terminations will contribute to our better knowledge of the periodic variables by furnishing the largest number of maxima or minima of the largest number of stars, having especial regard to stars whose characteristics are at present not very well known." The award of four hundred dollars will be given for the "most thorough discussion of the rotation of the earth, with reference to the recently discovered variations of latitude." The manuscript (which will be returned to the author) is to be transmitted to some one of the judges not later than March 31, 1895.

For the award of these prizes the judges are Messrs. Asaph Hall, Seth C. Chandler, and Lewis Boss.

GEOGRAPHICAL NOTES.

THE Liverpool Geographical Society has issued its first annual report, which, although not showing a very cordial reception of the new society by the public, is not without some promise of future growth. The Earl of Derby is President, there are twenty-two Vice-Presidents, a substantial Council, and a staff of honorary officials. Staff-Commander E. C. Dubois Phillips has been appointed Secretary. The second year of the society was inaugurated by a lecture on the Discovery of the Alps, by Mr. D. W. Freshfield, President of the Alpine Club, and one of the Secretaries of the Royal Geographical Society. Other lectures have been arranged for, and it is to be hoped that the membership of the society will rapidly increase.

THE tenth German Geographentag is announced to meet in Stuttgart on April 5, 6, and 7. The programme includes (1) The special geography of Würtemberg and the researches on the lake of Constance; (2) Recent geographical investigations with special reference to desert phenomena; (3) Cartography; (4) Economic or applied geography; and (5) School geography. An exhibition will be held at the same time, mainly of objects illustrative of the geography of Würtemberg.

PROF. PENCK has a long paper in the March number of the *Geographical Journal*, describing in detail his scheme for a map of the world on the scale of 1 : 1,000,000. The importance of having maps of every country on one scale has long been recognised by working geographers; but, with the exception of the little atlas on gnomonic projection by the late R. A. Proctor, we do not know of any effort having been made to place such maps before the public. The minute scale of the work referred to reduced its value to a minimum. Prof. Penck's scheme is one of great magnitude. He would allocate the production of the map to the Governments or public bodies of each country. On this principle, 769 sheets would be required to represent the land-surface of the globe, each sheet containing 5° square between the equator and 60°, and between 60° and the poles 5° of latitude and 10° degrees of longitude. The British Empire would be responsible for 222 sheets, Russia for 192, United States for 65, France 55, Scandinavia 54, China 45. Five countries would have from 20 to 30 sheets each, six more would have over 10, and ten countries would require a smaller number, Belgium, Switzerland, and Greece having only one each. One advantage of the proposed scale is that it corresponds within the limits of the shrinkage of paper with the 16 miles to an inch Survey of India maps (1 : 1013760) and with the 25 versts to an inch Russian maps (1 : 1050000).

MONGOLIA AND CENTRAL TIBET.

AT the meeting of the Royal Geographical Society on Monday Mr. W. Woodville Rockhill gave an interesting account of a journey in Mongolia and Central Tibet. Leaving Peking on December 1, 1891, Mr. Rockhill travelled to the frontier town of Kalgan, then, entering Mongolia, he passed through the pasture-lands of the Ch'ahar Mongols. After a few days spent at Kuei-hua Ch'eng, the traveller continued westward, and crossing the Yellow River on the ice at Ho-k'ou, he crossed the Ordos Mongols country, and afterwards Alashan. Again entering China proper the route led through Ning-hsia, Lanchou, and Hsi-ning, the westernmost town in China, on the high road to Tibet. On March 14 Mr. Rockhill left for Tibet by an unexplored route, passing south of the Koko nor and along the foot of the mountains to the south side of the Ts'aidam, making several excursions on the way, one of special importance from the Mongol village of Shang to Tosu Nor to determine by astronomical observations the position of this sheet of water discovered by him in 1889. Mr. Rockhill's party consisted originally of five Chinese, but one had to be invalided home a few days after leaving Kumbum, and two others deserted him at Shang. He was able to hire at this place an old Chinese trader, and with these three men, assisted for a while by a Mongol and then by a Tibetan guide, he travelled till he reached China again in October, 1892. On May 27 the final start for Tibet was made from the Naichi gol in western Ts'aidam, and a general south-westerly direction was followed until July 7, when a point some 30 miles from the north-west corner of the great central Tibetan lake, called Tengri nor by the Mongols, was reached. Between the Naichi gol and the Ts'aidam the party had to endure great hardships, the great altitude ranging from 14,000 to 17,000 feet above sea-level, terrible daily snow and hail-storms, fierce winds and frequent absence of fuel, and towards the end starvation. The route, moreover, led them through vast salt marshes, bogs, and across numerous rivers, in which quicksands were frequently found. The geographical results of this portion of the journey were important. (1) The determination of the limits of the basin of the Murus (the great Yang-Tzŭ Kiang of China) and the discovery of the sources of the main branch of this river in the snow-covered flanks of the great central Tibetan range of mountains known as the Dangla. (2) The discovery of the eastern limit of the lake-covered Central Asian plateau which becomes some 600 miles west of the route Mr. Rockhill followed the Pamir, but is in the section he crossed of it called Naktsang, and sometimes, though apparently erroneously, Chang T'ang or "Northern Steppe."

Game was scarce in the great part of this region, and so wild that it could not be approached.

On July 2 the last provisions were eaten, and from that date to the 7th the party subsisted solely on tea. On the latter day a small encampment of Tibetans was reached, and a little food purchased. The next day a valley was entered dotted over with tents; it was the pasture lands of the Namru Tibetans and Lh'asa governed territory. The headman refused to give the party food unless Mr. Rockhill agreed to await the arrival of the head chief, who would decide as to whether he should be allowed to proceed southward, or be sent back to the north.

After six days' discussion with the chief and several officials from Lh'asa a compromise was effected; and Mr. Rockhill, with an escort of ten Tibetan soldiers, started eastward to reach the frontier post of Nagchuká, on the highroad to Lh'asa from the Koko nor.

On July 27 Mr. Rockhill crossed the Dangch'u and found himself on the territory of Jyadé, or "The Chinese Province," which is governed by native chiefs appointed by the Chinese Minister, resident at Lh'asa (or Lh'asa Amban). This important province was separated from Lh'asa by the Chinese in the seventeenth century, in view of the enmity existing between its people, who profess the Bonbo religion, a form of the devil worship or shamanism, though now mixed up with lamaism to such an extent, that it is hardly distinguishable from it, and the followers of the yellow and red sects of Buddhism living on Lh'asa soil.

Passing to the south of the city of Ch'amdo, to which town Mr. Rockhill, like his predecessor, Captain Bower, was refused admittance, the high road to China was reached at Pungdé (two stages south of Ch'amdo), and from this point to China a Chinese escort was given the traveller, and he was able to enjoy (!) all the luxuries of Chinese travel. Stopping at Draya, at Gartok, Bat'ang and Lit'ang, Ta-chien-lu, in Ssŭ-ch'uan, was reached on October 2. Here, on the eastern border of Tibet the journey was practically ended, for, though several thousand miles still separated Mr. Rockhill from the seaboard, they could be travelled in comfort and rapidity. Leaving Ta-chien-lu on October 5, he was in Shangai on the 29th, exactly eleven months from the time he had left it. "In that time I had travelled about 8000 miles, surveyed 3417, and during the geographically important part of the journey crossed sixty-nine passes, all of them rising over 14,000 feet above sea-level, and not a few reached 18,000. I had taken series of sextant observations at a hundred points along the road, determined one hundred and forty-six altitudes by the boiling point of water, taken three hundred photographs, and made important ethnological and botanical collections. For two months we had lived at an altitude of over 15,000 feet, soaked by the rains and blinded by the snow and hail, with little or nothing to eat, and nothing to drink but tea, and yet not one of us had a moment's illness from the day we left till we reached our homes again."

GASES IN LIVING PLANTS.[1]

PLANTS are permeated by the same gases that make up the atmosphere surrounding them: oxygen, carbon dioxide and nitrogen. Nitrogen in the form of a gas is neither used nor generated by any part of plants, unless we except the tubercles of certain roots, and so it occurs in about the same percentage inside the plant as outside of it. On the other hand, both oxygen and carbon dioxide enter into combination with, and are liberated from, the plant tissues in varying amounts at different times. The percentage of these two gases in the cavities of the plant vary through a considerable range. In a series of determinations made by Lawes, Gilbert, and Pugh, in England, the oxygen ranged from 3 to 10 per cent., and the carbon dioxide from 14 to 21 per cent. in plants which had been for some time in the dark, while plants which had been standing in sunlight reversed these figures, and gave 24 to 27 per cent. of oxygen and 3 to 6 per cent. of carbon dioxide. The two gases, therefore, bear a somewhat reciprocal relation, their sum usually being about 25 to 30 per cent. of the total gas in the plant.

The variations in the relative amount of oxygen and carbon dioxide are due to two independent processes incident to the life of plants. One of these processes is assimilation, by which all green cells of plants in the presence of sunlight, or its equivalent, such as a strong electric light, absorb carbon dioxide and liberate oxygen. This process goes on with great rapidity in healthy cells, but is entirely checked upon the withdrawal of light, or when it reaches a certain low intensity. Of course it never takes place in roots, flowers, the central portion of large stems, or other parts which are not green, nor in any fungi or other plants not possessed of green colouring matter.

The other great cause of disturbance in the relation of oxygen and carbon dioxide in the plant is the process of respiration.

Respiration in plants is essentially the same as in animals, and consists in a fixation of oxygen and the liberation of carbon dioxide. It takes place in every living cell, whatever the kind of plant, whatever the part of the plant, and whatever the conditions of active existence. The rate of respiration varies with the temperature, the age of the cell, and the nature of the chemical transformations. In normal respiration the amount of oxygen absorbed is approximately the same as the amount of carbon dioxide evolved. There are, however, certain modified forms of respiration in which this does not hold true.

If living plants be placed in a vacuum, or in an atmosphere deprived of oxygen, it is found that they can still carry on life processes for some time, accompanied with an evolution of carbon dioxide. The oxygen necessary for this process is obtained from the breaking up of compounds in the cells, and it is therefore called intramolecular breathing.

The germination of seeds, which contain a large amount of oil, is somewhat the opposite of this last process. In order to convert the fat into a more directly serviceable food material for the plant, a large amount of oxygen enters into the new combination, for which there is no equivalent amount of gas liberated. It consequently comes about that oily seeds in germinating absorb a far larger amount of oxygen than they liberate of carbon dioxide. This is known as vincular breathing.

Another variation from normal respiration is known as insolar breathing, and which, with still some other modifications, I need not stop to explain. To this brief statement of plant respiration must be added that much yet remains to be discovered regarding the details of the processes.

Assimilation and respiration are the two great causes which disturb the relative volume of the two variable gases in plants.

We shall now turn to the movement of the same two gases, oxygen and carbon dioxide. There has never been a disposition as in the case of many other plant phenomena, to explain the movement of gases upon any other than purely physical principles. We have therefore to do simply with the question of the aids and hindrances to the establishment of an equilibrium between the gases inside and outside the plant, irrespective of whether the cells are alive or dead.

It has already been stated that the relative amounts of oxygen and carbon dioxide inside the plant are usually very different, and that within a few hours the relation of the two may be completely reversed. To this may be added that the pressure of the gases inside the plant is sometimes more, sometimes less than that of the atmosphere outside the plant, almost never the same. Hales observed in his early work that a mercury gauge connected with the inside of the trunk of a tree showed an internal pressure when the hot rays of the sun warmed the trunk. This was largely due, undoubtedly, to an expansion of the gases in the trunk, by the heat. Such an excess of pressure in water plants is very common, although due to other causes. It may readily be shown by breaking stems under water, when bubbles of gas will be liberated, as undoubtedly many have noticed in gathering water lilies, or other water plants.

On the other hand, the pressure of the gas inside the plant may be less than on the outside. This has long been recognised, but was best demonstrated by Von Höhnel in 1879, to whom it occurred to cut off stems under mercury. In doing so the mercury rose to a considerable height in the vessels of the stem, and as mercury is without capillarity, this can only be ascribed to the greater pressure of the outside air, or in other words, to a partial vacuum in the plant.

An observation was made by Hales, which we may use to illustrate how such a negative pressure, as it has been called, can be brought about. He cut off a branch, fastened an empty tube to the cut end, and plunged the other end of the tube into a liquid. He found that as evaporation of moisture from the leaves took place, the liquid was drawn up into the empty tube. This phenomenon can now be explained more satisfactorily than could be done at that early day. By evaporation the liquid water inside the plant escapes in the form of vapour, and the space it occupied is filled by the gases, thus rarifying them. This rarifaction may go on in uninjured plants until the internal pressure is greatly reduced. But in the experiment, the pressure is equalised by the rise of the liquid in the tube. A later modification of Hales' experiment is to use a forked branch, place the cut end in water to give a continuous supply of moisture for transpiration, and attach the empty tube to one of the side forks of the stem, cut away for that purpose.

It is self-evident that such condensation and rarifaction of the gases in the plant could not take place if the cell walls were readily permeable to gases. Thus it comes about that one of the most important topics in connection with the movement of gases in the plant, is the permeability of tissue walls of various kinds, and especially those constituting the surface covering of plants.

I shall not attempt to conduct you through the tangle of supposition and fact, errors in experiments, correct and incorrect conclusions, and the general confusion which has come from the labours of physicists, chemists and botanists for the last twenty-five years, during which the subject has received particular attention. The results of the later work have been to cast grave doubts upon the correctness, or at least the interpretation of some of the experiments most relied upon heretofore. Nevertheless many points still lie open for verification, and untouched parts of the subject await investigation.

In the earlier days it was found that the leaves and young stems of plants have their epidermis more or less well supplied with minute openings, called stomata, or breathing pores, which communicate with small air cavities inside, which in turn branch out among the cells into a network of minute passages rarifying throughout the plant. This intricate network of intercellular passages affords an air communication throughout the whole plant, and connects directly with the outside atmosphere through the stomata. Subsequent to the discovery of stomata, it was ascertained, that in stems more than one year old, the stomata are replaced by another kind of opening, known as lenticels, which in some form are doubtless to be found in the bark of shrubs and trees of whatever age.

Gases stream into and out of the plant through the stomata and simpler lenticels, according to the law governing the movement of gases through minute openings in thin plates. The rate of movement is accordingly proportional to the square roots of the density of the mixing gases. Such a movement of gases is known as effusion.

The movement by which gases pass from one part of the

[1] Reprinted from the *American Naturalist* for February.