chemotherapy, as they are relatively resistant to a number of antibiotics. Some strains of *B. fragilis* are particularly resistant to *β*-lactam antibiotics (penicillins and cephalosporins) because they possess a *β*-lactamase (see, for example, Britz & Wilkinson *Antimicrob. Ag. Chemother.* 13, 373; 1978) which is active even against some of the new generation of *‘β*-lactamase-resistant* cephalosporins. Fortunately, the genetic determinants of this *β*-lactamase seem to be chromosomally located, reducing the immediate possibility that they will spread to other *Bacteroides* species which are currently fairly sensitive to *β*-lactams. However, the presence of conjugative *R* plasmids in this genus must inevitably hasten the wholesale acquisition of resistance to these and other antibiotics.

In the colon, obligate anaerobes outnumber facultative anaerobes such as *E. coli* by as much as 1,000 to 10,000-fold. Such large populations may therefore provide considerable scope for the evolution of new *R* plasmids. The *R* plasmid described by Guiney and Davis in *B. ochraceus* and those of *B. fragilis* are capable of transfer to *E. coli*. These obligate anaerobes could therefore provide an extensive pool of resistance plasmids capable of infecting more commonly recognised pathogens such as *Campylobacter* and *Shigella*. It is not yet clear whether *Bacteroides* *R* plasmids originate within this genus or whether they have been acquired from other bacteria. It is known that *Bacteroides* spp. can receive a number of *R* plasmids from *E. coli* provided that recipient strains are heated to 50°C for 20 min immediately before mating, a procedure which presumably inactivates their restriction systems (Burt & Woods *J. gen. Microbiol.* 93, 405; 1976). A more detailed examination of *Bacteroides* plasmids by incompatibility testing and DNA sequence homologies should reveal whether they correspond to types of plasmid already known, in for example the Enterobacteriaceae.

It is worth noting that in laboratory experiments *Bacteroides*, if present in the high concentration found in the human intestine, are claimed to inhibit transfer of *R* plasmids between strains of *E. coli* (Anderson *J. med. Microbiol.* 8, 83; 1975). This inhibition of transfer does not seem to be due to mechanical interference but is probably due to a metabolite produced by *Bacteroides*. Whether or not this reflects the situation in the human gut has not been ascertained. Other factors, such as the presence of bile salts and anaerobiosis *per se*, may affect transfer frequencies between donor and recipient strains of *E. coli in vivo*. In strictly anaerobic conditions

in *vitro* *R* plasmids of some incompatibility groups do show reduced rates of transfer, whereas others show little or no effect (Burman *J. Bact.* 131, 69; 1977). Certainly an anaerobic environment provides no absolute barrier to bacterial conjugation, as witnessed both by the self-transmissible *R* plasmids of *Bacteroides* and those recently described in *Clostridium perfingens* (Brefort et al. *Plasmid* 1, 52; 1977).

The emergence of transferable drug resistance in *Bacteroides* is yet another example of bacterial populations responding to the selective pressure imposed by widespread use of antibiotics. This will undoubtedly increase the clinical problems associated with treating conditions caused by these organisms. As major human and animal commensals *Bacteroides* harbouring resistance genes also provide a potential threat to health by transmitting these determinants to more conventional pathogens.

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### Extragalactic molecular hydrogen

*from C. G. Wynn-Williams*

A GROUP of infrared astronomers using the 2.3 m telescope at the Steward Observatory, Arizona, have recently announced the first direct detection of molecular hydrogen in a galaxy outside our own Milky Way (Thompson, Lebofsky & Rieke *Astrophys. J.* 222, L49; 1978). The surprising feature of this discovery is that the galaxy in which the H$_2$ was found is not one of our near neighbours such as the Andromeda Nebula, but is NGC 1068, a well-known Seyfert Galaxy. At first sight this result is paradoxical. Interstellar molecules, as opposed to the more widespread free atoms and ions, exist mainly in dense, cold slow-moving clouds; the nuclei of Seyfert Galaxies, on the other hand, are renowned for their violent motions and their powerful ultraviolet radiation fields. The fact that molecules can survive under these conditions provides an important clue to the processes occurring in galactic nuclei and QSOs.

Although molecular hydrogen is much the most abundant of the forty or so molecules so far detected in interstellar space, it is one of the most difficult to observe since it has no spectral lines at radio or millimetre wavelengths. The rapid growth of molecular-line astronomy during the past decade has been based to a large extent on observations of transitions between adjacent rotational levels of the ground states of simple organic molecules. In dense interstellar clouds, such as those in the process of condensing to form new stars, the upper rotational levels are excited as a result of thermal collisions within the gas which has, typically, a kinetic temperature of 50 K. Molecules which have permanent dipole moments, such as CO and HCN, can then decay spontaneously to the lower state, giving rise to the spectral lines studied by radioastronomers. For symmetric molecules such as H$_2$, however, these transitions are forbidden and unobservable. The famous 21-cm spectral line of atomic hydrogen is also absent from the dimer. The presence of H$_2$ molecules can often be inferred indirectly by millimetre-wave observation of carbon monoxide and other molecules, but to study molecular hydrogen directly it is necessary to move to other less accessible wavelength ranges.

Rocket and satellite-borne telescopes have been used to study the ultraviolet spectrum of H$_2$ in absorption in front of bright stars, but problems of sensitivity and interstellar absorption by dust grains have confined these observations to relatively transparent low-density clouds close to the sun. The first successful infrared detection of molecular hydrogen was announced in 1976 when a group at the University of Arizona identified H$_2$ emission lines in the spectrum of the cloud OMc1, behind the Orion Nebula (Gautier et al. *Astrophys. J.* 207, L129; 1976). These lines are rotation-vibration quadrupole transitions between the ground and first vibrationally excited states of H$_2$; they lie in the wavelength range 2.0 to 2.5 μm, where the Earth’s atmosphere is relatively transparent. The same lines, or at least some of them, were subsequently detected in six other Galactic objects (Treffers et al. *Astrophys. J.* 209, 793; 1976; Beckwith et al. *Astrophys. J.* 219, L33; 1978). Unlike the Orion cloud, which is a region of active star formation, these latter sources are all planetary nebulae, small clouds of material ejected from the surface of old stars.

What has puzzled astronomers about the infrared detection of H$_2$, particularly in the Orion source, is the method by which the upper vibrational level is excited. If the excitation were thermal, a gas temperature of 2,000 K would be needed; such a temperature is at least an order of magnitude higher than that determined for the cloud from other fairly reliable evidence. A more specialised process is therefore necessary. The mechanism currently favoured is that of shock waves within the dense regions of the cloud, moving through it at such velocity, 10 to 20 km s$^{-1}$, that they are strong enough to provide the energy to excite the ν = 1 transition, but not so strong as to dissociate the
molecules completely (Hollenbach & Shull Astrophys. J. 216, 419; 1977, London et al. Astrophys. J. 217, 442; 1977). The origin of these shock waves is uncertain. None of the known stars or protostars in the Orion region is powerful enough to maintain these shocks; the possibility that a cataclysmic event such as a supernova has taken place deep within the Orion cloud is therefore being seriously considered (Kwan Astrophys. J. 216, 713; 1977). Indirect support for the notion that something unusual has occurred in the Orion cloud comes from the fact that searches for similar H_2 emission from other regions of star formation in our Galaxy have so far been unsuccessful.

It is this possible link between dense gas clouds and explosive events which makes the discovery of infrared H_2 emission from NGC 1068 of great interest. NGC 1068 is one of the nearest 'Seyfert' galaxies. These objects, of which about 100 are now known, are characterised by their very luminous nuclei and by the strong emission lines they display at visible wavelengths. These emission lines arise from clouds of hot ionised, as opposed to molecular, gas, and are very broad in profile, with Doppler velocity widths of the order of 1000 km s^{-1}. The Seyfert nuclei also show synchrotron emission at radio wavelengths. The observed properties of Seyfert galaxy nuclei suggest that the processes occurring there are related to those in radio galaxies and quasars, albeit on a smaller scale. One important property of Seyfert galaxies is that they are very powerful in the wavelength range 5 to 200 μm. In fact, the infrared emission from the nucleus frequently exceeds that from the rest of the galaxy at all other wavelengths. In most cases, perhaps all, the bulk of the infrared emission originates from microscopic dust grains at temperatures in the range 30–300 K. At the moment we do not know whether these dust grains are spread uniformly throughout the nuclear region, as in our Galaxy, or concentrated into dense clouds such as those which herald star formation. The discovery of molecular hydrogen in NGC 1068 seems to favour the latter model, although the possibility remains that the H_2 emission comes from a large number of old objects such as planetary nebulae. In either case it is significant that the Doppler width of the molecular hydrogen is comparable to that of the atomic species, indicating that the clouds themselves are involved in the violent motions of the nuclear regions.

Further observations of molecular hydrogen in Seyfert and other related galaxies should help us to establish how much of the violent activity in these objects is attributable to 'ordinary' processes such as bursts of star formation, and how much of it depends on the existence of an exotic compact object within the nucleus.

C. G. Wynn-Williams is at the Mullard Radio Astronomy Laboratory, Cambridge.

Clocks, pineals and compasses

from J. Krebs

The fact that living organisms have internal clocks is well established: a large number of physiological and behavioural rhythms continue their daily (circadian) oscillations under strictly controlled constant environmental conditions. One of the major goals of current work on circadian clocks is to identify their physiological basis, and small birds have proved to be well designed for tackling this problem because they have striking circadian activity rhythms, which can be recorded automatically in a cage by perches equipped with microswitches. At the XVIIIth International Ornithological Congress*, M. Menaker (University of Texas, Austin) summarised a series of exquisitely ingenious experiments with house sparrows, the sum of which show that birds may have circadian master clocks located in the pineal gland, a tiny light-sensitive neurosecretory structure in the brain and thought to have functioned as an eye in some ancestral vertebrates.

When the pineal is removed from sparrows kept in constant darkness, the normal endogenous (free running) rhythm of activity breaks down: instead of showing a clearcut daily alternation of active and inactive periods, the birds become arrhythmic. The pineal has both neural and vascular connections with the rest of the brain, but by severing the nerves, Menaker's group were able to show that the pineal's influence on circadian clocks is transmitted by way of the bloodstream. A chemical, rather than neural link is also indicated by experiments in which Menaker and his coworkers restored the endogenous activity rhythm to pinealectomised sparrows by pineal transplants into the anterior chamber of the eye. Here the tissue thrives and continues to secrete chemical messages, but presumably does not initially form any neural connections with the recipient. These results show that the pineal in birds (though it must be stressed that the same does not seem to hold for mammals) has a central role in circadian activity rhythms. They do not, however, say whether the pineal generates the rhythms or whether it acts only as an intermediary, transmitting messages from clocks located elsewhere in the body. Menaker's most persuasive evidence that the pineal actually generates rhythms is the so-called phase-translation experiment. In this, two groups of sparrows, whose activity rhythms are entrained by a dark-light cycle, are exchanged. The phase of one group shifts with respect to the other a relatively small amount, indicating that the pineal donors to both groups of arrhythmic, pinealectomised, recipients living in constant darkness. The remarkable result of this experiment is that the recipient bird adopts the phase of the donor's pineal. Two birds receiving pineals from two donors 180° out of phase will initiate their new free running rhythms with the same 180° phase difference. It seems therefore as if the avian pineal could be the master clock controlling activity and perhaps other circadian rhythms.

One of the hormones produced in the pineal is melatonin, and at least three lines of evidence suggest that melatonin is involved in circadian rhythmicity: the pineal has a rhythmic output of a melatonin precursor which is maintained in vitro; melatonin implants (giving a continuous output) can lead to a breakdown of the circadian activity rhythms in sparrows, and finally daily pulses of melatonin injected into pinealectomised starlings can act as a synchroniser for the activity rhythm. This last result was reported by E. Gwinner (Max-Planck-Institut, Erling Andechs), who also reported that the activity of pinealectomised starlings does not become completely arrhythmic as in sparrows, although the pineal certainly has a drastic influence on the rhythm. This leaves open the question of whether different species of birds differ in the extent of pineal control, or whether there may be after all some subordinate self-sustained oscillators which are synchronised by the pineal.

One of the ways in which birds can use internal clocks is in coordination with the Sun, as part of their extensive armoury of compass mechanisms used in migration and homing. The most recent work on navigation and compass orientation in birds has concentrated on scent and magnetism. In addition to a number of symposia devoted to navigation, W. T. Keeton (Cornell University) reviewed the whole field in his usual eloquent and lucid style. Among many recent findings, the last reported on the subject in 1975 (News & Views 257, 358) are the following: magnetic information on the outward journey seems...