ESTERASOPENIC AND ESTERASOPLENIC PERIPHERAL NERVE TERMINATIONS

DALE[1] simplified our thinking on function in the peripheral nervous system when he classified the peripheral nerve fibers in two groups, cholinergic and adrenergic. He pointed out that all the nerve fibers leaving the central nervous system are cholinergic, as are also the parasympathetic postganglionics and a few of the sympathetic postganglionics. Most of the sympathetic postganglionics, however, are adrenergic. Dale[2] had pointed out earlier that acetylcholine has two types of actions, the so-called "muscarinic" and "nicotinic" actions in which it mimics the corresponding drugs. In its "muscarinic" action, acetylcholine reproduces the peripheral effects of parasympathetic nerve stimulation, effects produced with low concentrations of acetylcholine and readily abolished by atropine. When the "muscarinic" effects have been abolished by atropine, then the "nicotinic" action becomes apparent as an intense stimulation of all autonomic ganglion cells. Skeletal muscle shows the "nicotinic" effects of acetylcholine even in those rare instances in which it receives a parasympathetic postganglionic innervation. Larger doses of acetylcholine are required to evoke the "nicotinic" effects and these effects appeared to be unaffected by atropine.

It is possible that the differences in acetylcholine concentrations required to elicit the "muscarinic" and "nicotinic" effects may be due in part to differences in cholinesterase concentrations at the respective terminations. High cholinesterase concentrations have been demonstrated by eserine potentiation of acetylcholine at autonomic preganglionic and voluntary motor termination where the "nicotinic" effects of acetylcholine are seen and where atropine is relatively ineffective. Eserine potentiations of the "muscarinic" effects of acetylcholine also have been frequently reported, but in these experiments no attempt was made to differentiate between potentiation due to cholinesterase generally distributed through the tissues and that specifically concentrated at the nerve terminations. This factor was controlled in experiments on the sphincter pupillae of small salamanders[3] and turtles.[4] The eyes were excised and all possible extraneous tissues removed, leaving the iris diaphragm, a supporting rim of sclera and the ciliary body. There was very little tissue covering the sphincter muscle in the thin free margin of the irises of these small eyes. The sphincters of both eyes receive a parasympathetic postganglionic innervation.

The sphincter pupillae of the turtle, which is striated muscle, has an acetylcholine threshold of one in one million which is potentiated a hundredfold by eserine, indicating relatively high concentrations of cholinesterase at its nerve terminations. Relatively high concentrations of atropine are required to reduce the pupillary constriction to acetylcholine. These findings are characteristic of the "nicotinic" action of acetylcholine. The sphincter pupillae of the salamander, which is composed of smooth muscle, has an acetylcholine threshold of about one part in one billion. Eserine does not potentiate the pupillary constriction resulting from the application of acetylcholine, so there is no demonstrable cholinesterase at its nerve terminations. Atropine in relatively low concentrations reduces or completely abolishes acetylcholine constriction. The threshold to acetylcholine and the great effectiveness of atropine are characteristic of the "muscarinic" action of acetylcholine.

It is suggested that there are two types of peripheral cholinergic nerve fibers, those at whose terminations there are relatively high concentrations of cholinesterase and those at which cholinesterase is lacking or present in only non-demonstrable concentrations. These might be termed respectively esterasoplenic and esterasopenic terminations. The generality of this classification can be definitely established only by additional work on other cholinergic postganglionic terminations. One should not overlook the possibility that there may be in some organs, which show both acetylcholine effects, both types of cholinergic terminations.

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[1] H. H. Dale, *Jour. Physiol.*, 80: 10–11, 1933.

[2] *Idem, Jour. Pharmacol. and Exp. Therap.*, 6: 147–190, 1914.

[3] P. B. Armstrong, *Jour. Cell. and Comp. Physiol.*, 20: 47–53, 1942.

[4] *Idem, Jour. Cell. and Comp. Physiol.*, 22: 1–19, 1943.

ON DIRECT VISION CHARACTERISTICS OF SPOTS PRODUCING TERRESTRIAL MAGNETIC PHENOMENA

IT is well known that the transit of a large group of sunspots may be followed by aurorae and disturbances in the earth's magnetic field; but this is not invariably the rule. Occasionally smaller groups may cause more violent disturbances than larger ones, and sometimes no effect whatever is noticed. Therefore not all spots will produce terrestrial electromagnetic effects; but, unless one knows what to look for, direct visual examination will reveal no essential difference between those spots which do and those which do not. However, the writer has worked out a method which appears to be very satisfactory.

In 1850 Lamont at Munich, with insufficient data, discovered that the mean variation of the diurnal magnetic oscillation showed a period of close to 10.33 years. This was followed in 1851 by Schwabe's announcement that the sunspots are periodic.

Based on 25 years of observations, Schwabe calculated a mean period, from maximum to maximum, of about 10 years; which was not far from the presently received value of 11.11 years. Wolf, Sabine and Gautier immediately recognized the coincidence of Schwabe's spot cycle with the magnetic cycle of Lamont. Subsequent work confirmed a general correspondence; and Loomis showed that there was a direct relation between the incidence of aurorae and the incidence of sunspots.

It was believed at first that the spots alone were in some manner responsible for terrestrial magnetic effects; but in 1859 Carrington and Hodgson, observing simultaneously and independently, saw two brilliant floccular masses suddenly appear at the edge of an umbra over which they passed before vanishing. The fact that these cloud-like forms passed over the umbra, without altering it sensibly in any way, showed them to be at a considerable elevation above it and probably in the chromosphere. This classical appearance was followed the same night by an extraordinarily brilliant aurora and an intense magnetic storm.

In 1872 Young, observing the chromosphere spectroscopically, noted a jet eruption which was followed by an almost instantaneous and violent oscillation of the needle; which caused him to believe that the disturbing emanation was propagated with the speed of light. This, however, was an exceptional case. Normally the magnetic manifestations occur about 26 hours after transit (Abetti), although there are great variations on either side of the mean.

Now it is generally believed that electrons, ionized atoms and "corpuscles," derived from the sun, all contribute to the production of terrestrial aurorae and magnetic disturbances. Since the velocity of escape for the sun is 383 miles per second, something other than the eruptive currents in spots is suggested as the probable source of the currents reaching the earth; and velocities approaching the critical velocity for the sun are more apt to be found in the prominences.

Pettit showed that the maximum mean velocity of a group of prominences studied by him was 94.86 miles per second, with several showing a velocity as high as 248 miles per second. Moreover, the velocity of a prominence is not entirely the result of a simple eruptive force. Bobrovnikoff demonstrated that the repulsive force acting on prominences *increased* with the mean distance of the prominence above the photosphere. Radiation pressure was therefore brought into the picture, and Milne showed that the limiting velocity of escape for an atom held in suspension in the chromosphere is 992 miles per second (1,600 km/sec). At such a speed atoms would be capable of penetrating the earth's atmosphere to a sufficient depth to account for auroral manifestations.

It is therefore to eruptions, rather than to the spots per se, that one should look for the source of the ionized atoms, electrons, etc., which disturb the earth's magnetic field and produce aurorae. This seems to have been suggested first by Tacchini, and was later confirmed by Hale, followed by others.

This being so, a means is at once afforded the telescopic observer for determining by direct vision which of any spots will be likely to produce disturbances. In a recent paper[1] the writer called attention to the possibility of studying the distribution and movements of flocculi, in the immediate neighborhood of a spot group, by direct vision observations of the apparent alterations in the penumbrae of the spots. Now frequent and rapid movements of flocculi over the penumbrae, manifested by great apparent changes in the latter, give evidence of profound eruptive disturbances in the chromosphere. Thus a spot group which may not be attended by other visible features, such as faculae, will nevertheless betray associated chromospheric activity. Such notably was the great group of February 25–March 1, 1942, which was followed by a violent magnetic storm about 12 h after transit.

But flocculi are frequently associated with and in some cases may be only high level extensions of faculae. Hence faculae may also be used to indicate probable electromagnetic disturbances on the earth. Since faculae are considerably brighter because higher than the photosphere (shown by the fact that they are conspicuous near the limbs but are almost always invisible at the center of the disc), the radiation pressure from such areas is correspondingly greater and therefore apt to be the source of a current of electrons or ionized atoms. Moreover a region of intense facular disturbances is likely also to be associated with active prominences. In general, therefore, any group associated with extensive faculae is also likely to produce aurorae and magnetic effects.

This was well illustrated by the magnetic disturbances following the transit of the large group on December 13, 1944. This group was associated with an extensive area of faculae, bright enough to be visible when three days from the following limb. On December 19, when this group was approaching the preceding limb, the writer observed two brilliant, cloud-like masses following it which were inclined to one another by almost 90°. These objects resembled in shape strato-cumulus rolls and were floccular in nature; they were associated with ordinary faculae.

The writer finds from personal observations, extending back to 1926, that such direct vision phe-

[1] SCIENCE, March 3, 1944; p. 180.

nomena are reliable indications of probable magnetic disturbances to be expected before or after transit; although they do not provide a measure of the probable intensity. They are therefore easily observed phenomena accessible to students who may lack elaborate accessory equipment, and are especially suitable to demonstration in small schools or colleges where the astronomical equipment may be limited to direct vision instruments.

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ELECTRONICS AS A POSSIBLE AID IN THE STUDY OF BIRD FLIGHT AND MIGRATION

SINCE the veil of secrecy which so long surrounded electronics, and particularly the functioning of radar equipment, has been partially lifted, I am at liberty to tell of certain observations made by an ornithologist friend who is a naval officer on duty in the Pacific. He states that on numerous occasions the radar equipment in use on his vessel has detected the presence of good-sized birds, albatrosses, man-o'-war birds, etc., at distances as great as five or six thousand yards. When distances as shown by instrument were checked against ocular estimates of distances of approaching birds from the vessel it was found that the two figures were in close agreement.

In the light of these observations I wish to record that we have discussed, and expect to carry out, experimental work on the study of bird flight and bird migration by means of radar equipment, when such equipment is made available for private use. We have tentatively selected a West Virginia mountain-top as a site for the work. Here there is an absence of obstructions, coupled with a good movement of migrating birds, particularly raptors.

We plan to attempt the use of this equipment in determining the speed of flight of birds large enough to produce a signal on our equipment, the height of flying birds, and the detection, and speed and height of flight, of night migrants. In some cases (wild geese, for example) it may be possible to make reasonably accurate identifications of passing night migrants. It seems likely that electronics holds the key to much more detailed information regarding bird flight than any which we now have.

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A TERTIARY RIVER

WITHIN recent years, considerable work has been done by geologists, in tracing the course of a large pre-glacial stream, called by W. G. Tight, the Teays River. This stream had its source near the eastern escarpment of the Blue Ridge, at the edge of the Piedmont Plateau in North Carolina and Virginia. In addition to the waters of the New-Kanawha system, the Teays River received the major portion of the drainage from an area including one half to two thirds of Ohio, a large part of Indiana, Illinois and northern Kentucky. The Teays River, after passing through the abandoned valley of that name, extended from a point near St. Albans to Huntington, W. Va., passing across Ohio in a northwesterly direction; its valley, buried beneath the glacial drift, extends from Chillicothe, Ohio, to the border of Indiana; not far from the St. Marys Reservoir, in Ohio. From there its course is westward across northern Indiana, to the eastern border of Illinois, where it continues in a westerly direction across the state into the bedrock valley of Illinois River. From Chillicothe, Ohio, westward, the course of the buried Teays has been determined by the study of well records by Ver Steeg in Ohio, Fidlar in Indiana and Horberg in Illinois. These studies indicate that the Teays River had many large tributaries. All the indications point to the fact that this stream was in the mature stage and drained a maturely dissected region in the Appalachian area. Well records, in Ohio, indicate that this stream occupied a broad, deep valley, with rather steep sides, similar to the valley from St. Albans, W. Va., to Chillicothe, Ohio. Farther west, in Illinois, the buried Teays valley becomes shallower and broader; according to Leland Horberg, it has a width of five miles in central Piatt County, about fifteen miles in De Witt County, Illinois, and an average depth of about 200 feet. This great stream, rising in the Piedmont, flowing across the entire Appalachian area, through the steep-walled Kanawha Valley and across the states of Ohio, Indiana and Illinois, is estimated to have been at least 800 miles long, and to have rivaled some of the larger streams on the continent.

During the Pleistocene ice-age, it is believed that the Teays River in Ohio was dammed by the Kansan or pre-Kansan ice-sheet and great ponded stretches of slack-water flooded large areas of southeastern Ohio. Thick deposits of slack-water silts, now at elevations of 860 feet, were laid down. It may be that the large glacial erratics found on the hills in Kentucky, at altitudes as high as 1,000 feet, were rafted to their present position by icebergs which floated on the deep waters of the ponded expanse.

The Teays River valley is believed by E. A. Transeau, the botanist, to have been a highway along which the Tertiary flora migrated from the Piedmont and southern Appalachians into southeastern Ohio.

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