of the mutants at least, a fundamental change in the structure of the nuclei had taken place, and that the external changes of characters in mutation had their origin in internal structural changes of the cells and their nuclei.

The premutation hypothesis, formulated by de Vries to account for the origin of the mutations before the facts regarding their cell-structure were known, assumes that new units gradually accumulated in the germ plasm of the species previous to the beginning of the mutation process, and that these afterwards passed from a latent to an active condition, thus producing the mutations. But since the structure of the nuclei in these forms is now known, and the manner in which changes in that structure originate, this hypothesis has been superseded, and the conception of a mutation period is no longer needed.

Various writers have also suggested that the mutations of Œnothera were merely re-combinations of characters, such as occur in Mendelian hybrids. This hypothesis is also contrary to our present knowledge of the nuclear structure and behaviour in Œnothera, and furnishes another instance, like that of the sex-chromosomes, where nuclear studies throw light upon the nature of the processes of heredity and variation. By combining the study of nuclear and cell structure with that of external characters, it is evident that much further insight into the nature of mutation and heredity may be gained.

A specific case of the type of germinal change here referred to is that of *Œnothera lata*. It has recently been found that when combined with characters derived by inheritance from various other forms (*e.g. O. biennis, grandiflora and rubricalyx*), the characteristic foliage and habit of *lata* is always accompanied by the presence of an extra chromosome in the nuclei of the plant, making the number of chromosomes fifteen instead of fourteen. In other words, this type of foliage is constantly associated with the presence of an extra chromosome.

Mutations are by no means confined to the evening primroses, but are now known, through experimental studies, to occur in bacteria, fungi, mosses, and many flowering plants. And among animals, instances of sudden and inherited departure from the parent form occur in various groups from Protozoa to man himself.

The new characters thus appearing form a varied and motley array, differing often in most unexpected ways from their parent types. Many of these mutations appear "spontaneously," that is, from unknown causes. These are probably often an indirect result of previous crossing, change of climate, &c. Others have been directly produced by a variety of experimental conditions. The study of the causes of these germinal aberrations and the manner of their production is evidently destined to play an important rôle in future experimental evolution. The results already achieved point to a wide and important field of research in the application of these methods to horticulture, agriculture, and experimental breeding.

R. RUGGLES GATES.

OBSERVATIONS IN THE SOUTH MAGNETIC POLE AREA.

I BEG herewith to enclose what I trust will prove for the scientific world in general an important preliminary report by Mr. E. N. Webb, magnetician to Dr. Mawson's Australasian Antarctic Expedition, on the magnetic work, and particularly the absolute readings taken by Mr. Webb himself on a very fine journey made by him and Mr. J. F. Hurley, under the leadership of Lieut. Bage, in the direction of the south magnetic pole for the distance of 300 miles to the south-east of Dr. Mawson's base at Commonwealth Bay in Adélie Land.

You will see that a large number of very valuable observations have been obtained on the north-west side of the south magnetic pole area, and these, when considered with the observations—fewer in number but accurate—taken by Dr. Mawson himself on the occasion of the Shackleton expedition on our approach on the south-east to the south magnetic pole area, should now enable the position of the south magnetic pole in 1912 to be calculated with a degree of accuracy considerably in advance of anything previously attained.

I have ventured to add some notes in reference to the observations made by Dr. Mawson in the party—consisting of Dr. Mawson, Dr. A. T. McKay, and myself—of which I was leader in a journey to the south magnetic pole area in 1908–9. I send with it a plan on tracing cloth showing the route followed by the Australasian Antarctic Expedition, with the positions of the stations where Webb made his observations. T. W. EDGEWORTH DAVID.

University of Sydney, May 26.

MAWSON'S AUSTRALASIAN ANTARCTIC EXPEDITION.

Preliminary Report on Magnetic Work, by E. N. Webb, Magnetician.

Early in December of 1911 the Australasian Antarctic Expedition, under the leadership of Dr. Mawson, left Australia to carry out a programme of scientific investigation on the Antarctic continent.

It was intended to conduct a magnetic observatory at one base station, and to make a magnetic survey of the coast between Cape Adare and Gaussberg. A large portion of this plan was successfully carried out. Through the kindness of Dr. Bauer, director of the department of terrestrial magnetism of the Carnegie Institution of Washington, D.C., the writer was trained during five months' field survey work in Australia, under Mr. E. Kidson, one of the department's observers.

Absolute instruments were lent by the Carnegie Institution, consisting of two unifilar magnetometers, one Kew pattern and one Lloyd-Creak dip circle, by Dover, Charlton, Kent, both fitted with 6 in. declinometer needles, and total intensity attachments.

Intercomparisons of all instruments with a set used by Mr. Kidson were made at Hobart before going south; also, the Eschenhagen magnetographs, comprising declination, horizontal and vertical intensity variometers, were set up under the direction of Dr. J. M. Baldwin, first assistant at Melbourne Observatory. Both the observatory and the field work at the main base were in charge of the writer. Field survey work was commenced at Macquarie Island, where determinations of the magnetic elements were made at two stations, one at the extreme north of the island, and the other at Caroline Cove. The average of determinations at the north end gave declination 18° 25′ E.; horizontal intensity, 0·13990; dip, 77° 47·8′ S. Leaving Macquarie Island, the expedition proceeded to Adélie Land, and at Commonwealth Bay in latitude 67° 0·0′ S., longitude 142° 39′ E., landed the main party. Here two magnetic huts were erected. In the larger, which was carefully constructed to resist wind and change of temperature, the magnetographs were set up with the frames on solid rock, and put in working order on March 21, 1912. Temperature-compensating systems were fitted to the H. and Z. variometers, and temperature effects have been almost entirely eliminated. Deflections were made once a fortnight for scale values.

In order to record the large declination changes (as high as 12°), a scale value of 2·25′ per mm. had to be employed, while the force ranges required a scale value of 8 to 10 γ per mm. The largest change in force occurred during an auroral storm, when a reduction of more than 1000 γ took place in horizontal intensity.

During the time of occupation a complete and accurate log of aurora was compiled. Between March and October, numerous displays were observed, varying from a dull nebulous glow low in the north to splendid designs of arches, curtains, and streamers vividly coloured in green, red, and heliotrope, far surpassing anything seen by Dr. Mawson in McMurdo Sound in 1908. The exact times of prominent phases were noted. A cursory comparison with the magnetograph records showed a remarkable coincidence of magnetic and auroral storms. The nebulous type of aurora seemed to have little accompanying magnetic disturbance, but when moving and coloured luminous bands scintillated across the sky, the phases of the accompanying magnetic storm would almost invariably be found to correspond to variations in form or colouring of the aurora. Three splendid displays in the evenings of July 4, 5, and 6 perhaps constituted the most brilliant series. There seemed to be some indication of a recurrence of aurora at definite intervals.

As previously arranged in a scheme of international cooperation, twenty-four special terms of two hours each were "quick run" on the magnetograph. These unfortunately proved wanting in incident, the most disturbed being that of April 16, 1912, when a fairly large movement was recorded.

From the end of March, 1912, to February 8, 1913, the magnetograph record is almost unbroken.

In the smaller hut absolute determinations of declination, horizontal force, dip, and total force were made once a week. The average values at the station were:—Declination, 6° 30′ W.; horizontal force, 0·0311 C.G.S.; dip, 87° 21·5′ S.

Observations often had to be carried out in winds of eighty to ninety miles an hour, and in a pitchy darkness, since the night hours were the only approximately calm ones magnetically.

As a check on the absolute hut station, an ice station was occupied during the winter in a cavern dug out of the glacier, half a mile distant. The difference between the two stations was trifling in all the elements. In the early spring Mr. Hannam was instructed in the conduct of the observatory, and later carried on all work there during the magnetician's absence on sledging journeys.

In early September, 1912, three reconnaissance parties were sent out. One full magnetic station was occupied 11½ miles south of winter quarters.

On account of the persistently furious gales, no start could be made on the long summer sledge journeys until the second week in November. Three main parties then got away, while a fourth was to move off in early December. Of these, one was to make a long journey east, and was provided with a theodolite trough needle for determining magnetic declination; a second was to explore the more adjacent eastern coast-line, and besides a three-inch theodolite with compass needle, carried a dip circle with two dip needles; a third party was to make a journey south along either a geographical or a magnetic meridian towards the magnetic pole; while the fourth, carrying a sextant and an improvised declinometer, was to make as far west as possible. All parties were to return not later than January 15, 1913.

The eastern coastal party, under Mr. C. T. Madigan, secured magnetic results at eight stations fairly distributed over 270 miles. Declinations were obtained with the 2-in. compass needle attached to the theodolite, and dips were determined with either one or two needles.

The third party, consisting of Lieut. R. Bage, (leader), J. F. Hurley (photographer), and E. N. Webb (magnetician), left winter quarters, Commonwealth Bay, on November 10, 1912, and was assisted by a supporting party. A 3-in. Cary theodolite was taken for astronomical observations, and for magnetic observations the dip circle with declinometer and total intensity attachment and four dip needles. Strong head-winds and heavy drift were met with throughout the following week, and, with heavy loads, the travelling, over *sastrugi* country, was very slow. On November 21, 67½ miles S. by E. from winter quarters, the supporting party left.

Magnetic observations indicated considerable local disturbance, so to get the advantage of a direct dip gradient to the magnetic pole, the magnetic meridian was followed as nearly as possible. In the course of the outward journey seven full magnetic stations were occupied at intervals of thirty to fifty miles, while, in addition, rough determinations of declination and dip were made at almost every camp.

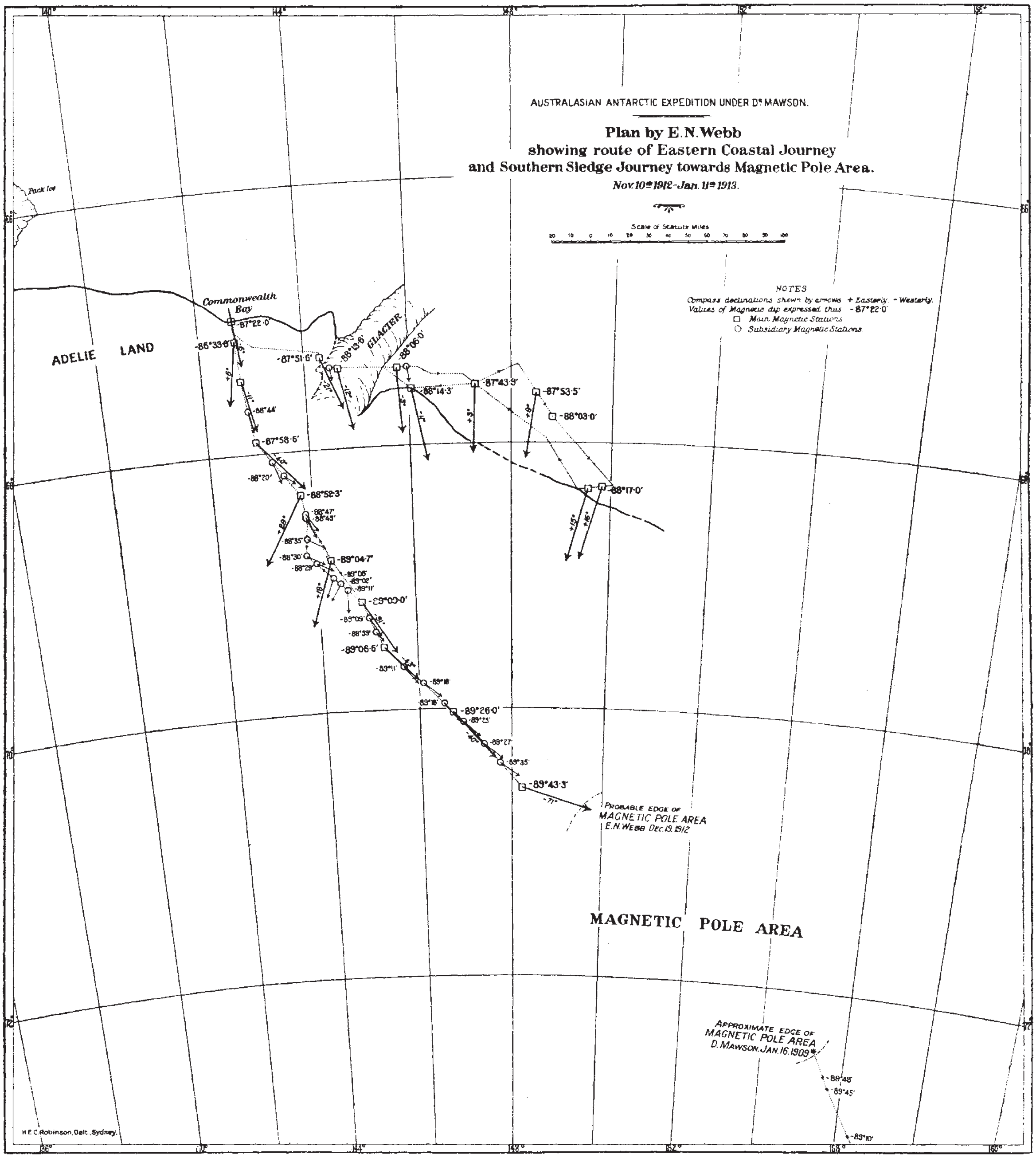
The observations at each full magnetic station comprised complete astronomical observations, observations of dip with four needles, double determinations with total force needles, and sixteen settings of the declinometer needle for declination. The declinometer trough needle proved an excellent instrument, even at the position of highest dip. Nearly all astronomical and magnetic observations were computed on the march as obtained.

For steering purposes on the journey a sun-dial or "shadow compass," computed for the sun's mean declination and equation of time, and the approximate mean latitude, was used. Granted clear weather, this is a very useful instrument. Steering south-east from the depôt, heavy head-winds were met with, the surface rising steadily and becoming rougher, with *sastrugi* increasing in size. At 100 miles and 174 miles out from winter quarters the party was held up by severe weather, but occupied itself with magnetic observations. Besides a full magnetic set at the 100 miles, a snow shaft 8 ft. deep was excavated, and a temperature gradient obtained, +9° F. at surface to −13° F. at 8 ft. At 174 miles a continuous observation of declination over twenty-five hours was made with the dip circle trough needle, the party living in a hole dug out of the snow.

On December 12 a depôt of food, oil, &c., was made at 200 miles. With the lighter sledge it was found that runs of from twelve to fifteen miles per day could be made. On December 21 the extreme station, 301 miles, was reached, at a height of 5900 ft. above sea-level, in latitude 70° 36′ S. and longitude 148° 12′ E. At most stations the magnetic meridian for dip observations was obtained by declinometer, but at this station dip was determined with four needles in two directions at right angles, and the meridian and true dip were thence computed; resulting dip, 89° 43·3′ S.; declination, 70° 49′ W.; total force, 0·6692 C.G.S. Between 200 and 300 miles out the surface was exceedingly rough, *sastrugi* 5 ft. high from trough to crest being met with.

Turning back on December 21, the first stages of the return journey were made more rapidly than had been expected, as much of the fresh snow had hardened. A depôt which had been laid at 200 miles on the out journey was picked up on December 27, and a full set of magnetic observations taken. During the remaining 200 miles almost continuous overcast weather obtained, making it extremely difficult to pick up snow-mounds built at almost every camp on the way out. The 109-mile mound was picked up, but the only other one seen was the ninety-mile. On reaching the locality of the sixty-seven-mile depôt, there were only two and a half days' rations on hand, and the ration was immediately reduced. Short marches were made in various directions, but the towards the supposed position of the depôt, but without success. Under these conditions, with but one day's ration in hand, it was decided to depôt all gear not essential to safety, and make a dash for the coast. The dip circle had to be left behind, but the needles were brought on.

The next two days continued heavily overcast, while



depôt could not have been seen 100 yards away, as light snow fell almost continuously. On the evening of the second day a fair latitude and longitude were obtained from altitudes of the sun. The party moved on to the computed position of the depôt, but could see nothing. Next day, after a long wait, a noon latitude was obtained, and a movement was made a strong blizzard wind with thick drift was experienced. The third day was much brighter, and, with infinite relief, the party reached the depôt five miles from winter quarters just after midnight.

During the whole journey complete meteorological observations were made every two hours, and minimum temperatures were obtained at night. Altitudes were obtained by aneroids, standardised by a hypsometer.

The only life seen consisted of two snow petrels at eighty miles, and a skua gull at 125 miles, while no sign of rock was seen.

Longitude observations at three stations on the outward march were repeated on the return, so that the chronometer rate over three sections could be determined, giving good final longitudes.

Between 100 and 200 miles strong magnetic disturbance was evident. Declination chopped round by 90° in as short a distance as ten miles, while reversion of dip gradient was very commonly experienced. From 200 to 300 miles the declination was much more constant, and a steady dip gradient was observed. Continuing this last fair gradient, the 300-mile station was probably about forty miles from a position of maximum dip.

At the extreme western base 200 miles east of Gaussberg, and 1100 odd miles distant from the main base, magnetic conditions were better, but weather conditions were harassing. No magnetographs were provided, but periodic absolute observations were to be taken by the magnetic observer, Mr. A. L. Kennedy. Observations with magnetometer and dip circle were taken when possible. The station was situated on a floating glacier or barrier, and during the year determinations of the azimuth of the mark showed a progressive movement. During the sledge journeys—as far as Gaussberg in the west, and for 150 miles to the east—declinations were obtained at intervals with a prismatic compass, or with a declinometer attachment to a Lloyd-Creak dip circle. Two sets of dip were obtained on the eastern journey.

Term days were kept at the western base when possible by continuous eye readings of declination, while auroræ were observed and several observations of declination taken during active auroral disturbance. The accompanying plan shows most of the declinations and dips obtained. The possibilities of highly disturbed areas are illustrated by the anomalous declinations and dips about 100 to 174 miles. At 132 miles heavy crevasses were found, which seemed to indicate some unconformity beneath the ice-sheet.

Notes by Prof. Edgeworth David.

I have only just received by wireless some of the actual dips obtained by Dr. Mawson with a Lloyd-Creak dip circle other than those already published in Shackleton's work, "The Heart of the Antarctic."

First, at the Nordenskjöld ice-barrier, lat. 76° 14′ S., long. 163° 9′ E., the dip was found to be 88·1° S.; at the Drygalski Ice Barrier Tongue, in lat. 75° 28′ S., long. 163° 15′ E., the dip was 87·5°. On the Reeves Glacier, in lat. 74° 48′ S., long. 161° 30′ E., it was 87·9°. All these three sets of observations were very carefully taken. Again at lat. 73° S., long. 156° 10′ E., a careful set of observations showed the dip to be 89° 10′. The next observation, which may not be looked upon as quite so accurate as the others, gave the dip as 89° 45′, in lat. 72° 42′ S., long. 155° 40′ E., and the last observations, also of approximate accuracy only, indicated a dip of 89° 48′, at a spot thirteen miles to S. 30° E. of our furthest point to N.W., the latter being in lat. 72° 25′ S., long. 155° 16′ E.

When we reached the spot where we recorded a dip of 89° 45′, on January 15, 1909, Mawson concluded that as the rate of change of dip had considerably increased in the last twenty-five miles we were close to the edge of the area of the vertical needle. The evening of the same day, when seven miles nearer the south magnetic pole area, Mawson's measurements gave the dip as 89° 48′. On striking a curve, he estimated that the actual edge of the region of verticity was only about thirteen miles distant from where our dip of 89° 48′ was recorded. We had already travelled twenty-seven miles beyond the spot where the results of the *Discovery* observations had placed the south magnetic pole during 1902–3. Accordingly we determined to march on thirteen miles and put up the flag there, as being the edge of the area of the vertical needle. Our proceedings have already been described in vol. ii., "The Heart of the Antarctic," pp. 180–2. During these last thirteen miles we took no observations with the dip circle, the tripod of which we utilised as a mark to guide us back on our return march.

Mawson estimated that the position of our furthest point to the north-west was in lat. 72° 25′ S., long. 155° 16′ E. A short distance on our return from the spot considered to be the edge of the area of vertical needle, Mawson experimented with the horizontal needles of an ordinary prismatic compass and a Brunton transit instrument. While he considered both needles worked "dead"—that is to say if the compass boxes were twisted the needles followed them around—it was found that on tapping the boxes and making the needles spin, the more sensitive of the two showed a slight tendency for its south-seeking end to come to rest within the western hemisphere of the compass. Mawson felt satisfied at the time that even if we might not have been within the area of vertical needle, at the particular moment—about 3.30 p.m., on January 16, 1909—when the end of our journey was reached, we were still well within the region of the diurnal swing of that area. In view, however, of the recent remarkable observations by Mr. E. N. Webb, it seems doubtful whether there may not have been some local disturbing influences affecting Mawson's observations on the Shackleton expedition, such as Webb's map shows affected the magnetic observations of Mawson's present Antarctic expedition. Reference to the map will show that at several spots along their route declination varies to the amount of from 40° up to 69° within a distance of only a few miles, and the dip, in some places, lessened considerably, instead of increasing, as the magnetic polar area was approached. This suggests that it is possible that at our furthest point north-west we may have been on the edge of either a local pole, an "outlier" of the main south magnetic polar area, or on a local lobe of the magnetic pole area, or may even have been just outside an area of absolute verticity altogether. By how much, if at all, we may have been outside, can, of course, only be determined when all the magnetic results are reduced, and compared.

MEROË: FOUR YEARS' EXCAVATIONS OF THE ANCIENT ETHIOPIAN CAPITAL.[1]

ON behalf of the University of Liverpool, and aided by the support of private benefactors, the lecturer has been at work for four years in scientifically uncovering the ruins of the once-famous Ethiopian capital. When his first expedition arrived upon the scene, there was little to suggest the great extent and interest of the city which has now come to light; in fact, only one wall and a few objects of sculpture were visible above the soil. Now, however, a number of temples, palaces, and public buildings have been laid bare; the walls of the royal city have been traced; and during the past season's work, from which the lecturer has just returned, a considerable portion of this enclosure has been excavated so that a visitor may enter by the city gate and walk along the ancient

[1] Summary of a discourse delivered at the Royal Institution on Friday, April 25, by Prof. John Garstang.