

describe the quantum system. The conventional procedure of introducing an S matrix therefore fails when black holes are present. Instead one has to deal with density matrices. This modification could be profound in quite general circumstances if quantum gravity effects are taken into account, because virtual black holes might form out of high energy virtual photons when the wavelength approaches the Planck length.

With such a concentration of provocative new ideas, this paper is bound to generate a great deal of debate about fundamental physics. In particu-

lar, Hawking's argument for the inevitability of singularities will be challenged by those who have long sought to avoid them. They could be avoided if quantum matter effects can lead to the violation of the so-called energy conditions. Indeed, negative energies and pressures have long been known to be possible in quantum field theory.

The conclusion which Hawking draws is stated with characteristic wit and daring. There is a new level of uncertainty or randomness in physics because "God not only plays dice, He sometimes throws the dice where they cannot be seen". □

Genetic modification of plant cells: a reappraisal

from Edward C. Cocking

CELL genetics is now one of the most rapidly developing areas of plant biology, stimulated by the considerable improvement over the past decade in our knowledge of plant tissue and cell culture, and in particular the availability of isolated plant protoplasts. Genetic modification as a result of the fusion of isolated protoplasts and the regeneration of somatic hybrid plants has advanced dramatically in the past five years.

One of the more controversial aspects of recent developments in genetic modi-

fication has been the question of the modification of plant cells by exogenous DNA (see for example Ledoux *Nature* **249**, 17; 1974). The general view now is that the present genetic evidence for the modification of plant cells by prokaryotic DNA is circumstantial and weak. Kleinhofs *et al.* (*Proc. natn. Acad. Sci. U.S.A.* **72**, 27481; 1975) concluded that contamination of plant material by bacteria was the likely explanation for what had been interpreted as evidence for the integration of exogenous DNA, as

related to the appearance of "hybrid" bands on centrifugation, since no "hybrid" bands ever turned up provided a stringent sterilisation procedure was used. A re-examination last year by Redei *et al.* (*Proc. Int. Course on Cell Genetics in Higher Plants* (eds Dudits, D. *et al.*) *Académiai Kiadó Budapest*, 1976) of the correction of genetically thiamineless *Arabidopsis* mutants by bacterial DNA is of particular interest. Using supposed DNA-corrected mutants, supplied by I. Ledoux and others, these workers concluded that the 'corrected mutants' were mechanical contaminants either of Langridge's mutant 1018-6, or other mutants, or were wild type. No evidence of DNA-mediated correction in the material examined could be found. So it must now be recognised that even though the work from Ledoux's laboratory has been a great stimulus, on present evidence there are explanations other than genetic modification for the results obtained.

Somewhat similar conclusions can be reached regarding the work of Hess and collaborators. They observed that treatment of a white-flowering pure line of petunia with the DNA of a red-flowering anthocyanin-synthesising pure line results in a genetically stable correction for anthocyanin synthesis in 0.06% of the treated plants. Bianchi and Walet-Foederer (*Acta botan. neerl.* **24**, 1; 1974) have cogently argued that Hess

THE function of the thymus as one of the controlling organs in the ontogeny of immunological responsiveness was defined in the early 1960s. The argument about the manner in which this function is exercised has sputtered ever since. The protagonists of the view that cell outflow from the thymus is largely responsible engendered the concept of the 'T' lymphocyte of thymic origin which is part of our contemporary mythology. The alternative notion, that the thymus functions as an endocrine organ, has led a more chequered life. Its latest form is that the thymus does exert a humoral influence but on lymphocyte populations inside the thymus and perhaps on T cells outside the organ. As J.-F. Bach *et al.* indicate in this issue of *Nature* (page 55) the idea is attractive but the evidence has so far not been compelling.

Bach and his colleagues have concentrated on the isolation and characterisation of a thymus-dependent entity in the serum of pigs. Their material, which they designate *facteur thymique serique* (FTS), they find to be a non-peptide of determined sequence which

Serum thymic factor

from A. J. S. Davies

they have now synthesised.

The test system used during the isolation procedure of Bach and his colleagues relied upon the capacity of FTS to influence spleen cells from thymusless mice in the sensitivity of their rosette-forming capacity to inactivation by either azathioprine or anti-theta antiserum. This assay is, as Bach himself says, esoteric and it may or may not reflect the manner in which the same material influences cells *in vitro*. In other studies it has been found that partially purified FTS can induce theta positivity, that it can alter the cytotoxic potential of T cells from thymusless mice, that it can sometimes enhance mitogenic responses of lymphocytes and that it can influence the immunological reactivity of the autoimmune NZB mice. All this evidence suggests that FTS can affect T cells, perhaps by modification of their cell membrane, but is far from the proof of either the existence or identity

of a thymus hormone and Bach correctly refrains from making such a claim.

Bach's approach has been unusual in concentrating on serum as a source of 'thymus hormone'. It will now be possible to determine whether materials similar to FTS can be obtained by squeezing the thymus itself. Also injection of labelled synthetic material will allow its tissue predilections, if any, to emerge. It would be ironic, but not without precedent in the endocrine system, if FTS production was not in the thymus, but only regulated by it.

FTS will doubtless be widely synthesised and may, like transfer factor, be used for a variety of clinical purposes. There are very many factors which either emanate from or are dependent upon the various components of the lymphoid system. Their disentanglement will rest upon the extent to which their characterisation can be achieved. Bach, in presenting a sequence for a small readily-synthesised biologically active peptide, will certainly engender much fluttering in the lymphocyte doves. The effects of this disturbance could be considerable. □