Radioastronomy

A new signpost in the sky

Ray P. Norris

SINCE the discovery in 1951 of radio emission from neutral hydrogen in our Galaxy, radioastronomers have persistently been seeking other molecules, and additional transitions of detected molecules, with which to probe the interstellar medium. Recent rapid advances in receiver technology have prompted an ever-increasing rate of discoveries of new transitions, so that nowadays the detection of a new transition rarely attracts much attention. The discovery of a new methanol maser, reported by W. Batrla, H.E. Matthews, K.M. Menten and C.M. Walmsley on page 49 of this issue, is surely an exception to this trend of complacency. Batrla *et al.* have discovered not just another weak transition of a well-known molecule, but a source of strong maser action whose intensity rivals that of the well-known OH and water-vapour masers (Elitzur, M. *Rev. Mod. Phys.* **54**, 1225–1229; 1982). The significance of their result lies not so much in its immediate astrophysical implications, but in its implications for the observational study of star formation.

OH and water-vapour masers have been studied extensively since their discovery in the late 1960s in regions of star formation and around old, dying stars. In only a few cases, such as the OH emission from OH infrared stars, do we have any understanding of the inversion mechanisms that must be present to cause the maser action. Despite this staggering ignorance, these masers have turned out to be powerful tools for radioastronomers, primarily because of their sensitivity to physical conditions in the surrounding gas. Observations of masers can, in principle, reveal something of the molecular abundance, density, velocity, temperature and magnetic field. In addition, their high intensity and small size renders them easily accessible to radio telescopes (Norris, R.P., Diamond, P.J. & Booth, R.S. *Nature* **299**, 131–134; 1982). Thus, OH and water-vapour masers stand as signposts in the swirling interstellar gas cloud, indicators of the conditions and kinematics of the gas around very young and very old stars. It is fortunate that the OH and water-vapour masers occur in different regions of the gas, allowing two different regions to be probed.

Batrla *et al.* now add a third type of signpost. Unlike the other, weaker maser transitions of methanol and formaldehyde, the new methanol masers are strong enough to be studied in fine detail by radio synthesis telescopes, and their spectra show structure that promise the complex detail familiar from OH and water-vapour observations. Because the methanol masers probably occupy a different regime from the OH and water-vapour masers, they offer a chance to add pieces to some very sparsely filled jigsaws.

The sources in which the methanol masers were discovered are the old faithfuls of the OH and water-vapour literature. Each is a known region of active star formation in which OH and water-vapour masers have already been found. The search will now be on for methanol masers in other types of object. Extragalactic methanol masers will no doubt soon feature in these pages, and diverse types of object, ranging from comets to supernova remnants, will be fair game for maser-hunters.

These methanol masers suffer, however, from one major drawback. They have been discovered too late for the radioastronomy lobby to try to safeguard (as was done for hydrogen atoms and OH molecules) that portion of the radio-frequency spectrum in which they lie. Symptomatically, Batrla *et al.* were unable to study several sources because of satellite interference. By the same token, few radioastronomy telescopes will be equipped to study the frequency of this methanol transition (12.179 GHz), even though it is technically very accessible. One hope lies in the common availability for this band of commercial satellite receivers, which could easily and cheaply be fitted to existing radioastronomy antennas. Whether this will actually happen will depend on the degree of pressure which interstellar astronomers are able or willing to apply to their engineering and administrative colleagues, and the extent to which such observations would be sabotaged by satellite interference. □

Ray P. Norris is in the Division of Radiophysics, CSIRO, PO Box 76, Epping, New South Wales, Australia 2121.

Protein evolution

Positively darwinian molecules?

Andrew Leigh Brown

ACCORDING to the neutral theory of molecular evolution, almost all nucleotide substitutions that are fixed during evolution are selectively neutral, or effectively so. That is, the absolute value of s, the selection coefficient, is much less than $1/2N_e$, where N_e is the effective population size[1]. It is now well known that synonymous nucleotide substitutions, which do not lead to an amino-acid change, occur at least 2–3 times more rapidly than those substitutions that do cause such a change, during the evolution of most proteins. In addition, in pseudogenes (defective coding sequences sometimes found in multigene families) the rate of non-synonymous substitution accelerates until it equals the synonymous rate. Thus, at the molecular level, rapid evolution has become associated with the lack of any functional difference between substituted alleles. But exceptions to such generalizations can often be more interesting than the rule. Two recent studies[2,3], one reported by R.E. Hill and N.D. Hastie on page 96 of this issue[2], provide just such an exceptional case.

Serine proteinase inhibitors are a large group of proteins found in many prokaryotes and eukaryotes. Several families have apparently evolved the inhibitory properties independently, and the interaction of these inhibitors with their target proteinases has been studied in considerable detail (see ref. 4 for a review). A region sometimes called the reactive centre, which may be duplicated within the molecule, interacts with the active site of the enzyme. One peptide bond within this region is the target for cleavage (see figure). Cleavage occurs extremely slowly, however, and the cleaved products also form a very stable complex with the enzyme. The result is a series of very effective inhibitor molecules. The biochemistry of inhibition is fairly well known for all such inhibitors and so is the precise physiological role of some: for example, controlling the multiple plasma proteinases of proteolytic cascades such as blood clotting. But there are many serine proteinase inhibitors whose physiological role is unknown.

Among the serine proteinase inhibitors of mammalian blood plasma[2] and of ovomucoids (serine proteinase inhibitors isolated from egg-white of birds)[3], the protein sequence of the reactive centre region has undergone much more rapid evolution than the rest of the molecule. As it is known from *in vitro* biochemical studies that amino-acid substitutions in this region can completely alter the substrate specificity of the inhibitor, the biochemical function of these inhibitors must be evolving rapidly. One of the most remarkable features of these data is the way in which the acceleration of the rate of evolution is confined to the functionally active region. If our current understanding of the function of these molecules is correct, then these results lead almost inescapably to the conclusion that changes