linked enzymes. Calculations suggest[6] that even in the aqueous phase the movement of protons should be so rapid that without special barriers the protons have rapid access to the whole surface of the membrane and to the bulk aqueous phases. But the results of Prats *et al.* indicate that proton movement away from a phospholipid membrane is not rapid, even in the absence of special barriers, and so steady-state fluxes of protons between sources and sinks on the membrane surfaces and to the internal and external aqueous phases should be considered.

On this basis the bulk-phase *p*H and membrane potential are not equal to the local values either for the reduction–oxidation enzymes or for the ATPase, but there is no definite distinction between localized and delocalized coupling. An analogy can be made with a spring or fountain where a collector placed close to the source can collect water at a higher potential energy than that in the surrounding pool. Unless diffusion of protons across the surface of the membrane is infinitely fast then there will be a progressive tendency for proton-linked enzymes to be more tightly coupled and more isolated from the bulk phases the closer they are on the membrane surface. With this type of situation, depending on conditions, the system may tend either towards localized or delocalized behaviour, and indeed Beard and Dilley recently showed such a change by storing thylakoids in high rather than low ionic-strength medium.

Adam and Delbrück[9] proposed that intracellular membranes enhance reactions rates by constraining diffusion to two dimensions on the surface of the membrane. This hypothesis has been criticized , partly on the grounds that a great reduction in diffusion rate at the surface offsets much of the advantage. But the rapid movement of protons at the membrane surface may affect the rate of many reactions and maintain uniformity of cytoplasmic *p*H. Although monolayer experiments are a very simple model, they should also stimulate investigation of other ions and non-biological surfaces. □

1. Prats, M. Teissié, J. & Tocanne, J. F. *Nature* **322**, 756 (1986).
2. Teissié, J. Prats, M. Soucaille, P. & Tocanne, J.F. *Proc. natn. Acad. Sci. U.S.A.* **82**, 3217 (1985).
3. Prats, M., Tocanne, J.–F. & Teissié, J. *Eur. J. Biochem.* **149**, 663 (1985).
4. Mitchell, P. *Biol. Rev.* **41**, 445 (1966).
5. Williams, R.J.P. *Biochim. biophys. Acta* **505**, 1 (1978).
6. Westerhoff, H.V. Melandri, B.A., Venturoli, G Azzone, G.F. & Kell, D.B. *Biochim. biophys. Acta* **768**, 257 (1984).
7. Ferguson, S.J. *Biochim. biophys. Acta* **811**, 47 (1985).
8. Beard, W.A. & Dilley R.A. *FEBS Lett.* **201**, 57 (1986).
9. Adam G. & Delbruck, M. in *Structural Chemistry and Molecular Biology* (eds Rich, A. & Davidson, N.) 198 (Freeman, New York, 1968).
10. McCloskey, M.A. & Poo, M. *J. Cell Biol.* **102**, 88 (1986).

M.J. Selwyn is in the School of Biological Sciences at the University of East Anglia, Norwich NR4 7TJ, UK.

Astronomy

Neutron stars in Nanjing

from Virginia Trimble

NEUTRON stars form in supernova explosions, manifest themselves as radio pulsars or X-ray binaries, and fade away as their rotation slows, their magnetic fields decay away and their energy supplies are used up. This basic framework has been accepted for nearly 15 years, so that one might wonder whether there was anything left for a conference on the origin and evolution of neutron stars to discuss.

But several fundamental questions (and a host of minor ones) remain. Are there other ways of making neutron stars? And, perhaps most important, when and how do they acquire, then lose, the strong dipole magnetic fields and rapid rotation that permit pulsar emission and provide signatures of neutron-star presence in X-ray sources? Unsurprisingly some possible answers are emerging from studies of two very rare classes of pulsars — those with rotation periods less than 10 ms and those with compact (white dwarf or second neutron star) binary companions. The classes overlap in that two of the three known millisecond pulsars are among the seven known binary ones. Two papers by Joseph H. Taylor and colleagues on pages 712 and 714 of this issue report the most recent additions to each group. More can be expected, for they probably make up about 10 per cent of all galactic pulsars, according to Taylor (Princeton University) and Ramesh Narayan (University of Arizona), and are currently under-represented in catalogues only because their intrinsic faintness and rapid pulsation makes detection difficult.

What are the binary and millisecond pulsars telling us? First, they provide the firmest evidence so far for neutron-star formation not from the collapse of the core of a massive star, but rather from collapse of a roughly solar mass white dwarf driven above the Chandrasekhar (maximum stable) mass by accretion from a companion .

This mechanism, originally invoked to account for young-looking neutron stars with 10^{12} Gauss magnetic fields among old, low-mass X-ray binaries, seems to be the only way to explain the combination of young neutron star (10^{11} Gauss surface field) and old system (wide, circular orbit) that characterizes the binary pulsar 0820+02 (ref. 4). A recent detection of the companion[5] strengthens the explanation. The other star is a hot white dwarf, which must have ceased transferring material to its companion about 10^{7} years ago, the elapsed time being just right for the white dwarf to cool to its present temperature and for the neutron star to have reached is present field and rotation period (0.865 s).

Initially strong fields and rapid rotation are expected simply from conservation of magnetic flux and angular momentum as stellar cores collapse to neutron stars. Statistics of pulsar periods, period changes, and associations with supernova remnants tell us, however, that only about 20 per cent are born with the largest possible values of both field and angular velocity. Stanford E. Woosley (University of California, Santa Cruz) suggested that some neutron stars might be born as slow rotators from progenitor stars larger than 10 solar masses, because core convection during carbon and silicon burning could transport angular momentum outward. Lower masses without such convection would give rise to rapid rotators.

The alternative of low initial surface field must also sometimes occur, for instance in LMC X-4, whose massive companion requires the neutron star to be young. Given the 69-ms rotation period, the accretion that fuels observed X-ray emission can only occur with a surface field less than 3×10^{10} Gauss, acording to Nicholas E. White (Darmstadt). If, when

*IAU Symposium No. 125 was held in Nanjing, China, 26–30 May 1986.

100 years ago

The August Perseids

THE shower of Perseids has been a fairly conspicuous one this year notwithstanding the somewhat unfavourable circumstances attending the display. On the nights of August 9, 10, and 11 the nearly-full moon was visible during the greater part of the time available for observation, and robbed the phenomenon of its chief prominence during the evening hours. Those, however, who continued to watch the heavens until after the moon set on the early morning of the 11th must have been rewarded by a tolerably rich exhibition of meteors. The number observable by one person fell little short of 100 per hour, and this rate compared with similar observations in past years proves the late display to have fully maintained its decided character. Numerically this shower of Perseids cannot be placed in the same category as the brilliant meteoric storms of November 13, 1866, and November 27, 1872 and 1885, but it must be remembered that the August shower is one which returns *annually*, and apparently without much variation in its leading features.

From *Nature* **34**, 372; 19 August 1886.