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Author

Trimble, V

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linked enzymes. Calculations suggest⁶ 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 pH 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 Delbrück⁹ 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 pH. Although monolayer experiments are a very simple model, they should also stimulate investigation of other ions and non-biological surfaces. □

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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 companion⁵ 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 its 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, according to Nicholas E. White (Darmstadt). If, when

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.

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

or how such initially low fields grow to typical values of 10^{12} Gauss is not certain, though mechanisms have been suggested⁶.

In any case, pulsars then live on their rotational (and, perhaps, magnetic) energy until dropping below detectability at periods of a few seconds and affective fields of 10^{11} Gauss, preventing the study of later phases. One catch is that only the dipole part of the field perpendicular to the rotation axis is measured, so that one could not rule out the field aligning or evolving to higher multipoles rather than decaying in the 10 – 10^7 years over which pulsars fade away. The binary pulsars have opened a new window for observation of senile neutron stars. As the companion evolves and expands, gas transferred to the neutron star spins it back up to an equilibrium rotation period, depending somewhat on orbit parameters and field strength, but typically a few milliseconds. Later, when the companion itself has become compact or unbound and ceased to interfere, we see a recycled pulsar with rapid rotation and low field.

One might expect the magnetic field strength to continue to drop. Apparently it does not⁷. All three millisecond pulsars have fields very close to 5×10^8 Gauss, according to Taylor. This includes the binary 0655+64, whose white dwarf companion has been cooling for several billion years since it stopped spinning up the neutron star. Corroborative evidence for stalling of field decay at 10^8 – 10^9 Gauss comes from models for quasi-periodic oscillations in old (low mass) X-ray binaries⁸, although so many different kinds of correlations of the frequencies of these oscillations with X-ray intensity and colour temperature have now been seen that the connection with any one model has become very tenuous according to Guenther Hasinger (Max Plank Institute, Munich).

Apparently, then, we can add to the basic framework mentioned above an alternative mechanism (accretion-driven white dwarf collapse) and alternative evolutionary histories for rotation and surface magnetic field more complex than simple monotonic decay with time.

Other neat, new things that were reported at Nanjing included a report from Andrew Lyne (Jodrell Bank) of the largest glitch ever, $\Delta P/P = 4 \times 10^{-6}$, which occurred in January or February 1986 in PSR 0355+534 ($P = 0.156$ s). The recovery has also been unprecedentedly rapid ($P = -52 \times 10^{-24}$ s⁻¹). One might or might not want to tie this up with the suggestion by Charles Alcock (MIT) that post-glitch behaviour is a possible test to distinguish true neutron stars from interlopers made of strange quark matter. Claire Flanagan (SAAO) described a new glitch in the Vela pulsar almost as large ($\Delta P/P = 10^{-6}$).

Jichao Huang (Nanjing University)

advocated dividing pulsars into two roughly equally numerous groups that emit at polar caps and at their speed-of-light cylinders respectively; and Tan Lu (Nanjing University) had statistical evidence that the fading of pulsar radio luminosities may not be monotonic with time.

Patrizia Caraveo and Giovanni Bignami (Milan) have added another late-1985 EXOSAT point to the curve of period as a function of time for the 60 s pulsation of Geminga. The object is still slowing down and now shows two harmonics as well as the fundamental. Caraveo and Bignami have not, however, been able to get additional optical images to test the possibility of large proper motion. Zhenru Wang (Nanjing University) suggested several new possible identifications between Chinese guest stars and young neutron stars and supernova remnants (including Geminga!).

W. David Arnett (Chicago) has found a new instability following core collapse in massive stars that may advect enough energy and momentum outward to cause

envelope ejection and a supernova explosion. The most recent round of neutron-star cooling calculations requires pion condensation, strange quark matter or some other non-standard physics to prevent the Vela pulsar from emitting more thermal X rays than the observed upper limit, according to Ken'ichi Nomoto (Tokyo) and Sachiko Tsuruta (Montana State University). These are just a few of the facts presented at Nanjing, which it is hoped will form the raw materials for a new synthesis. □

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Virginia Trimble is at the University of California Irvine California 92717 and is in the Astronomy Program, University of Maryland, Maryland 20742, USA.

Immunology

The ins and outs of antigen processing and presentation

from Ronald N. Germain

THE striking differences in antigen reactivity shown by T and B lymphocyte subpopulations has been the primary research interest of many members of a whole generation of immunologists. The expectation that elucidation of the structure of the T-cell receptor would, by itself, reveal the how and why of the differences has proved false. Therefore, increasing attention has been paid to understanding the form of antigen actually involved in the T-cell recognition process. The studies of Townsend and his collaborators, culminating in a recent paper, provide a major advance in our understanding of the form of antigen seen by T cells and provide an intellectually and physiologically satisfying explanation for several poorly understood immunological phenomena.

Although very similar gene segments and DNA rearrangement events are involved in generating the receptors used by T and B cells, the functional specificity of these two cell types differs markedly. B cells express surface membrane versions of serum immunoglobulin molecules that directly bind soluble antigens of diverse chemical composition. In contrast T cells use a recently characterized heterodimer to co-recognize particular combinations of protein antigen and class I or class II major histocompatibility complex (MHC)-encoded molecules on the surface membrane of other cells.

As early as 1958, Gell and Benacerraf pointed out that antibodies tend to be specific for native protein molecules, whereas cell-mediated (now known to be T-cell-mediated) responses such as delayed-type hypersensitivity are stimulated by determinants preserved after protein denaturation. Pioneering work by Ziegler and Unanue demonstrated that antigen presentation to class II MHC-restricted T cells is an active time-dependent process involving an acidified intracellular compartment whose function is sensitive to drugs such as chloroquine. These results suggested that the antigen seen by T cells is not intact, but rather degraded or denatured intracellularly before exposure on the surface of the antigen-presenting cells. Shimonkevitz *et al.* provided direct evidence in support of this hypothesis by showing that proteins enzymatically degraded *in vitro* could be presented by metabolically inactive cells bearing the proper class II molecules.

Thus, physiological priming of class II restricted T cells to degraded forms of antigen accounts for the presence of secondary T-cell responses to protein antigens denatured *in vitro* and for the success many have had using protein fragments or synthetic peptides as stimuli for T cells originally generated by immunization with intact proteins. Both indirect and direct methods have now revealed that at