activities of δ -aminolævulinic acid synthetase and dehydrase were also reduced, and synthesis of these enzymes was apparently inhibited. She also found that the transference of organisms from highly aerobic conditions in the dark to conditions of low oxygen tension in the dark, or to anaerobic conditions in the light, not only caused pigment synthesis but also resulted in an increase in the activities of δ -aminolævulinic acid synthetase and dehydrase. This adaptation could be inhibited by inhibitors of protein synthesis. Lascelles¹¹ observed that hæmin represses formation of the synthetase and dehydrase in whole cells, and there was some evidence that formation of these two enzymes could be regulated by the concentration of iron porphyrins present in the cells. We have found that hæmin, in addition to its repressive effect on the formation of these enzymes, inhibits the synthetase activity in cell extracts and that protoporphyrin inhibits the dehydrase activity. Accumulation of hæmin and of protoporphyrin under certain conditions of growth may thus reduce synthesis of pigment both by repression of enzyme formation and by inhibition of the activities of enzymes already present in the cells.

There is, however, good evidence that levels of porphyrins and hæm are not the only factors controlling synthesis of pigment. The experiments on the effects of ethionine and threonine demonstrate the importance of the methylation step; and the excessive amounts of porphyrins excreted in the cells in the presence of moderate quantities of ethionine and threonine in the medium suggest that porphyrin formation is normally controlled by a substance X, possibly a phæoporphyrin derivative, which occurs after magnesium protoporphyrin in the biosynthetic pathway of bacteriochlorophyll. If this substance is not synthesized, for example, owing to inhibition of the methylation of magnesium protoporphyrin or to inhibition of methionine formation, porphyrin synthesis 'runs wild' and excessive amounts are formed which are released into the medium. In addition to these direct mechanisms of control, it appears that in general the rates of formation of chlorophyll and of carotenoids are closely

parallel, and we know little about the factors regulating the formation of the latter. Similarly, phytol is a component of the bacteriochlorophyll molecule and its mode of synthesis is still obscure, although it would appear likely that it is derived from a carotenoid or a carotenoid precursor. Mechanisms which increase or depress terpene synthesis might therefore also control synthesis of bacteriochlorophyll through the availability of the phytol side-chain.

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ANIMAL BEHAVIOUR

A SYMPOSIUM on animal behaviour was held on September 4 by Section J (Psychology) of the British Association for the Advancement of Science, during the recent meeting at Norwich. As was pointed out by the chairman, Mr. D. E. Broadbent (Medical Research Council Applied Psychology Research Unit, Cambridge), the Section has usually considered primarily human behaviour; but in this it is ceasing to be in step with university departments of psychology, which are devoting more effort than they once did to research on animals. Animal behaviour is a subject of great interest in itself. It also has relevance to human beings, because it reveals simple general principles about behaviour that may also apply to men, and it makes possible experiments on causal factors in behaviour which cannot, for moral and practical reasons, be performed on men. Thus the influence on behaviour of rewards, of the structure of the brain, of restricted infantile experience, and of drugs and instincts, can be studied in animals, and

papers on each of these topics were included in the symposium.

Mr. H. M. B. Hurwitz and Dr. J. R. Millenson (Birkbeck College, University of London), proceeded to discuss and demonstrate the control of behaviour by reward. Their emphasis was on the possibility of building up valid empirical statements about observed relationships without appeal to theoretical concepts. Thus, if a response R was followed by a reinforcing agent S^r , such as food, the frequency of R would increase. If S^r ceased to follow R , the latter would decrease in frequency. Such statements could be made without any discussion of events within the animal. In a similar way, but with more complex experimental manipulations, behaviour such as problem solving or delayed reaction could be studied.

The authors then demonstrated a pigeon and a rat the behaviour of which had been shaped in a complicated fashion. The pigeon would look at three keys, peck the middle one, and observe a coloured light on

that key which was sometimes red and sometimes green. One of the other two keys was red and one green, and the bird would then peck the key which was the same colour as the middle key. This sequence occurred continuously at a rate rather faster than most humans could make the comparison. The method of training had been, first, to teach the bird that food would appear in a certain place when a light was on, then to teach that pecking either of the two end keys would produce the food; this training was followed by withholding the food unless a peck at the centre key was made before the peck at the end key, and so on until the full sequence was learned.

The rat had been taught in a similar way to press one lever five successive times, and then press another lever to obtain food. Both animals behaved as they had been taught despite the strange surroundings and the audience: and provided a most convincing demonstration that suitable manipulation of reward could indeed control behaviour so as to produce exceedingly complex learned actions.

Dr. L. Weiskrantz (University of Cambridge) emphasized the importance of such behavioural techniques, but he was concerned with the brain and with its relation to behaviour rather than with purely external observations of animals. Historically, the cortex of the brain had been regarded as composed of projection areas through which messages entered and left, and association areas which were more general in function. Indeed, according to Lashley's principle of mass action, the amount of deterioration, in performance in mazes, produced by removal of association cortex from a rat's brain depended on the weight of cortex removed and not the location. More recent research had shown both that the projection areas were less specific and that the association areas were more so than had been thought. Removal of the projection area which was fed by the ear had little effect on the ability of an animal to detect sounds. On the other hand, damage to the frontal association areas would produce an impairment in the ability to remember, over a short period, which of several possible hiding places contained food. The latter impairment did not occur with damage elsewhere in the brain. Similarly, damage to the temporal lobes would affect the ability to discriminate between two stimuli whereas damage to the frontal lobes would not. Thus different parts of the brain do have different functions.

Experiment in this area is made difficult by the irreversible nature of a lesion in the brain: once the frontal lobe has gone the animal cannot be tested again in its normal state. Recent work at Cambridge had, however, explored the possibility of temporary interference with particular regions by electrical stimulation, and it seemed that the ability to make delayed responses to hiding-places could indeed be removed temporarily while stimulation was being applied in the frontal lobes. The animals were afterwards normal in their performance. Once again different parts of the brain showed different effects.

Whereas the classical view of the nervous system was of a series of levels, in which the lower mechanisms dealt with isolated actions and higher ones with combined and co-ordinated ones, a different interpretation was now gaining support. On this view the nervous system might rather be compared with a candle in which the wick dealt with gross and undifferentiated action of the whole organism, and

the outer skin of the candle dealt with finely discriminated functions. To take another analogy, on the old view, lower levels might be compared with isolated instruments and the cortex to the whole orchestra; on the new view, the contrast was rather between the orchestra tuning up, all simultaneously, and the orchestra playing in complex harmony.

Dr. Weiskrantz ended with a clear and well-reasoned argument for a physiological approach to behaviour as well as the approach in which actions alone are studied without reference to events within the animal; and as well as the approach in which mechanical models are constructed without physiological reference. He regarded these approaches as healthy in their scepticism, but negative, and firmly supported the importance of the brain in behaviour. It may be added that his paper was both witty and modest, and that it produced a deep impression on the audience.

Dr. R. Stretch (Queen's University, Belfast) gave a general review of experiments on the early experience of animals, including a few which show effects of ante-natal experience. It appears that exposure of pregnant rats to frightening situations may produce offspring which are unduly susceptible to fear: possibly through some ill-understood hormonal mechanism. Most research has, however, concentrated on early post-natal experience, and in this area the relationships seem to be complex. Electric shock administered to rats during infancy seems, for example, to produce adults which are more resistant to emotional disturbance. On the other hand, if animals are reared in a very restricted environment they seem as adults to be poor in ability to learn. There is some evidence that exposure to a complex environment in infancy produces adults with a lower concentration of cholinesterase in the brain, and this may be related to the differences in ability. There are also genetic differences as well as those produced by environment, and in this connexion it is interesting that wild rats differ from laboratory rats in the extent to which they will show curiosity or exploration. Wild rats avoid novel objects, while laboratory animals will investigate them and even feed in their presence. There may therefore be some interaction between anxiety and curiosity, and the effects of early experience on curiosity are of interest.

Dr. Stretch then turned to some experiments of his own on this latter problem. One group of rats was kept in ordinary laboratory wire-mesh cages for the period just after weaning, while another group of rats was kept in restricted cages through the walls of which they could not see. In the latter case there was little background noise, and the environment was in general a rather unstimulating one. As adults the rats were tested for curiosity in two ways. One of these was a maze shaped like an *H*, the measure of exploration being derived from the number of parts of the maze entered. On this test the animals which had had a restricted environment explored more. Another test could, however, be applied. For this a box was used, in an alcove of which novel cards with patterns on them were placed, and a record was kept of the extent to which the rats entered the alcove rather than the rest of the box. On this test the restricted rats gave a lower score. As Dr. Stretch pointed out, these results suggest that rats with a restricted early experience were more fearful. They therefore avoided particular novel objects, but if placed in a completely novel situation ran around looking for a means of escape. There are therefore

implications both for the methods to be used in studying curiosity and also for the possible mechanism by which variety of early experience has its effect.

The last speaker, Dr. J. M. Cullen (University of Oxford), was a zoologist rather than a psychologist. Accordingly he gave more attention to the natural behaviour of animals than did the other members of the symposium. His particular interest was the possibility of separating different classes of behaviour as affected by one drug rather than another. By this means one might ultimately disentangle the mechanism by which drugs affect behaviour. The animal which he had studied was the stickleback, and the drug benactyzine.

The stickleback lives in schools in the winter, but in the breeding season each male defends a territory in which it builds a nest. It courts an approaching female, she lays her eggs in the nest, departs, and the male then looks after the eggs. When defending the territory, the male will attack other males close to his own nest, but flee from them at greater distances. The border-line between these two behaviours moves nearer to the nest under benactyzine, which suggests at first sight that fear is increased.

When the female appears, drugged males less frequently court her, and are more likely to attack her than undrugged males are. This is not altogether consistent with the effect on size of territory, but might perhaps be explained by supposing that sexual behaviour is even more sharply reduced than fear is.

On the other hand, kicking the tank in which the fish live causes them to cluster into a school, which suggests that schooling is a fear response; and the drug reduces schooling rather than increases it.

Feeding is reduced by frightening stimulation and also by the drug; but closer examination shows that the effects are rather different. In feeding, the stickleback orients towards the food, possibly several times, before each grasp at it. When frightened there are fewer grasps but also fewer orientations per grasp; whereas under benactyzine there are fewer grasps with a normal number of orientations per grasp. The latter type of behaviour also results simply from reduced hunger, so that the drug is in this respect apparently similar to a reduction in hunger.

The common factor in all these effects might perhaps be a reduced responsiveness to visual stimulation, and in fact sticklebacks placed in a situation where a striped wall rotates around them are less responsive to this stimulation. At the moment the most promising hypothesis is therefore that the drug reduces responsiveness rather than the strength of one category of behaviour; but the experiments remain an illustration of the way in which a knowledge of instinctive patterns may be used to analyse the operation of drugs.

It was clear from all four papers that work on animal behaviour is developing rapidly, and that important principles are beginning to emerge.

D. E. BROADBENT

NEWS and VIEWS

Pharmacology at St. Bartholomew's Hospital Medical College: Prof. J. P. Quilliam

DR. J. P. QUILLIAM, at present reader in pharmacology in the University of London at St. Bartholomew's Hospital Medical College, has been appointed to the newly created chair of pharmacology at that Medical College as from October 1. Dr. Quilliam graduated with honours (physiology) in the University of London, and took his M.Sc. in 1938, and his M.B., B.S. (London) in 1941. After a period of war service, in the Royal Air Force, he was appointed lecturer in pharmacology at King's College, London, and in 1946 he was appointed part-time lecturer in pharmacology at St. Bartholomew's Hospital Medical College to assist in the early development and expansion of that Department. In that early development he played a very active part and was appointed senior lecturer in charge of the Department and later reader in pharmacology in 1958. Dr. Quilliam has built up at St. Bartholomew's a very active Pharmacology Department with wide research interests and comprehensive teaching courses for medical, dental and science students. He has developed a department which is particularly well equipped for the use of electro-pharmacological techniques for research in pharmacology and for the teaching of that subject. He has built up a very strong and enthusiastic research team, with many postgraduate workers in his group, and he has attracted for his work important and valuable research grants from the United States. His research interests are manifold and his particular interests have centred on neuromuscular and ganglionic transmission and its modification by centrally-acting drugs. He has had wide experience of teaching methods, and he has spent a year as a Fellow in

residence at Johns Hopkins University, Baltimore. He has had much experience as an examiner in the University of London and other universities in Britain, and is the chairman of the Board of Studies in Pharmacology in the University of London. He is a member of the General Optical Council. He has carried out important editorial duties as an editor of the *British Journal of Pharmacology and Therapeutics*, and his own publications involve investigations on the pharmacological action of hypnotic drugs, fluorophosphonates and many other drugs.

New Zealand Department of Scientific and Industrial Research: Senior Research Fellowships

THE New Zealand Department of Scientific and Industrial Research has announced the award of the 1961 Senior Research Fellowships to Dr. B. H. Howard, principal scientific officer, Rowett Research Institute, Bucksburn, Aberdeen, Scotland, and to Dr. R. Melville, principal scientific officer, Royal Botanic Gardens, Kew, Richmond, Surrey, England. Dr. Howard's work has been concerned since 1954 with the study of the biochemistry of micro-organisms of the rumen, under Dr. D. P. Cuthbertson, director of the Rowett Research Institute. Prior to that he was studying biochemistry of micro-fungi, under Prof. H. Raistrick at the London School of Hygiene and Tropical Medicine. He has published several papers, and in his work under the Fellowship in New Zealand he hopes to apply techniques used in the United Kingdom to the different ruminal flora and fauna found in New Zealand ruminants. Dr. Melville is in charge of the Australasian Section of the Herbarium at Kew and is working mainly on Australian plants and to some extent on New Zealand plants, in