the arterial connexions of the circle of Willis and of the detailed vascular architecture of the diencephalon and the hypophysis in the dog, and further, with the help of suitable coloured substances, to study the distribution of vertebral and carotid blood in the brain. These careful studies of the vascular supply of the dog's brain will certainly be of the greatest value to anyone who, in the future, traces the distribution of arterially injected substances in the brain of the dog.

After an account of these preliminary studies, the authors describe experiments performed to localize the osmoreceptors. Having tested the antidiuretic response obtained from infusions of hypertonic saline into the common carotids in dogs supplied with carotid loops but otherwise intact, they started to study the effect of tying one or more of the carotid branches supplying the brain with blood. Tying of the branches of the internal carotid intradurally, especially, necessitated a very delicate operative technique. After killing the animals, the distribution areas of both carotids were traced with the help of coloured substances. In all cases where an antidiuretic response to infusions of hypertonic saline was obtained on the side of the brain where the distribution of carotid blood had been restricted, the anterior hypothalamus and adjacent parts of the pre-optic area had been reached by hypertonic blood. No other part of the brain was reached directly by the infusions. The authors thus have good reason to conclude that the neurohypophysial osmoreceptors are localized in the anterior hypothalamus and perhaps also parts of the pre-optic area.

The results of the last two experiments reported in the work might at first sight seem somewhat confusing. In these, all three main branches of the internal carotid had been tied intradurally on one side, leaving some smaller branches to supply the ipsilateral parts of the hypothalamus with arterial blood. The result in both cases was that the antidiuretic response seen before the operation, due to intracarotid infusions of hypertonic saline, vanished completely. The occlusion of these three branches of the internal carotid had, however, in one of the dogs, caused the formation of a cyst in the anterior hypothalamus, and a reduction in the number of cells in the remaining nuclei. In the other dog a large cyst was formed in the thalamus, and the greater part of the anterior hypothalamus had been supplied from the carotid of the opposite side. This seems in itself to be a possible explanation for the lack of response to the infusion of hypertonic saline on the side operated upon.

On the basis of these two experiments, and of other observations which cannot be mentioned here, the authors put forward the interesting hypothesis that the functioning of the hypothalamic osmoreceptors may be dependent upon the integrity of nervous connexions with the thalamic paraventricular nucleus. Further experiments to test the validity of this hypothesis are suggested at the end of the paper.

In short, this solid work of Jewell and Verney forms an extremely valuable complement to Verney's earlier pioneering research on the physiological regulation of the function of the neurohypophysis. Their results have meanwhile been fully supported by the work carried out at the Royal Veterinary College of Stockholm by B. Andersson and his collaborators, who have been able to elicit not only thirst, but also an inhibition of water diuresis in conscious goats, by electrical stimulation within the anterior hypothalamus.

YNGVE ZOTTERMAN

MOSAIC EVOLUTION IN HYDROIDS

IN many animals different organs are capable of undergoing independent evolution at different rates. The idea of 'mosaic evolution' is becoming familiar to systematists in a number of groups. It both enriches the story of phylogeny, and bedevils those classifications that have relied on a few 'good taxonomic characters'. In the hydroid cœlenterates, moreover, the two phases of the life-history—polype and medusa—have an almost independent existence, and it is peculiarly easy for them to evolve separately and each acquire new characters not apparent in the morphology of the other. In traditional classifications, the polype and medusa of the same species have often had different names, separate families and have been described by different workers. Realization of this was not wanting, even in 1864 with Allmann's lament that "the principles of classification that have been regarded as the only sound ones in other groups have been almost entirely ignored in our attempts at a systematic arrangement of the Hydroida".

With modern knowledge the need for dual classification is ending, and in a recent report* by Dr. W. J. Rees, proposing a new arrangement of the capitate hydroids, a large advance has been made. Dr. Rees has, for the first time, merged polypes and medusæ into a single phylogenetic classification; and in this he has had much careful work to draw upon, especially the studies of Russell, Kramp and himself. This must be an important paper for the hydroid specialist; and it is a stimulating one for the general zoologist who is fond of hydroids or teaches marine biology. The author gives a lucid account of the suborder Capitata, drawing his evidence widely from both polype and medusa, with particular attention to the relation of form and function in his own experience of living hydroids. The resulting classification is a 'liberal' and broad-based one.

Theories of alternation of generations (there seems no good reason to avoid this term) are reviewed. The older hydroid theory held the sexually propagating polype to be the primary form in Hydrozoa. The medusa arose from a later 'division of labour', though this hypothesis could never properly account for the Trachylina. Dr. Rees firmly supports Brooks's theory (now most widely accepted) of the ancestral role of the simple 'actinula', which gradually took advantage of attachment, and by vegetative proliferation gave rise to a polypoid phase. The earliest hydroid was probably a primitive medusa, comparable with a trachylinid, and the medusal theory and actinula theory are in fact complementary.

The body of the paper is a consideration of evolutionary trends and mosaic patterns developed in the polype and the medusa. Dr. Rees rejects Kramp's view that the colonial corynoids are the most primitive polypes: colonial forms—he holds—have arisen from solitary forms, and the existing lower Corymorphines come nearest to the ancestral form of the hydroid polype. Here we have types like *Hypolytus* and *Euphysa* with a feeble perisarc, no diaphragm and no well-developed stem canals. The oral tentacles are capitate or moniliform but the aboral circlet always moniliform, corresponding with the tentacles of the

* Bulletin of the British Museum (Natural History). Zoology. Vol. 4, No. 9: Evolutionary Trends in the Classification of Capitate Hydroids and Medusae. By Dr. William J. Rees. Pp. 453–534 + plates 12 and 13. (London: British Museum (Natural History), 1957.) 25s.

early medusa. In these lower polypes they form the long fishing tentacles suited to life on a muddy substrate. Capitate tentacles arose later. Polypes have evolved along three broad lines. In the *Corymorpha–Tubularia–Margelopsis* line, we find the largest and most elaborate polypes, the Tubulariidae acquiring a firm perisarc and settling on hard substrata, and the margelopsid polypes becoming specialized and pelagic. The larger polypes of this line develop a most complex internal structure; *Corymorpha nutans* is 11·4 cm. in length, *Brachiocerianthus imperator* a giant of 224 cm. In the second or *Acaulis–Myriothela* line, starting with the primitive *Acaulis*, the polypes become vermiform, with short capitate tentacles scattered over the intertentacular area. *Myriothela austrogeorgiae* reaches 30 cm. in length. The third series—the corynoids—have become colonial, with the individual polypes much smaller, and the aboral tentacles lost, as in the "deceptively simple polypes of the Corynidae". Food circulates from polype to polype by a continuous cœnosarc, and in the higher corynoid family, the Zancleidae, Russell and Rees have found sexual and nutritive differentiation among the polypes (elsewhere much more emphasized among Hydroida).

The position of the gonophores, egg size and encystment and evolution of the perisac are considered, followed by a survey of evolution in the medusæ. Dr. Rees regards the medusæ of capitate hydroids (the Codonidae of Haeckel) as the most primitive of all. The ancestral form—not unlike a modern *Sarsia*—had a deep bell-shaped umbrella with scattered nematocysts, four per-radial tentacles with moniliform nematocyst batteries, four radial canals, a ring canal and a ring gonad surrounding the stomach. Moniliform tentacles are retained in many corymorphine polypes, but only *Euphysa* has them in both polype and medusa.

Dr. Rees agrees with Broch and Kramp that the condition of the gonophore—an attached sporosac or a free medusa—is by itself of little taxonomic value. But the free medusa has much higher claims: it is not so much an organ only a little removed from a fixed eumedusoid, but an independent organism undergoing its own evolution. Its morphology, duration of life and reproductive behaviour carry great weight in discrimination of species, genera and even families. Many species find "fuller opportunity for expression in a free planktonic phase than in a sedentary benthic phase".

Phyletic lines of polypes and medusae are summarized in two schematic figures (57, 58). Generalized though these must be, they might have been even more helpful to the non-expert if they could have been given fuller captions. Dr. Rees's classification introduces four superfamilies into the suborder Capitata of order Anthomedusae. The Tubularoidea contains the Corymorphidae, Tubulariidae and Margelopsidae; the Tricyclusoidea is set up for the unique species *Tricyclusa singularis*. The Acauloidea includes the Acaulidae and Myriothelidae; and in the Corynoidea are grouped ten colonial families with simple hydranths centring around the Corynidae. For some of these, such as the Cladocorynidae and Asyncorynidae, this grouping is provisional and common ancestry is not claimed. J. E. Morton

HOW DOES THE EHRLICH ASCITES TUMOUR OBTAIN ITS ENERGY FOR GROWTH?

By A. KEMP and Prof. B. MENDEL, F.R.S.
Pharmaco-therapeutic Laboratory, University of Amsterdam

In the peritoneal cavity of the mouse, cells of the Ehrlich ascites tumour multiply rapidly. After transplantation their number increases about 25-fold within five or six days. This growth is accompanied by a corresponding increase of ascitic fluid.

Since the ascitic fluid contains only traces of glucose and oxygen[1], it seems surprising that the cells can grow in this medium. In the course of recent experiments *in vitro*, Warburg[2] "placed varying amounts of energy at the disposal" of the ascites cells and then transplanted them. He observed that the cells died when neither glucose nor oxygen was supplied for twenty-four hours, but that "one-fifth of their growth energy" was sufficient to preserve transplantability. Though these experiments seem to show that ascites cancer cells can survive under conditions of near-starvation, the question still remains as to how they find the energy for *growth* in the ascitic fluid.

Glucose Concentration and Glycolysis

It is well known from Warburg's experiments with surviving tumour slices that a glucose concentration of about 200 mgm./100 ml. is required for maximum glycolysis. At glucose concentrations lower than 80 mgm./100 ml. the rate of glycolysis decreases sharply, amounting to less than one-fifth of its maximum at a glucose-level of 5 mgm./100 ml. A similar relation between glucose concentration and fermentation has been found with cell suspensions, for example, with yeast cells. Here, too, the rate of fermentation diminishes considerably once the glucose concentration has dropped below 200 mgm./100 ml.

When we became interested in the metabolism of the ascites tumour cells *in vivo*, we first inquired into their glycolysis in relation to the glucose concentration in the medium. This seemed necessary in view of the extremely low level of glucose in the ascitic fluid. We found that, *in vitro*, the maximum rate of glycolysis is still maintained at a glucose concentration as low as 4 mgm./100 ml. Once the level of glucose has fallen off to about 3 mgm./100 ml., glycolysis ceases abruptly. Ehrlich ascites tumour cells would thus be able to make full use of their glycolysing capacity, if the ascitic fluid were to contain a minimum of about 4 mgm./100 ml. of glucose.

Concentration of Glucose in the Ascitic Fluid

As far as we have been able to ascertain, the concentration of glucose in the ascitic fluid has not yet been accurately determined. Since the amounts of glucose present in the fluid are too small to be estimated quantitatively by the usual methods, we