fact, abnormal, and the decision given by the Minister of Fuel and Power in favour of the Electricity Board's proposal to serve farms in Martindale by overhead lines.

In Langdale no change is reported in the Electricity Board's policy of withdrawing the scheme on grounds of economy; but reference is again made to the improvement of the Hardknott from a mountain trackway with a loose rough surface into a motoring road in spite of the clear and unequivocal assurance to the contrary given in November 1946 by the chairman of the Highways Committee of the Cumberland County Council. Attention is also again directed to the general difficulty that arises because the virtual control of road-widths and traffic policy is in the hands not of the new Planning Board or even the local highway authorities, but of the Licensing Authority, a body which is detached from any interest in the preservation of the countryside. The intricate work of completing the footpath survey and official statutory map is likely to continue for another two years at least, but the review of open country in the area has been completed in the counties of Cumberland and Westmorland and in the National Park as a whole.

The Friends of the Lake District have been concerned in a preliminary review of the needs and possibilities of new footpaths on the shore of Lake Windermere, and representations have been made regarding the minimum flow in the Dash Beck water scheme for the rural district of Wigton as well as the construction of any necessary buildings. Together with the Council for the Preservation of Rural England, the Friends of the Lake District have made representations regarding the Forestry Commission's proposal to plant Low Holme Park exclusively with conifers and its effect on the footpath between Eskdale and Nether Wasdale.

NEUROSECRETORY PATHWAYS IN THE HEAD OF CRUSTACEANS, INSECTS AND VERTEBRATES

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STUTINSKY[1,2] and B. Scharrer[3,4] have recently proved that the chrome–hæmatoxylin–phloxin of Gomori selectively stains the neurosecretory pathways in several of the Pterygota in identically the same way as it stains the neurosecretory tractus supraoptico-hypophyseus in vertebrates (Bargmann[5], Hanström[6]). Thus, to the formerly known detailed similarities between the corpus cardiacum – allatum system in insects and the hypophysis in vertebrates—similarities which were originally pointed out by me in 1941 [7]—the fact has been added that the neurosecretory tracts, which in insects connect the pars intercerebralis of the brain with the corpus cardiacum and in vertebrates the nucleus supraopticus (and the nucleus paraventricularis) of the diencephalon with the neurohypophysis, both react positively and selectively with the Gomori stain. I think it worth while also to consider whether the neurosecretory substance in insects—as seems to be the case in vertebrates (Bargmann and E. Scharrer[8])—is connected with the production of a hormone regulating water-balance.

In 1940 [9] I described in some of the Apterygota two groups of cells on the surface of the protocerebrum which lie within a separate connective tissue sheath, only connected with the brain through a small aperture in their capsule. On account of their position, these groups of cells ought to be the homologue of the lateral frontal organs in crustaceans and the X-organs of these arthropods, which in 1934 were described by me as neurosecretory structures and which are transformed frontal organs. In the Apterygota these groups of cells give rise to a pair of nerves which take a characteristic course through the brain and can be traced outside it into the corpora cardiaca. In addition, I found that the cells in *Petrobius maritimus* contained secretory droplets which could be traced for a considerable distance along the axons. In higher insects these groups of cells ("the medial neurosecretory cells"), which give rise to the same nerve, are situated within the ordinary brain capsule, but otherwise show the same relations. Thus the lateral frontal organs, which in several lower crustaceans are located in the hypodermis and completely independent of the brain (though connected to it by a nerve), in other crustaceans are transformed into the X-organs, which adhere to the brain, and in the Apterygota into the groups of neurosecretory cells on the surface of the protocerebrum. In the Pterygota, finally, they have been thoroughly retraced into the brain as the medial neurosecretory cells of the pars intercerebralis, which cells, according to E. Thomsen[10] (cf. M. Thomsen[11]), must be regarded as the over-all controlling centre of the endocrine system in insects.

For comparative neurological reasons, I first assumed that a synapse may be present in the nervous pathway between the groups of neurosecretory cells and the corpora cardiaca in the Apterygota, though I did not try to verify this assumption by using special nerve-staining methods. Owing to the considerable physiological importance of the medial neurosecretory cells, which has been proved by a number of recent investigators for the Pterygota, I have now applied the chrome–hæmatoxylin–phloxin method of Gomori to several series of sections through the head of *Lepisma saccharina* and one series of *Petrobius maritimus* with the following result, which mainly deals with the former species.

Within the whole brain, nothing but the medial neurosecretory cell groups, their axons, and their endings within the corpora cardiaca have stained deep blue or blue-black with the hæmatoxylin. The plasm of the cells themselves contains conspicuous small droplets or irregularly formed larger colloid masses of the secretory product, and small droplets are also found along the greater part of the axons. The axons are very delicate, and since the number of neurosecretory cells is very small, the axons cannot be clearly observed without an oil-immersion lens. With the aid of an oil-immersion objective, however, the thin bundle of axons could be seen standing out very sharply, stained blue-black against the phloxin-red of ordinary nervous tissue from the entry of the nerves at the surface of the brain all the way into the corpora cardiaca. Thus, there were no signs of any synapse in the neurosecretory pathway, either in *Lepisma* or in *Petrobius*; further, no such structure has been mentioned in the Pterygota by Stutinsky[2] or by B. Scharrer[3]. At the entrance of the secretory fibres into the corpora cardiaca of *Lepisma*, they become thicker and are equipped with smaller or larger—often relatively considerable—enlargements, which stain as blue-black as the axons and droplets within the cell bodies. The special cells of the corpora cardiaca, on the contrary, do not show any hæmatoxylin reaction at all. This seems to be another parallel to the relations in the hypophysis, in which only the neurosecretory nerve endings from the hypothalamus in the neural lobe and no other colloid in this or the glandular lobe is truly Gomori-positive (Hanström[6]).

In this connexion it is interesting to note that Passano[12] and Bliss[13] seem to have detected at last a function for the X-organ in crustaceans. According to these authors, it is actually the cells of the X-organ which secrete the moult-inhibiting hormone and transport it through their axons into the sinus gland, described by me in 1931, in which structure it is accumulated, and then released into circulation in the adjoining blood sinus. As regards the nature of the secretory mechanism, the X-organ plus the sinus gland can thus be compared with the hypothalamo–hypophyseal system in vertebrates, and the pars intercerebralis–corpus cardiacum system in insects. This latter interpretation further supports the parallels between the X-organ and the medial neurosecretory cells. In addition to the common origin from the lateral frontal organs, there is a similar neurosecretory function: the secretory product is not directly released into the circulation but is transported to a place of storage, the sinus gland in crustaceans and the corpus cardiacum in insects.

It should, however, be pointed out that the parallel between the X-organ – sinus gland system in crustaceans, the pars intercerebralis – corpus cardiacum – allatum system in insects and the complete hypothalamo – hypophyseal system in vertebrates is less perfect than the mutual comparison between the latter two systems, as shown by me and by the Scharrers in earlier papers. Thus, in crustaceans, only the first two links of the chain are present, the X-organ and the sinus gland (comparable, respectively, to the medial neurosecretory cells and the corpus cardiacum in insects, and the neurosecretory nuclei of the hypothalamus and the neural lobe of the hypophysis in vertebrates), while the third link is missing, being represented by the corpus allatum and the glandular lobe (adenohypophysis), respectively, in the other two animal groups. Exceedingly interesting and suggesting a similar structure is the light blue colour which distinguishes not only the neurosecretory cells of the pars intercerebralis of the insect brain, the cells of the X-organ (and the sinus gland) in crustaceans, and, at least in some instances, the neurosecretory cells of the hypothalamus in vertebrates.

Though the medial neurosecretory cells in the Apterygota are placed on the surface of, not within, the brain, they show the same specific staining reaction and the same relations to the corpora cardiaca as in the Pterygota. In accordance with B. Scharrer[3], I conclude that the neurosecretory substance is produced by these groups of cells and transported along their axons into the corpora cardiaca, from which it can easily be released into the circulation because these glands adhere to the aorta.

It may finally be added that an investigation of the function of the endocrine system of the head of apterygotous insects, such as *Lepisma* and *Petrobius*, might yield interesting results. The position of the medial neurosecretory cells outside the brain should facilitate extirpation and transplantation experiments, and the particularly simple structure of the incretory system (in which the corpora allata are missing; Hanström[9], Cazal[14]) and the simpler development of these primitive insects, examined in relation to hormonal factors, may be able to throw new light on the regulation of the more complicated development of their higher relatives.

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[1] Stutinsky, F., *Bull. Soc. Zool. France*, **76**, 307 (1951).
[2] Stutinsky, F., *Bull. Soc. Zool. France*, **77**, 61 (1952).
[3] Scharrer, B., *Anat. Rec.*, **111**, 554 (1951).
[4] Scharrer, B., *Anat. Rec.*, **112**, 386 (1952).
[5] Bargmann, W., *Z. Zellforsch.*, **34**, 610 (1949).
[6] Hanström, B., *K. Fysiogr. Sällsk. Förhandl.*, **22**, No. 6, 1 (1952).
[7] Hanström, B., *K. Fysiogr. Sällsk. Handl.*, **52**, No. 4, 1 (1941).
[8] Bargmann, W., and Scharrer, E., *American Scientist*, **39**, 255 (1951).
[9] Hanström, B., *K. Svenska Vetenskapsakad. Handl.*, (3), **18**, No. 8, 1 (1940).
[10] Thomsen, E., *J. Exp. Biol.*, **29**, 137 (1952).
[11] Thomsen, M., *Dan. Biol. Skr.*, **6**, No. 5, 1 (1951).
[12] Passano, L., *Anat. Rec.*, **111**, 502, 559 (1951).
[13] Bliss, D., *Anat. Rec.*, **111**, 502 (1951).
[14] Cazal, P., *Bull. Biol. France et Belgique*, Supp. 32, 1 (1948).

THE LIGAMENT IN THE LAMELLIBRANCHIA

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THE ligament in the Lamellibranchia should be considered in relation to the different layers of the shell, of which it is an integral part, and so in terms of the areas responsible for the secretion of these layers. As is well known, the shell consists of a superficial periostracum and underlying outer and inner calcareous layers. These three layers have different origins. The periostracum is secreted as a thin sheet within a groove between the outer and middle lobes of the mantle edge, while the outer calcareous layers are produced by the outer lobe of the mantle margin and the inner calcareous layers by the general surface of the mantle. Thus growth of the periostracum and of the outer calcareous layers is by increment from the periphery of the mantle, while the inner calcareous layers normally continue to increase in thickness throughout life.

The Lamellibranchia were probably derived from ancestors having a simple dome-like shell with a single centre of calcification[1]. In the course of evolution the mantle became greatly extended and laterally compressed. This must have been accompanied by the partial division of the mantle into lateral lobes each possessing a centre of calcification. These two pallial lobes remained connected mid-dorsally by a neck of tissue, the shell in this area being left largely uncalcified[2] and constituting the ligament. Thus the shell in the Lamellibranchia consists of two valves with a dorsal connecting ligament.

It is proposed to describe the connecting neck of tissue between the two lobes of the mantle mid-dorsally as the 'mantle isthmus'. This represents the original mid-dorsal surface of the mantle. This region has frequently been described as the pallial