers — to make dishonest risk appraisals and use their "clout" to sink even the timid guidelines by means of which prudent government administrators and legislative bodies sought to protect the common weal. So it is left to investigative reporters, consumer and environmental protection organizations, and "social-responsibility-in-science" groups, whom Cavalieri cites mainly in support of his arguments, to identify the substantial biohazards associated with recombinant DNA. Of just what these hazards actually consist is, however, not — probably for lack of expertise — clearly or credibly spelled out. If Cavalieri's low opinion of the moral fibre of what he calls the "science community" were an accurate perception, the real world, being deprived of reliable expert opinion on vital scientific matters, would really be in serious trouble.

Fortunately I can recognize the scenario that has the legion of molecular biologists currently engaged in research using recombinant DNA techniques, carelessly risking the survival of mankind to satisfy their idle curiosity or venal cupidity, as merely a paranoid fantasy.

As for the long-term hazards, Cavalieri finds that in them lie "the most serious dangers of recombinant DNA technology". But, of just what these serious dangers consist Cavalieri spells out even less clearly than he does for the short-term biohazards. He merely points to the history of twentieth-century technology, which shows that many developments originally thought to be benign later turned out to have unanticipated malign side-effects. Thus Cavalieri calls on the journalist John Lear to remind us that Henry Ford's invention of the mass-produced automobile, though it provided mobility to Everyman, turned out to deprive him of a livable habitat. And Cavalieri wants us to "remember the nuclear spills, and how we were reassured about the safety of nuclear power plants". So how *does* "the irreversible socio-economic entrenchment of recombinant organisms" present a long-term danger? Because it will

provide technological fixes for past failures that cannot be rooted out at the source. Thus we try to find a technique for curing lung cancer while we continue to . . . advertise cigarettes, and we develop oil-eating bacteria to clean up oil spills,

instead of redesigning oil tankers or re-examining our energy-intensive and wasteful economy or making a serious effort to shift to renewable and ubiquitous energy sources.

That in the socialist countries, where there is no advertising, cigarette consumption is even higher than in the capitalist world, and that work is already in progress to produce genetically engineered microbes intended to provide a renewable energy source which would do away with oil tankers altogether, is apparently not known to Cavalieri. But for him the most ominous long-term hazard is the application of recombinant DNA techniques to the human genome. He admits that there is the possibility of performing "gene therapy" on a number of hereditary defects. But Cavalieri finds that it is not "a high priority line of research to be chosen in preference to other directions" and its benefits pale in comparison with the spectre of eugenics, which "received considerable support from industrialists like the Harrimans, Kelloggs and Carnegies". Though "its demise was aided by the repugnancy of emerging Nazism . . . with the development of new genetic techniques the eugenics movement in America could rise again".

To this it can be said, first, that whereas it is true that the project of improving the human "gene pool" by eugenic methods has fascinated many prominent geneticists, it is also a fact that despite the long-time availability of techniques (such as artificial insemination) for implementing eugenic goals by methods more humane than those practised in Nazi Germany, wide-scale eugenics has not come into use in any democratic society. So, there seems to be a firm (probably religiously rooted) resistance to eugenics, leaving its advocacy mainly to scientistic cranks. Second, and more importantly, it may be the case that any answer to "the classical question: who decides what is a defect?" could lead to procedures "clearly open to abuse". But, all the same, opposing on those grounds the use of diagnostic, prophylactic and corrective procedures in medical genetics reveals a lack of genuine empathy with and concern for people in the real world, since there are hereditary disorders that every person would judge to be defects with which no human being ought to be born. Thus Cavalieri's argument against genetic engineering from long-term hazards consists merely of general cant about Henry Ford, nuclear spills and the Nazis, and puts forward no specific prognosis that can be critically examined and discussed. Rather, just as does the argument from immediate biohazards, this argument, too, merely indicates a radical lack of faith in the honesty and wisdom of the leaders responsible for the management of our democratic society and of our scientific colleagues.

3. The potential benefits of molecular-genetic engineering are too small to offset the enormous risks. "The now familiar list of potential benefits that may accrue from recombinant DNA includes . . . the production of insulin . . . antibiotics . . . vitamins and hormones . . . and . . . food crops. . . . Do we need them?". Cavalieri answers "no". As for insulin, a "thoughtful approach to the problem of diabetes . . . was given by Harvard's Professor Ruth Hubbard" who declared insulin to be a "technological gimmick". She counsels that we should rather try to find "the causes of diabetes, which are, as with all other diseases, heavily influenced by social and environmental factors". And as for antibiotics, vitamins and hormones, in the United States we have already 20,000 pharmaceutical products in medical use, when "the World Health Organization has indicated that only 210 drugs would be sufficient to fill world health needs". And as for food crops, "we must not let our understandable sympathy for the hungry people of the world lead us into mistaking the cause of the problem, which is not one of production or quality but of distribution and utilization. The world now produces enough grain to feed everyone adequately". That is to say, abundant food is available to feed the hungry, if only the nations with undernourished populations would organize better politically and economically so that they can buy food from the affluent countries that waste their food surpluses anyhow. So "no real need has yet been brought forward to justify the serious ecological hazards of introducing major disturbances into the complex balance of things" by recombinant DNA methodology.

It is not necessary here to enter into a discussion of the merits of Cavalieri's claims. For even if these claims were just, the finitude of his list of potential benefits and his additional pronouncement that "we are no longer in an area when practical applications of scientific research are unforeseeable and the human consequences unknown" show a demagogic refusal to allow that what is sauce for the goose is also sauce for the gander. If it is the case that, as Cavalieri claims elsewhere, history teaches us that the long-term *hazards* of scientific and technological developments are always unforeseeable, he cannot in good faith allege that the time has come when all their *benefits* are foreseeable. Moreover, Cavalieri's competence to discuss, not ethics, but modern DNA research is put into question by his failure to mention the amazing advances that recombinant DNA techniques have brought to our understanding of the molecular organization of genetic structures in the past three or four years. An author of a book on recombinant DNA that appeared in 1981 who does not mention the discoveries of the fragmentation of eukaryotic genes and the mechanism of generating the diversity of antibody specificity, neither of which could have been made without the use of recombinant DNA methods, commands just about as little credence among biologists as one who, in the 1960s, would have failed to mention the discovery of the genetic code.

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A haunted house of cards

D.R. Newth

A New Science of Life: The Hypothesis of Formative Causation. By Rupert Sheldrake. Pp.229. ISBN 0-85634-115-0. (Blond & Briggs: 1981.) £12.50. To be published in the US in January 1982 by Tarcher, Los Angeles.

THE title of this book is misleadingly modest. The author is not content to propose only a new science of life, for he reassesses many features of the real world that have been revealed by natural science, and proposes that there exists a great conservative principle making itself felt as much, or more, by sub-atomic particles as in developing embryos or in the behaviour of human beings. The principle is that what happens, or has happened, can exert an influence that is without decrement in space or time upon future events of a similar kind. This influence acts to promote a repetition of what has gone before. The degree of similarity qualifying a living organism to respond to these persuasive messages appears to be conspecificity. Not all decisions or events, however, are susceptible to the principle of "formative causation".

The immediate recipient of the messages is a "morphogenetic field" which guides formal change in its associated "morphogenetic germ" until its prescriptions have been met and the "morphic unit" is finally co-extensive with the field. The morphogenetic field blends the experience of all previous similar morphic units by a process of "morphic resonance". Neither morphic resonance nor the obedience of the morphogenetic germ to the dictates of its morphogenetic field involve exchanges of matter or energy.

This, I understand it, is the burden of Dr Sheldrake's argument.

It is, of course, brave to expound in little more than 200 pages so revolutionary a denial of everything that empirical science has made seem probable. Nor should we deny some leniency to the holders of really way-out ideas. They lack the support of an established terminology, and the com-