ever, there is no other eukaryotic system in which rDNA has been found integrated in the nuclear chromosomes as a unique sequence.

But perhaps in the case of *Tetrahymena* this situation seems quite reasonable. The micro and macronuclei can be considered analogous to the germinal and somatic cells of higher eukaryotes except that, with the two nuclei occupying the same cell, the micronucleus does not have to direct the synthesis of ribosomes to support itself. The macronucleus can supervise the household functions such as transcription and translation. Perhaps in higher eukaryotes where the somatic and germinal functions occur in separate cells it is necessary to have multiple rDNA genes integrated into the germinal chromosomes in order to achieve the rRNA synthesis needed to maintain the germinal cell. Hence, '*Tetrahymena* may represent an evolutionary linkage between eukaryotes and their procaryote-like ancestor.' □

Electron diffraction up to date

from A. Howie

A conference on Electron Diffraction was held at Imperial College, London on 19–21 September, 1977.

FEW fields can surpass electron diffraction in illustrating the disparity in the pace of scientific revelation and the more measured tread of technological change. The fiftieth anniversary of the subject, marked by the conference, proved to be a timely occasion to discuss the recent work which has at last realised the promise held out by the initial experiments. Although the two main active branches of the subject stem directly from the original low energy reflection experiments of Davisson and Germer and the high energy transmission experiments of Thomson and Reid, progress in both cases has been dependent on major instrumental technology such as the development of electron microscopes and ultrahigh vacuum equipment. As emphasised by T. Mulvey (University of Aston) in an entertaining review of the early work, formidable problems of specimen preparation had also to be overcome.

The high energy work is now concentrated in electron microscopy which has become a key discipline both in materials science and in biology and depends (as in the Abbe theory of the optical microscope) on the transmission diffraction imaging process. The diffraction contrast method, most widely used in materials applications, does not resolve the atoms directly but can provide images of crystal defects at a resolution of 1.5 nm (with weak beam methods) and an accuracy of 2×10^{-3} nm in the atomic displacements. It is particularly suitable for structures like metals with small unit cells and was described by Sir Peter Hirsch (University of Oxford) who concentrated on the detailed way in which dynamical theory can explain the observations both qualitatively and quantitatively. Improvements in electron microscope performance have stimulated considerable activity in direct lattice imaging, discussed by J. M. Cowley (University of Arizona) with reference to the study of complex oxides and related materials with large unit cells. The information about the projected structure obtained in this way is of great significance in numerous chemical and mineralogical applications as well as in biology.

Despite the activity in real space imaging, all interest in the transmission diffraction pattern itself has not been lost, particularly for the study of diffuse scattering in highly disordered materials. In addition, the use of convergent beam diffraction patterns taken from small areas of crystalline specimens using focused illumination and pursued for many years by P. Goodman and colleagues at CSIRO Melbourne, has become a much more routine technique with better vacuum and other instrumental improvements. A major contribution to the meeting by J. W. Steeds and his team (University of Bristol) showed how local information about structure, composition and lattice parameter can be conveniently obtained from convergent beam patterns taken along crystallographic zone axes. It can be predicted that this technique will be increasingly popular, particularly in the context of scanning transmission microscopes where extremely small areas can be probed.

The increasing use of zone axis orientations, previously avoided because of the large number of diffracted beams excited, was perhaps the best evidence presented of the mounting confidence in the use of high energy diffraction theory in such situations. This has followed increases in computing power and efficiency enabling features of electron microscope images to be interpreted more and more quantitatively with various plane wave formulations of dynamical theory but has also been helped along recently by several useful tricks borrowed from molecular and solid state valence electron theory. Indeed for the band theorist, high energy diffraction theory has emerged as an exciting new two-dimensional game with a ball of variable mass whose behaviour becomes classical in the limit of tight binding.

Electrons rarely scatter only once, particularly in the low energy electron diffraction (LEED) range. The development of a successful dynamical diffraction theory has therefore been even more crucial in the recent use of LEED for detailed studies of surface structure. Probably the key here was the recognition about 1969 of the importance of inelastic scattering described by an optical potential which is now fairly well understood over the whole energy range, even if some basic questions such as the treatment of thermal diffuse scattering or the use of the Dobye Waller factor in LEED may require more study. S. Y. Tong (University of Wisconsin) gave an excellent survey of the recent results on surface structures. About 80 structures have now been determined including a considerable number of gas-covered surfaces so that the stage of looking for trends and general principles has now been reached. The fit between theory and experiment, though not quite perfect, is most impressive and generates considerable confidence that the structures deduced will be confirmed when tested by other methods such as X-ray diffraction, in the case of sufficiently perfect underlying crystals, or angle-resolved Auger emission and similar techniques which lean on LEED for their interpretation. More speculative topics on which some progress was reported were the use of spin-polarised LEED and of surface resonance effects when a diffracted beam is parallel to the surface.

Surface structure can also be studied by reflection high energy electron diffraction (RHEED) at glancing angles. J. B. Pendry (Daresbury Laboratory) described efforts to extend LEED theory to this case using the 'chain method' where scattering from atomic rows is treated as a cylindrical problem. The ultimate advantage of electron diffraction over X-ray diffraction, the ability to form real space images, can be pressed home much more easily at these energies, particu larly using scanning electron microscopy. It looks probable, therefore, that yet another development in instrumental technology will eventually allow electron diffraction to extend its steady progress to the detailed study of real surfaces. □

A. Howie is a Lecturer in Physics at the University of Cambridge.