two different routes: the eastern route, Hami to Sa-chou, and the western route, from Kurla to Lob-nor, and thence eastwards to Sa-chou, along the northern foot of the great border ridge, the Altyn-tagh. Two excursions made, for 150 miles, into the interior of the desert gave an insight into its physical features, flora and fauna. Moreover, before crossing the Gobi, the expedition explored in detail the remarkable Lukchun depression (in the south-east of Turfan), which was discovered by the brothers Grum-Grzimailo, and proved to be some 150 feet below the level of the ocean, although it is surrounded on all sides by high plateaus. Roborovsky established there a meteorological station, at which the barometer was observed for two consecutive years, and, accordingly, it may now be taken as certain that the surface of this depression is really from 150 to 300 feet below the sea-level.

Spending nearly one year in the Nan-shan highlands, the expedition has covered them with a whole network of surveys; so that when these surveys, as well as Obrucheff's researches are taken into account (as they are in a preliminary map appended to the *Izvestia* of the Russian Geographical Society), we see this region, almost entirely unknown three years ago, better explored now than many parts of Siberia. Where one ridge only was formerly drawn, we find on the new map a series of parallel ridges all running W.N.W. to E.S.E., intersected by high valleys, and attaining by their snow-clad peaks the heights of from 14,000 to 16,000 feet in the chains of Humboldt, Ritter, Da-sue-shan, and Alexander III.'s. The beginnings also have been made of a careful exploration of the Altyn-tagh, which was formerly known through Prjevalsky's and Littledale's journeys along its outer border.

It is pleasant to add that Roborovsky's health has much improved during the return journey, and that, on arriving in Russian Turkestan after a two years' absence, he could report "all well." The account of this journey will add several more important volumes to the scientific literature of Central Asia.

EVAPORATION.[1]

THE quantities of water added to the atmosphere daily by evaporation from the oceans and the continents constitute a fundamental consideration in meteorology; the quantities evaporated from cultivated fields, forests, and other forms of vegetation are equally important in agriculture, but as yet we have confessedly attained to only a very imperfect knowledge of this subject. Meteorologists have generally observed the amount evaporated from a small surface of water exposed either in the open air and sunshine, or else within such a shelter as is used for the open-air thermometer; lately a disc of moist paper has been substituted for the surface of water, as in the Piche evaporometer. Agriculturists, on the other hand, have made use of the lysimeter, which consists of a deep metallic box buried in the earth and having its open upper side flush with the surface of the ground. This box is filled with soil in which plants may or may not be growing, according to the object of the investigator. Record is kept of the amount of water or rain that is added to the lysimeter box from day to day, and also of the amount of water that drains from the bottom of the box. The difference between the two is adopted as the natural evaporation from the soil. The soil in the box may be kept very wet, to imitate a morass, or very dry to imitate a desert; the fineness of the soil may vary from coarse gravel to the finest silt.

If we desire the actual amount evaporated into the atmosphere, we must do more than record the results of the above forms of apparatus. The evaporating surface of water in the shaded thermometer shelter will indeed give up its moisture in proportion to the temperature of the water and to the velocity and dryness of the wind at its surface; but these three important factors have values so different out of doors from those within the shelter, that such records can, at the best, only give us a crude idea of the actual evaporation from surfaces in the open air. A great evaporation within the shelter, caused by a strong, hot, dry wind, may be accompanied by but little evaporation from the surrounding country if the latter be a desert of rock and gravel.

On the other hand, by means of the lysimeter, one may indeed determine directly the evaporation from soil of any character exposed to the natural outdoor conditions; but there then remains the difficult task of determining how much soil of each respective kind really occurs in the surrounding territory. In order, therefore, to determine the actual evaporation from land surfaces, one must observe a large number of lysimeters, and make an extensive minute survey of the country. The calculations incident to this latter method are very laborious.

The ordinary psychrometric observations give the dew-point or quantity of moisture in a small unit volume of air at any moment. If in the course of the day this quantity increases, we are not thereby warranted in concluding that the increase is due to a local evaporation; it may have been brought from a distance by the wind, or it may even have come down from the clouds as rain. If observations of dew-point are carefully made on all sides of a large field, over which a gentle wind is blowing, and if it should appear that there is a little more moisture in the air on the leeward side than on the windward side, one might conclude, provisionally, that this increase represented the quantity of moisture thrown by evaporation into the air as it gently moved over the surface of the field. But even this conclusion must be modified indefinitely by the consideration that in blowing across the field the wind does not move horizontally, but in a series of rolls and whirls by which the lower air in which we are observing becomes mixed with upper air, about whose moisture we know little or nothing.

In the midst of all these uncertainties it seems almost hopeless to attempt anything like an accurate determination of the moisture actually added to the atmosphere by evaporation from any extensive region of land or water; the question is far more complex than the determination of the evaporation from a reservoir of water, which latter problem is often attacked by the hydraulic engineers. Including the earth and its atmosphere in one comprehensive view, we may certainly say that the total annual evaporation from snow and ice, fresh water and salt water, must average the same as the total annual precipitation. We may even make an annual average for each continent, and say that the evaporation from the land plus the water that flows away in the rivers must equal the rainfall, and as the river discharge is frequently well known, we may, by subtraction, infer the evaporation. For the oceanic surface, on the other hand, the evaporation must equal the rainfall plus the river discharge from the continents.

The latest contribution to our knowledge of evaporation from land surfaces is published by Prof. E. Wollny, of Munich, at page 486, vol. xviii., of his "Forschungen." As the result of three years' continuous observations of five lysimeters and a neighbouring evaporometer, he concludes:

(1) That the quantity of moisture evaporated from the soil into the atmosphere is considerably smaller than that evaporated from a free surface of water.

(2) That the evaporation is smallest from naked sand, and largest from naked clay, whereas naked turf and humus or vegetable mould have a medium value.

(3) That the evaporation is increased to a considerable extent by covering the ground with living plants.

As the result of a minute analysis of the complex relations between the evaporation and the meteorological elements, on the one hand, and the physical features of the soil, on the other, Dr. Wollny further concludes as follows:

(4) Evaporation is a process that depends both upon the meteorological conditions and on the quantity of moisture contained by the substratum of soil.

(5) Among the external circumstances temperature is of the greatest importance, inasmuch as, in general, evaporation increases and diminishes with it; but this effect is modified according as the remaining factors come into play, and in proportion to the quantity of water supplied by the substratum.

(6) The influence of higher temperature is diminished, more or less, by higher relative humidity, greater cloudiness, feebler motion of the wind, and a diminished quantity of moisture within the soil, whereas its influence increases under opposite conditions. On the other hand, low temperatures can bring about greater effects than high temperatures if the air is dry, or the cloudiness small, or the wind very strong, or if a greater quantity of water is present within the evaporating substance.

(7) For the evaporation of a free surface of water, or for earth that is completely saturated with water, the important elements are—first the temperature, next the relative humidity

[1] Prof. Cleveland Abbe, in the U.S. *Monthly Weather Review.*

of the air, and then the cloudiness, direction and velocity of the wind; whereas, for the ordinary moist earth, no matter whether the surface is naked or covered with living plants, it is the quantity of rain upon which the soil depends for its moisture that is the important additional consideration. The effects of the external elements on evaporation become less important, as explained in paragraph 5, in proportion as the precipitation is less and as the soil is more completely dried out by the previous favourable weather, and *vice versa*. For these reasons the rate of evaporation from a free surface of water not infrequently differs largely from that from the respective kinds of soil.

(8) Free surfaces of water, and soils that are continuously saturated, evaporate into the atmosphere on the average more water under otherwise similar circumstances than soils, whether naked or covered with plants, and whether watered artificially or naturally. Only at special times, viz. when the influence of the factors that favour evaporation is most intense, when the plants are in the most active period of growth, and when the soil contains a large percentage of water, can the land that is covered with plants show a larger evaporating power than the free-water surface.

(9) When a soil that is not irrigated is covered with plants, it evaporates a far greater quantity of moisture than when the surface is bare. In the former case the evaporation can not exceed the quantity received by the soil from the atmosphere before or during the period of growth. Swampy lands and those that are well irrigated, as also free surfaces of water, can, under circumstances favourable to evaporation, sometimes give to the atmosphere a greater quantity of water than corresponds to the precipitation that occurs during the same time.

(10) The evaporating power of the soil is, in itself, dependent upon its own physical properties; the less its permeability for water, or the larger its capacity for water and the easier it is able to restore by capillarity the moisture that has been lost, by so much the more intensive is the evaporation. For this reason the quantity evaporated increases with the percentage of clay and humus in the soil, whereas it diminishes in proportion as the soil is richer in sandy and coarse-grained materials.

(11) Soil that is covered with plants loses by evaporation so much more water in proportion as the plants are better developed, or stand thicker together, or have a longer period of vegetation, and *vice versa*.

In conclusion, Wollny repeats that the use of apparatus giving the total evaporation from free-water surfaces does not respond to the needs of the agriculturist [and we may add of the meteorologist], but that instruments must be used for measuring the evaporation from masses of earth that are wet with rainfall only, and free from stagnant wet soils. Lysimeters are recommended having a section of one-tenth of a square metre and a depth of soil one-half of a meter, and set out in the open air, sunk flush with the surface of the ground, and arranged so as to be easily weighed at any moment, and so that the drainage water can easily be measured.

The foregoing results of Wollny's laborious observations confirm us in the general conclusion that the quantity of water actually evaporated from a large surface of land, such as a definite watershed maintaining a single river, can only be determined by the following considerations. The quantity of water contained in the soil at the end of any given period in excess of what it contained at the beginning, plus the water that is carried off by drainage and river flow, plus whatever is evaporated into the atmosphere either directly or through the crops and forests, must equal the rain and irrigation water added to the soil during that time. As the soil content of water, the riverflow and drainage, and the rainfall can be severally determined by direct observation far better than the evaporation, the latter is to be determined by taking the difference between the rainfall and all other sources of loss or consumption.

LONDON UNIVERSITY COMMISSION BILL.

REFERENCE was made in our issue of July 9, to the Bill introduced by the Duke of Devonshire in the House of Lords, for the purpose of appointing a statutory Commission to make further provision with respect to the University of London. The Bill reads as follows:—

Whereas the Commissioners appointed to consider the draft charter for the proposed Gresham University in London, have by their report made recommendations with respect to the reconstitution of the University of London, and to the appointment of a statutory Commission for that purpose:

Be it therefore enacted by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:—

I. *Appointment of Commissioners.*—(1) There shall be a body of Commissioners styled the University of London Commissioners, and consisting in the first instance of the following persons [names not yet announced].

(2) If and whenever any vacancy occurs among the Commissioners, it shall be lawful for Her Majesty the Queen to appoint a person to fill the vacancy; but the name of every person so appointed shall be laid as soon as may be before both Houses of Parliament.

(3) The Commissioners may, with the consent of the Treasury as to number, appoint or employ such persons as they may think necessary for the execution of their duties under this Act, and may remove any person so appointed or employed.

(4) There shall be paid to any person so appointed or employed such remuneration as the Treasury may assign, and that remuneration and all expenses of the Commissioners incurred with the sanction of the Treasury in the execution of this Act shall be paid out of moneys provided by Parliament.

II. *Duration and proceedings of Commissioners.*—(1) The powers of the Commissioners shall continue until the end of the year one thousand eight hundred and ninety-seven, and no longer; but it shall be lawful for Her Majesty the Queen, from time to time, with the advice of Her Privy Council, on the application of the Commissioners, to continue the powers of the Commissioners for such time as Her Majesty thinks fit, but not beyond the end of the year one thousand eight hundred and ninety-eight.

(2) The Commissioner first named in this Act shall be the Chairman of the Commissioners; and in case of his ceasing from any cause to be a Commissioner, or of his absence from any meeting, the Commissioners present at each meeting shall choose a chairman.

(3) The powers of the Commissioners may be exercised at a meeting at which three or more Commissioners are present.

(4) In case of an equality of votes on a question at a meeting, the chairman of the meeting shall have a second or casting vote in respect of that question.

(5) The Commissioners shall have a common seal which shall be judicially noticed.

(6) Any act of the Commissioners shall not be invalid by reason only of any vacancy in their body; but if at any time, and as long as, the number of persons acting as Commissioners is less than four, the Commissioners shall discontinue the exercise of their powers.

III. *Powers and duties of Commissioners.*—(1) The Commissioners shall make statutes and regulations for the University of London in general accordance with the scheme of the report hereinbefore referred to, but subject to any modifications which may appear to them expedient after considering any representations made to them by the Senate or Convocation of the University of London, or by any other body or persons affected.

(2) In framing such statutes and regulations, the Commissioners shall see that provision is made for securing adequately the interests of collegiate and non-collegiate students respectively.

(3) Statutes and regulations made under this Act shall have effect notwithstanding anything in any Act of Parliament, charter, deed, or other instrument.

IV. *Approval of statutes and regulations.*—(1) When any statute or regulation has been made by the Commissioners, a notice of its having been made, and of the place where copies of it can be obtained, shall be published in the *London Gazette*, and the statute or regulation shall be laid as soon as may be before both Houses of Parliament, and shall not be valid until it has been approved by Her Majesty the Queen in Council.

(2) If either House of Parliament within forty days, exclusive of any period of prorogation, after a statute or regulation has been laid before it, presents an address praying the Queen to withhold her assent from the statute or regulation, or any part thereof, no further proceedings shall be taken on the statute or regulation, or on the part thereof to which the address relates, but this provision shall be without prejudice to the making of a new statute or regulation.