

causes increased synthesis of helium and decreased synthesis of deuterium (see, for example, Yang, Schramm, Steigman & Rood *Ap.J.* **227**, 697; 1979). It might be possible to account for the observed deuterium in the Universe by production in other sites — perhaps supernova envelopes, although nobody has been able to think up an efficient enough mechanism. But overproduction of helium is a much more difficult problem, since it is not significantly destroyed (but rather added to) in normal stellar evolution and the observational limits on the maximum amount which could have been produced in the Big-Bang are now quite good.

The nuclear arguments would imply that the mass of nucleons in the Universe is not more than a tenth, and probably not more than a twentieth, of that required for closure. This corresponds to what we see in galaxies, although the error bars might just allow us to squeeze in the extra mass in galactic dark haloes as nucleons. The hidden mass in clusters, or that implied by Davis *et al.*'s Virgo supercluster argument would cause too much primordial helium production and far too little deuterium. A possible solution lies in the existence of a sea of massive neutrinos, left over from the Big Bang. The case for such a sea has been eloquently argued by D.N. Schramm and G. Steigman in this year's Gravity Research Foundation first-prize essay (to be published in *General Relativity and Gravitation*. See also Symbalis, Yang & Schramm *Nature* **288**, 143; 1980). They argue, on the basis of consideration of the clustering properties of massive neutrinos (see Tremaine & Gunn *Phys. Rev. Lett.* **42**,

407; 1979) that the most likely neutrino mass would be $3\text{eV} \leq m \leq 10\text{eV}$. The extra mass of these neutrinos would allow the missing mass in galaxy clusters to be explained, but problems would still remain if Davis *et al.*'s (albeit indirect, and somewhat uncertain) mass density is correct, or if closure is desired. The difficulty is that putting more and more neutrinos into the Universe will eventually cause degeneracy of the neutrino sea, which would again affect primordial element production. At one-tenth closure density, this does not appear to be a problem, but at much higher densities a more massive neutrino would be required, and it is not clear that such a neutrino would cluster in the right way to provide the increase of missing mass fraction with linear scale of the system considered. Astrophysicists will be eagerly awaiting experimental evidence of neutrino masses (see *Nature* **286**, 755; 1980), and further investigation of the clustering of neutrinos would seem important.

Whether the majority of mass in the Universe really is a sea of neutrinos, or whether it is conventional nucleon matter, remains to be decided. But the existence of considerable dark matter has been demonstrated. It is not so long ago that a headline appeared in a North American newspaper reporting "Caltech astronomers declare Universe open". Although the evidence still remains in favour of openness, one cannot help wondering if (in apparent obedience to current financial stringencies) the Universe may not be all that far from closing again. □

expanded the structural details along more speculative lines to propose evolutionary trees based on the variations between polypeptide subunits in ATPases.

The argument still rages in mitochondrial bioenergetics as to how many protons are translocated at each energy conservation site in the electron transport chain, S. Papa (Bari) favouring two whilst other groups favour three or four. Unfortunately, experimental measurements show little prospect of resolving this problem. Since extensive research has failed to implicate any quinone in the transfer of electrons from cytochrome *b* to cytochrome *a*, there is speculation about an alternative mechanism of proton translocation, possibly involving multiple H^+/e ratios. In contrast, research using chromatophores has provided strong evidence for the involvement of a specific quinone (Z) between cytochromes *b* and *c*, and the requirement for a quinone pool for ATP synthesis.

New evidence for the role of quinones in electron gating was discussed by A. R. Crofts (Urbana). In both chloroplasts and photosynthetic bacteria there is evidence that a quinone reduces cytochrome *b* only on even flashes of light, that is, only after the formation of QH_2 , which would fit with the original ideas of a Q cycle. As Z has been identified as different from Q_2 however, this must be rejected and an alternative mechanism of quinone oxidation invoked, although the proponents of a linear chain model have not explained how it copes with two electrons simultaneously. The concept of gating raises many problems, not least being the interpretation of the results of repetitive flash experiments used to measure rates of electron transport in photosynthetic systems. In mitochondria, although much evidence now points away from a classical Q cycle, no real alternative was put forward.

A system for examining an alternative non-Mitchelian mechanism of proton translocation is the bacteriorhodopsin proton pump from halobacteria. However, it was evident from the discussion that this apparently simple system is resistant to experimental analysis and is still a long way from providing a useful model. One recent, interesting development is the discovery that there is also a light-driven sodium pump in these organisms, possibly using a second retinal protein (J.K. Lanyi, Max-Planck-Institute, Munich).

Calcium transport was covered extensively but no new theories were presented and the sessions were devoted to discussing the alternative mechanisms for calcium release from mitochondria which are sodium insensitive. There is still no consensus as to which of three different methods is the more probable, polyunsaturated fatty acid induced-efflux, oxidation of mitochondrial pyridine nucleotides or an indirect inorganic phosphate-induced pathway.

Bioenergetics in Europe

from Judith Armitage

THE First European Bioenergetics Conference, held in July in Italy, showed that, with the general acceptance of the chemiosmotic concept of energy transduction, interest has moved from the gross theory to the finer, molecular and genetic details.

The problem of elucidating the functional, *in vivo* structure of the membrane-bound energy-transducing proteins using isolated systems and physical techniques was one of the basic themes of the conference. This problem was well illustrated by the many discussions on the possible structure of cytochrome oxidase, and its relation to function. R. Capaldi (Oregon) using X-ray diffraction and image reconstruction on the isolated enzyme described the possible functional

arrangement of the seven polypeptides across the membrane. Although local interactions *in vivo* and the precise role of each subunit is still unknown, the experimental data and *in vitro* structural studies were used by M. Wikström (Helsinki) to speculate on the possible mechanism of proton translocation by the protein and its relationship to the conservation of the membrane potential, emphasizing the need to consider both molecular and electrical topography within the protein.

Using very similar *in vitro* techniques on the crystallized $\text{F}_1\text{-ATPase}$ M. Amzel and coworkers (Johns Hopkins) proposed a model for the structure of $\text{F}_1\text{-ATPase}$ as a functional dimer, rather than the previous triple/single structure. There are, however, at least two arrangements of the subunits which would yield a dimer and fit *in vivo* experimental data. Some speakers