where a low surface energy is believed to reduce the tendency of implants to cause blood clotting. The amino-substituted polymers can be made water soluble and are susceptible to hydrolysis to varying extents. Uses as resorbable sutures and slow release drug carriers are being investigated.

There are a number of groups of polymers where a wide range of properties can be produced by altering the side groups. The proteins and polysaccharides are two classes which have proved their value over the years. Vinyl polymers which range from polyethylene to polyacrylamide could also be seen as such a class. Polyphosphazenes are unlikely ever to be used on a large scale but they do seem to have promise in terms of tailoring polymers for specific, small scale uses. Here the ability to add substituents without having to perform a new polymerisation is a real advantage. This approach of designing polymers for specific purposes would be real molecular engineering, something that is more often talked about than practised. The snag is that our current methods of predicting properties such as solubilities and transition temperatures are so crude as to shame most other branches of engineering.   □

Neural systems

by Miranda Robertson

The Dahlem Conference on the Formation and Function of Neural Systems was held in Berlin on 7–11 March, 1977. The proceedings will be published and can be obtained from Dahlem Konferenzen, Delbrückstrasse 4c, D-1000 Berlin 33.

ALTHOUGH nominally the meeting was addressed to the function as well as the formation of neural systems, it was effectively dominated by the question of formation.

The growing contribution of genetics to the issue was divided by Peter Lawrence (MRC Cambridge) into two categories: the identification of genes which control development directly, and the identification of crucial cellular interactions through neurological mutants in which they have gone astray.

Two recent advances discussed at the meeting fall into the first category. One is the addition of isogenic locusts to the menagerie of mutants, mosaics and isogenic invertebrates on which much neurodevelopmental insight depends. A series of isogenic strains has been used by C. Goodman (in experiments described by D. R. Bentley, University of California) to distinguish genetically controlled variation from

Parental care

from John Krebs

ONE characteristic of higher vertebrates is that they usually look after their eggs or young, a trait which is rather rare in fish, amphibians, and reptiles. The advantages of parental care in terms of survival of young may be obvious, but it is less clear why one sex rather than the other should provide the care. In birds and mammals the trend is for females to do more than males for their young, while in fish it is often the other way round.

The theory of natural selection leads one to expect that each parent should, at any time during its reproductive life, adopt the course of action which maximises the number of young produced in the remainder of its career. (It should not, of course, make the Concorde Fallacy of directing its future action on the basis of past investment (Dawkins & Carlisle *Nature* **262**, 131; 1976)). For example, if the survival of young is greatly enhanced by care from one parent, but the second parent makes rather little difference, it would pay each parent to try and leave the young in the care of its partner, to go off and mate again. On the other hand if the survival of young depends (as in most birds) on care from two parents, it will pay neither to desert.

An analysis of the theory of parental care and desertion has recently been published by J. Maynard Smith (*Anim. Behav.* **25**, 1; 1977). He considers two situations in which breeding is synchronised and seasonal: in one the factor-limiting production of young is parental care, whereas in the other, the number of eggs laid by the female is also important. In the first model, it would not pay the female to produce extra eggs since they would not survive without additional care. The first model applies to most birds. Birds are usually monogamous and both parents care for the young, but if one parent can look after the young (as in species with precocial young such as gallinaceous

birds) and there is a reasonable chance of a second mating, it is usually the male which deserts. Although it would equally pay the female to desert, she is subject to a time constraint: she has to wait after copulation until she has laid the eggs, and this may mean that she is too late to have a chance of finding a second mate when there is synchronised seasonal breeding. The female can however encourage male fidelity by delaying tactics. If she refuses to copulate until the male has little chance of finding a second unmated female, she may force him into faithful monogamy.

In most fish, and a few birds, parental care takes the form of guarding and not feeding, so that the number of young reared by a female will depend not solely on the amount of parental care, but also on the initial production of eggs. Here the female has, so to speak, a choice of directing her reserves into parental care and laying fewer eggs, or channelling all her reserves into eggs and deserting each clutch. As long as one parent can rear the young, it will pay the female to desert, which she often does. As pointed out by Dawkins and Carlisle (*op. cit.*), an additional factor favouring male parental care in fish is external fertilisation. With external fertilisation the male has to deposit his sperm after the eggs have been laid; as a result the female has the chance to desert first, just as in species with internal fertilisation the male has first chance.

Mammals are rarely monogamous; male desertion is common because of the physiological commitment of the female to parental care, at least in the early stages. There are, however, some monogamous mammals, such as the gibbons (*Hylobates* spp.), and it is perhaps somewhat surprising that these species have not evolved more male parental care, for example in the form of male lactation.   □

epigenetic 'noise' in the determination of an identified neurone. While the position of the cell body varied only between strains (implying genetic control), the terminal branching of the axon varied between three positions, at different axonal lengths, within strains (implying epigenetic control).

Deducing the nature of the genetic control from mutants is, according to Lawrence, enormously complicated by the fact that most developmental mutations are bound to be lethal,

which means that survivors are probably 'leaky' mutants and the investigator is thus faced with deducing wild-type function from the effects of its reduction rather than its total absence. The problem was well illustrated by the effects of homoeotic mutations on the nervous system of *Drosophila* (J. Palka, Washington University). Homoeotic mutations transform one entire structure into another—for example, wing into haltere; but the innervation of the

mutant structures seems to bear no consistent relationship to the target tissue, since it can correspond either to that of either the wild-type or the mutant appendage, or to a mixture of the two, sometimes in conjunction with an abnormal pattern unlike either.

Genetic mosaics, which can be used to circumvent the lethal consequences of developmental mutations, can also distinguish direct from indirect effects of such mutations. Myerowitz and Kankel (as reported by F. D. Ready (Stanford University Medical School)) have found, for example, that a small group of mutant retinula cells in the eye of *Drosophila* mosaics causes a 'cascade' of abnormal projections in the first and second optic ganglia, although all the other cells involved are wild type.

A similar 'cascade' seems to characterise the visual system of the Siamese cat, in which a discrete subset of optic nerve fibres which projects ipsilaterally in normal animals instead crosses at the chiasm. This gives rise to abnormal connections in the lateral geniculate and at the cortex, where the callosal connections have now been shown to be abnormal as well (C. Shatz *J. comp. Neurol.* **171**, 229; 1976). This abnormality is common to albinos of all species so far tested and is known to result from the absence of pigment rather than from the action of the albino gene itself, or the tysosinase deficiency which is its direct effect. (The incrimination of the pigment is due to numberless mink-breeders, who have produced animals synthesising pigment in varying quantities through mutations in no less than five different genes; and to R. W. Guillery, who has established that the degree of optic fibre misrouting in minks corresponds to the pigment deficiency and not to any particular gene.)

Guillery (University of Wisconsin), following up this clue to the cause of the mis-specification of the retinal fibres, has found that (in hamsters) a small group of pigment epithelium cells is born and dies at the base of the optic stalk at a time when no other pigment tissue has yet appeared, but the optic fibres are just beginning to grow out from the eye. It seems possible that those pigment cells induce the specification of the ganglion cell axons.

Another example of induction of neural function by non-neural cells is that of the induction of biochemical differentiation in superior cervical ganglion cells *in vitro*. Rat sympathetic neurones cultured on their own are adrenergic, but when grown in medium 'conditioned' by various types of non-neural cell they synthesise acetylcholine and form nicotinic cholinergic synapses (Furshpan *et al. Proc. natn.*

Acad Sci. U.S.A. **73**, 4225; 1976). Further experiments with these cells (P. Patterson, Harvard Medical School) have shown that all tissues seem to be able to induce cholinergic function, though to widely varying degrees which do not seem to be related to whether they normally receive cholinergic or adrenergic innervation, or any innervation at all. There is evidence in the spinal cord *in vivo* that transmitter induction is determined by position (Le Douarin *et al. Devl Biol.* **41**, 162; 1974).

The question of how far neural development is dictated by other tissues arises in a more specific form in the context of synaptogenesis, which has been investigated principally at the neuromuscular junction. Do neurones, for example, recognise their target issue by its neurotransmitter receptors? Experiments showing synaptogenesis in the face of receptor blockade imply that if they do, it is not by virtue of their transmitter binding sites (Cohen *Brain Res.* **41**, 457; 1972; Anderson *et al. Neurosci. Abstr.* **2**, 707; 1976). The possibility, fleetingly raised, that receptor clusters (hotspots) might attract innervating fibres has also been ruled out by Anderson *et al.*, who showed by fluorescence labelling of receptors during synaptogenesis that innervating fibres did not make synapses at existing hotspots but induced receptor clustering very rapidly on contact.

It is now clear that an important contribution to the pattern of synapse formation is made by the withdrawal of most of the contacts initially made by the innervating neurone. The evidence for this selective elimination comes both from physiological and anatomical investigations on the neuromuscular junction (Brown *et al. J. Physiol., Lond.* **261**, 387; 1976) and from anatomical studies on the cat visual system (Rakic *Nature*, **261**, 467; 1976; Hubel *et al. Phil. Trans. R. Soc.* in the press). Its mechanism is not known, but seems to reside largely in the nerve. Brown *et al.* have ruled out competition between lenses by the demonstration of withdrawal of synapses from rat soleus after 75% of the innervating axons have been cut, even when that leaves many fibres denervated. They do not however rule out some influence of the muscle itself in the selection of which fibres are to be retracted.

Investigation of this phenomenon in nerve–nerve synapses has been made possible for the first time by the discovery of J. Lichtman, reported by D. Purves (Washington University), that four out of five terminals made by guinea pig submandibular ganglion cells are withdrawn within four weeks after

birth.

The broader implications of selective synaptic elimination are suggested by the proposal (D. Hubel, Harvard Medical School) that the period over which it occurs may correspond to the 'critical' period within which the development of the central nervous system can be influenced by its input. But the demonstration that the effects of monocular deprivation can be reversed during the critical period implies that fibres must be able to sprout as well as to withdraw.

So far, anatomical evidence of plasticity has been available only for the distribution of ocular dominance in the innervation of the visual cortex and anatomical data on the distribution of orientation selectivity (the nature of whose plasticity has been fiercely disputed) have been beyond neurology's technical means. Now however the anatomy of the orientation columns has become accessible through the discovery that ^{14}C-deoxyglucose can be used for the selective staining of active neurones (Kennedy *et al. Proc. natn. Acad. Sci. U.S.A.* **73**, 4230; 1976). Hubel has applied this technique to the autoradiographic mapping of the vertical orientation columns of the monkey visual cortex, confirming the indications from electrophysiological mapping that there is no regular anatomical relationship between the orientation columns and the ocular dominance columns. Whether this technique can be brought to bear on the issue of plasticity in orientation selectivity remains to be seen.

In the meantime, however, invertebrate neurophysiologists are preparing to join the fray. R. Murphey (State University of New York) reported that unilateral immobilisation of the mechanoreceptive hairs on the cerci of developing crickets raises the sound threshold of the medial giant interneurone which receives its input from the cercal mechanoreceptors on the treated side of the animal. Matsumoto and Murphey (*J. Physiol., Lond.* in the press) suggest on the basis of the directional tuning curve of the giant neurone that an increase in the activity of the crossed inhibitory input from the contralateral cercal hairs may at least partly account for their result.

While this has interesting echoes of the suggestion (Duffy *et al. Nature* **260**, 256; 1976) that in monocular deprivation, a tonic inhibitory input to the visual cortex from the non-deprived eye may explain the unresponsiveness of deprived cortical cells, there is much too much uncertainty about the precise mechanism of either the invertebrate or the vertebrate results to justify firm conclusions, let alone direct comparison, at this stage.   ☐