brain, like a computer, can be "programmed" to do different jobs at different times. Indeed, the animal-computer analogy was heard more than once, from Dr J. D. Delius (University of Durham) and also from Dr D. J. McFarland (University of Oxford) who argued that animals allocate their time between different behaviours by "time sharing".

Physiological interpretation of a behaviour pattern is facilitated by an accurate description of the phenomenon to be explained, so that methods of recording and analysing behaviour are extremely important. Dr U. Weidmann (University of Leicester) illustrated his technique of frame-by-frame film analysis of the displays of mallard ducks as a method of discovering spatial and temporal relations between the birds that would be impossible by more conventional means. Dr P. Slater (University of Sussex) talked of the difficulties of describing and making sense of complex sequences of behaviour, and Drs R. Dawkins and M. Dawkins (University of Oxford) presented some methods of describing and predicting moment to moment changes in the fine structure of a behavioural act.

Better methods of description and the application of statistical techniques to uncover underlying patterns may well prove as useful a method for gaining an understanding of what goes on inside an animal as the already fruitful physiological approaches.

PROTEINS

# Oxidation to Order

from our Molecular Biology Correspondent

A GROUP at the University of Padua, Jori, Scoffone and their colleagues, have cornered the market in photo-oxidation of proteins. By a series of chemical subterfuges they have shown how the scope and precision of the method can be extended to make it potentially one of the most useful resources of the protein chemist. In their latest article (on papain) they present a striking demonstration of the delicate molecular surgery that is now feasible (Jori *et al.*, *J. Mol. Biol.*, **59**, 151 ; 1971).

Papain contains a single thiol group, which is a part of the active site, and is readily modified. A suitable chromophoric group attached to it can then be used as a sensitizer for the photo-oxidation of reactive side chains in the immediate vicinity. Jori and his colleagues examined two such sensitizers—the dinitrophenyl and the fluorescein thiocarbamyl groups. Their insertion caused no disturbance in the structure of the protein, as reflected in its optical properties. The dinitrophenyl group gave rise to its own Cotton effect in circular dichroism, indicating that it was rather rigidly set in its place in the protein. The fluorescein chromophore on the other hand showed no such effect, and from its low fluorescence polarization it could be inferred that there was little restraint on its rotation.

It might consequently be supposed that with its less restricted orientation it might function as a less discriminating photosensitizer. This expectation is borne out: the dinitrophenyl chromophore permits the destruction of only two residues, which were identified by separation of tryptic peptides as a histidine and a tryptophan. The fluorescein chromophore sensitizes the oxidation of both of these and also of a further tryptophan in the early stages of irradiation, and then increasingly indiscriminate destruction of residues in all parts of the chain. If the protein is denatured before irradiation, the side chains in the dinitrophenyl derivative are also extensively oxidized on irradiation.

From the papain structure, and indeed from what is known of its chemistry, the two residues destroyed in the native dinitrophenyl derivative are known to be in the active site, and no more than about 5 Å from the substituted cysteine. The protein so modified retains its native conformation, with unimpaired thermal stability. The second tryptophan initially modified in the fluorescein derivative is not in the active site, but is tucked into a tight-packed internal region close by. When this residue is oxidized, previously inaccessible groups become exposed, the optical properties change, and all the indications are that the tertiary structure has broken down. The conclusion is that the tryptophan in question is indispensable for maintaining the integrity of the conformation of the native enzyme.

A further refinement to the photo-oxidative approach has been evolved in the same laboratory (Jori *et al.*, *Biochim. Biophys. Acta*, **236**, 746 ; 1971). It is well known that paramagnetic ions are efficient quenchers of electronically excited states, and presumably for this reason are able to afford protection against photo-oxidative damage. The possibility then arises of making use of specific binding of such ions by proteins to achieve selective protection of some of the side chains which would otherwise be destroyed in a sensitized photo-oxidation process. Lysozyme is known to have a single strong binding site for zinc or cobalt. The site is known from protein magnetic resonance studies to consist of the carboxylate groups of glu–35 and asp–52. When the zinc complex is irradiated in the presence of proflavine as photosensitizer, tryptophan and methionine side chains are annihilated and the enzymatic activity vanishes. If on the other hand the paramagnetic cobalt ion is substituted for zinc the activity after irradiation does not fall below 85 per cent of native, and two indole rings are found to have been degraded. These are external side chains (trp–63 and 123), and do not perceptibly affect the conformation of the protein.

Experiments with ribonuclease gave similar results: the free enzyme or its zinc complex were extensively damaged but the cupric complex was modified only at two residues, met–79 and his–105, with substantial retention of activity. This result answers finally the question of whether met–79 is implicated in the enzyme mechanism. The protective effect of the paramagnetic ion is clearly a function of distance and orientation, and the possibility exists of exerting a finer control on the reaction by the choice of metal ions with different orientations of ligand orbitals.

# Accurate Radio Source Positions from Cambridge

As the relationship between radio, optical and high energy emission from sources both inside our galaxy and from extragalactic sources is becoming increasingly important to an understanding of the processes operating in these objects, so it is of increasing importance that radio sources should be pinned down by accurate measurements of their positions. Without the painstaking work which this implies, no correlation can be made between radio sources and optical objects. Equally important is the establishment of an absolute reference scale, so that positions determined using different antennae can be adequately compared In next Monday's *Nature Physical Science* J. W. Smith reports the latest progress made in this field by the team operating the Cambridge One Mile radiotelescope.

By carrying out simultaneous observations at 2.7 and 5 GHz, corrections allowing for the curvature of the atmosphere, and seasonal variations in the electrical lengths of the delay cables in the equipment are included—these terms are as small as 0.01 arc s. The overall accuracy of the positions given by Smith for twenty-eight sources is not, of course, as accurate as 0.01 arc s. But the better than 0.05 are s accuracy quoted for right ascension, and better than 1 arc s for declination, is already pressing the optical astronomers, who will now need to improve their own measurements before a deeper insight into these sources can be achieved.