THE LUMLEIAN LECTURES

ON

AËRO-THERAPEUTICS IN LUNG DISEASE.

Delivered before the Royal College of Physicians of London.

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LECTURE I.

[AFTER a few introductory observations, Dr. Williams proceeded as follows:]

THE FACTORS AND ELEMENTS OF CLIMATE.

Before dealing with the subject of these lectures—aëro-therapeutics, or the healing influences of climate on mankind—it will be necessary to say a few words on climate generally and briefly to consider its principal factors. The chief factors of any climate are:

1. Latitude—naturally the greatest influence as describing the position of the sun towards the earth in a certain region, and thus determining the length and intensity of sunshine.
2. Altitude, by which the effects of latitude may be to some extent neutralised, for even in the tropics, at a height of 16,000 feet, snow and ice may exist, the temperature falling in ascending mountains 1° F. for every 300 feet.
3. The relative distribution of land and water, and especially the presence of vast tracts of either desert or ocean, the former accentuating extremes of temperature, and the latter tempering them.
4. The presence of ocean currents flowing from higher and lower latitudes (as the case may be) and qualifying thereby the climate.
5. Proximity of mountain ranges and their influence on the shelter from wind and on the rainfall.
6. The soil, its permeability or impermeability to moisture.
7. The rainfall, its amount and annual distribution.
8. The prevailing winds.

Such are the factors of a climate. We shall next come to its elements, which are five: Temperature, hygrometry, atmospheric pressure, wind force, and atmospheric electricity.

The effect of altitude on temperature may be illustrated by the instance of South America, where in the tropics are to be found large cities enjoying a temperate clime, owing to their altitude. Quito, the capital of Ecuador, on the equator, at an altitude of 9,451 feet, possesses the climate of perpetual spring, having a mean temperature of 60° F. for every season, and Santa Fé di Bogotà, in New Granada, 8,648 feet, about five degrees north of the equator, has a climate resembling that of Malaga without the extremes. If we want instances of the third factor of climate—the influence of the relative distribution of land and water—we find it best illustrated by a diagram which Mr. Scott has modified from Dr. Supan's work (Diagram 1), showing the equal annual range of temperature for the globe; from which it appears that the range of temperature increases from the equator to the poles, and from the coast towards the interior of a continent. The regions of extreme range in the northern hemisphere coincide with the districts of lowest temperature in winter, and, as might be expected from the southern hemisphere being largely covered with water, the range is far greater in the northern hemisphere than in the southern. The line of 20° F. range—the most moderate, owing to the Pacific influence—extends up the coast of Vancouver and California, crossing the American continent in Florida and passing north east to the Faroe Isles, where it turns sharply, runs nearly due south along the west of the United Kingdom and Portugal to North Africa, where it reaches nearly to the Gold Coast, from whence it skirts the north coasts of the Indian Ocean to the south of China. Here is prominently brought out the equalising influences of the oceans, and specially of the Atlantic in its Gulf Stream on the extremes of temperature, reducing what would be ranges of 40° or 50° to that of 20°.

On the other hand we see that on the purely land areas of Northern Asia ranges of 60° and 80° obtain, and in the region of Yakutsk in Siberia, 100° F. is reached, and at Werchojansk, Siberia, 120.4° F. Yakutsk itself has a temperature of 65.8° F. in its warmest month, and one of—44.9° F. in its coldest. In North America a mean range of 75° is reached in Northumberland Sound.

Inland climates tend to extremes, while those of coast and island are of a more or less temperate character. In the interior of continents the range in mountainous districts diminishes with the height above the sea, [1] and in the middle and higher latitudes of both hemispheres the western coasts have a less range than the eastern—the two exceptions to this rule being Greenland and Patagonia, which owe their special climate to the overwhelming cold of arctic currents.

The fourth factor, ocean currents, is perhaps the most important of all, and certainly so to Great Britain and Ireland, for without the influence of ocean currents our climate would resemble that of Labrador.

The deep sea researches of the *Lightning*, *Porcupine*, and *Challenger* expeditions have established now beyond doubt that there exist both in the Atlantic and Pacific Oceans (1) a superficial layer of water extending to a depth of 500 to 600 fathoms, the temperature of which is regulated by surface currents arising from periodic and variable or from permanent winds, and (2) a deep layer of far greater extent, which fills up the trough of the ocean, and does not vary greatly in temperature at different seasons, and is always below 39° F. This is a mass of cold water, which is constantly moving northwards from the Antarctic towards the Arctic Pole, and is evidently an indraught from the Southern Ocean, of which both Atlantic and Pacific Oceans may be regarded as inlets or gulfs.

Thus far the deep layers of the oceans; let us now turn to the superficial currents, which may be divided into (1) warm equatorial currents, flowing from east to west, the result of the north-east and south-east trade winds, and (2) the polar currents flowing from the Arctic or Antarctic circles.

THE GULF STREAM.

The most important equatorial current is the Gulf Stream, which is produced by the action of the north-east and south-east trade winds, and flows westwards to South America and, splitting in two off Cape St. Roque, part goes southwards to Cape Horn and the Falklands, and part flows north-eastwards along the coast of South America. This crosses the Caribbean Sea, and, making the circuit of the Gulf of Mexico, passes through the Straits of Florida, issuing as the Gulf Stream—a current 30 miles broad, 2,200 feet deep, with a temperature of 86° F. and a velocity of 4 miles an hour. It follows the American coast line, abuts on the cold Labrador current, than which it is warmer by 30° F., turns eastwards off Cape Cod in latitude 41°, and spreads, like a fan, over the Atlantic with diminished velocity. It divides off the Azores, part going southwards along the coast of Portugal and the Cape de Verde islands, joining the equatorial current, and the other portion skirts the coasts of Great Britain, Ireland, Scandinavia, and Spitzbergen.

The Atlantic steamers' winter course from New York to Queenstown lies for some time in the track of the Gulf Stream, and during a recent passage (in December, 1892) I noted the temperature of the water, which was tested twice daily. After the second day of the voyage it ranged from 56° to 58° F., the temperature of the air being generally 1° lower. The passengers used the water for bathing purposes without any artificial heating. In this track the weather was mild, and occasional showers fell. The Gulf Stream water has been found to move slowly off our west coast, not faster than 300 feet an hour, but its influence, especially in winter, though variously estimated, is undoubted, as every map of the North Atlantic isotherms will show; for the isotherm of 45½° F. starts from the American coast at about latitude 38°, runs to the north of Scotland and far up into Norway to latitude 60°, causing a diversion of the temperature lines to the extent of 20° of latitude. According to the Rev. Dr. Haughton's estimate, the result of the Gulf Stream on climate in July is a cooling one, but in winter (January) it raises the temperature between latitudes 40° to 60° from 14.1° F. to 37° F. The effect on the shores of Great Britain in winter is best seen by a chart depicting the temperature of the waters of the British and Irish Channels during the winter months (say, in February), and showing how closely the air temperatures follow these.

It will be seen from Diagram 2, issued from the Meteorological Office, which is the result of numerous observations of the Channel water made at the various lightships and coastguard

[1] This is well shown in Pike's Peak, where the mean daily range is about half that noted on the prairie plain at its foot.

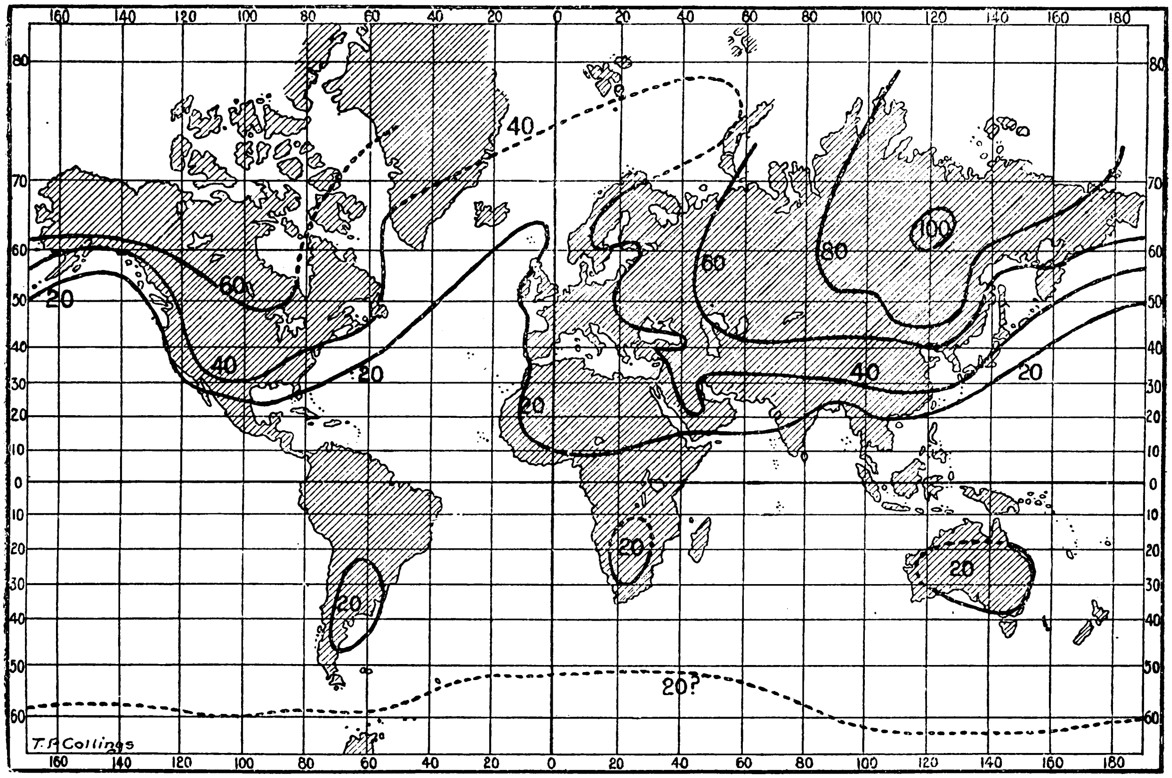

Diagram 1.—Lines of Equal Annual Range of Temperature for the Globe.

stations, that the temperature of the British and St. George's Channels varies according to the proximity of the Gulf Stream; the nearer to the stream, the warmer. The difference in water temperature between the sea off Scilly Isles and that off Sussex amounts to 5° F., the sea off the Norfolk coast being still cooler, and showing a difference of 10° F. from that of Scilly. The air temperatures follow the marine, being from 1° to 2° F. lower. There are few better instances of the warming and equalising effects of an ocean current than this, by which a northern island is made a participator in the warmth of the tropics without their extreme heat.

That the Gulf Stream influence extends to the coasts of Great Britain, Ireland, and Scandinavia, and even further, is proved by the North Atlantic isotherms already given, by the warmth of the water in the British and St. George's Channels, by the driftwood and tropical products found on the coast even of Spitzbergen, and lastly by the temperature soundings of Professor Mohn, of Christiania off the Trondhjem and Sogne Fiords, which prove the existence of a warm surface current on the Norwegian coast, ranging from 60.8° F. to 61° F.; also that it is of considerable extent. Owing to the North Atlantic being, to a great extent, a basin closed to the northwards, the current of the Gulf Stream, on reaching the barrier, is turned southwards in a southern eddy, so that there is a certain tendency for the hot water to accumulate in the northern basin, and to bank up along the north-east coasts.

THE NORTHERN EQUATORIAL DRIFT IN THE PACIFIC.

In the Pacific a similar phenomenon is observable. The northern equatorial drift, produced by the north-east trade, directs its course to the East Indian Archipelago and to the coast of New Guinea, and there divides, the southern part flowing on till it strikes the coast of Australia, and there turns eastward again, and the northern portion, known as the Kuro Siwo, or Great Black Stream of the Japanese seas, sweeps upwards in a north-easterly direction outside the chain of islands formed by the Phillipines, the Loo Choo group, and Japan, and turning westwards towards the western coast of North America, strikes it on the south side of the promontory of Alaska, and, flowing down the American coast, eventually joins the equatorial drift.

This warm stream, which is intensely salt, is estimated by Dr. Haughton as nearly three times the size of the Gulf Stream, but never attaining the velocity of the latter, from its waters not being confined in a narrow channel. A large portion of it reaches the American coast, and produces, according to von Baer, such an effect on its climate that, on the southern side of the narrow promontory of Alaska, humming birds are found, while the northern shores, which are washed by the cold current from Behring's Straits, are visited by walruses.[2] This warm current bends the isotherms northwards, as is seen in Diagram 3, and gives Sitka and the coasts of British Columbia their immunity from the ice which imprisons the harbours of Asia in corresponding latitudes. (Diagram 3.)

To this current the fine climate of South California owes its equability, and its protection from the great extremes of its inland neighbour, Arizona. The Kuro Siwo current, like the Gulf Stream, has a cooling influence in summer, and the effect of the westerly winds it produces may be seen in the contrast between the July temperatures of the Pacific Coast stations and of those at some little distance inland. For instance, at San Diego, in South California, the July mean is 67° F., whereas at Yuma, in Arizona, at the same latitude, and less than 200 miles inland, it is 92° F., a difference of 25°; and again at Cape Mendocino, on the Pacific Coast, compared with Red Bluff, less than 100 miles inland, there is a difference of 28°. On the other hand, in January, the Pacific Coast temperatures are higher than the inland ones, that of San Diego being 54° against 50° of Yuma, and that of Cape Mendocino being higher than that of Red Bluff.

THE INDIAN EQUATORIAL CURRENT.

In the Indian Ocean the equatorial currents are, to some extent, embayed, as there is no exit on the northern side, and they become drift currents depending on the monsoons and changing with them, but the main equatorial current east of the line splits on the coast of Madagascar, and the main por-

[2] Scott, *Elementary Meteorology*, p. 306.

tion of it flows down the Mozambique Channel, and becomes the warm Agulhas current which washes the east coast of the Cape of Good Hope.

COLD CURRENTS.

The principal cold currents are two flowing into the Atlantic from the north circumpolar sea, according to Sir George Nares, one passing along the west coast of Baffin's Bay, and the other along the east coast of Greenland at the rate of four miles a day. The one from Baffin's Bay flows along the American coast, and is to be distinguished as a surface current as far south as Cape Cod. For part of its course it abuts on the Gulf Stream. The American survey shows that it then dips under, and is to be found, at a depth of 100 fathoms, flowing under the Gulf Stream in an opposite direction, and dividing in the Strait of Florida into two streams, one portion passing under the hot Gulf Stream into the Gulf of Mexico, and the remainder coursing round Cuba. This current, flowing southwards, hugs the American coast, and influences the temperature as far south as Cape Cod in latitude 42°, contributing to the cold climate of Labrador, Nova Scotia, and Newfoundland, and Eastern Canada.

The cold currents from the Antarctic Pole are (1) Humboldt's current, which appears on the western coast of South America, and lowers the climate of Chili and Peru, and another Antarctic current strikes on the West African coast near Cape Town, making the temperature about 20° lower than at the corresponding latitude on the east coast, and filling Table Bay with a profusion of fish, most of the edible varieties inhabiting cold water.[3] Both these currents exercise a marked influence on the adjacent coasts. The above description of ocean currents must be taken with the proviso that the whole subject is undergoing fresh investigation, and it is not impossible that our knowledge will be considerably extended by such investigation.

MOUNTAIN RANGES.

The proximity of mountain ranges and their influence on the rainfall and on the shelter from winds is the fifth of our factors, of which plenty of examples are at hand. The neighbourhood of mountains, and especially the environment of lofty ranges, has been ascertained to increase the rainfall, except under certain conditions of protection; for, if the range rises abruptly to a great elevation and the locality be to the lee-side of it, the air currents prevailing to the windward are forced upwards, and, becoming lowered in temperature, are obliged to part with their moisture, and thus pass over the range as dry winds. This is the case with the Colorado sanitaria, which are under the lee of the Rocky Mountains and possess exceedingly dry climates.

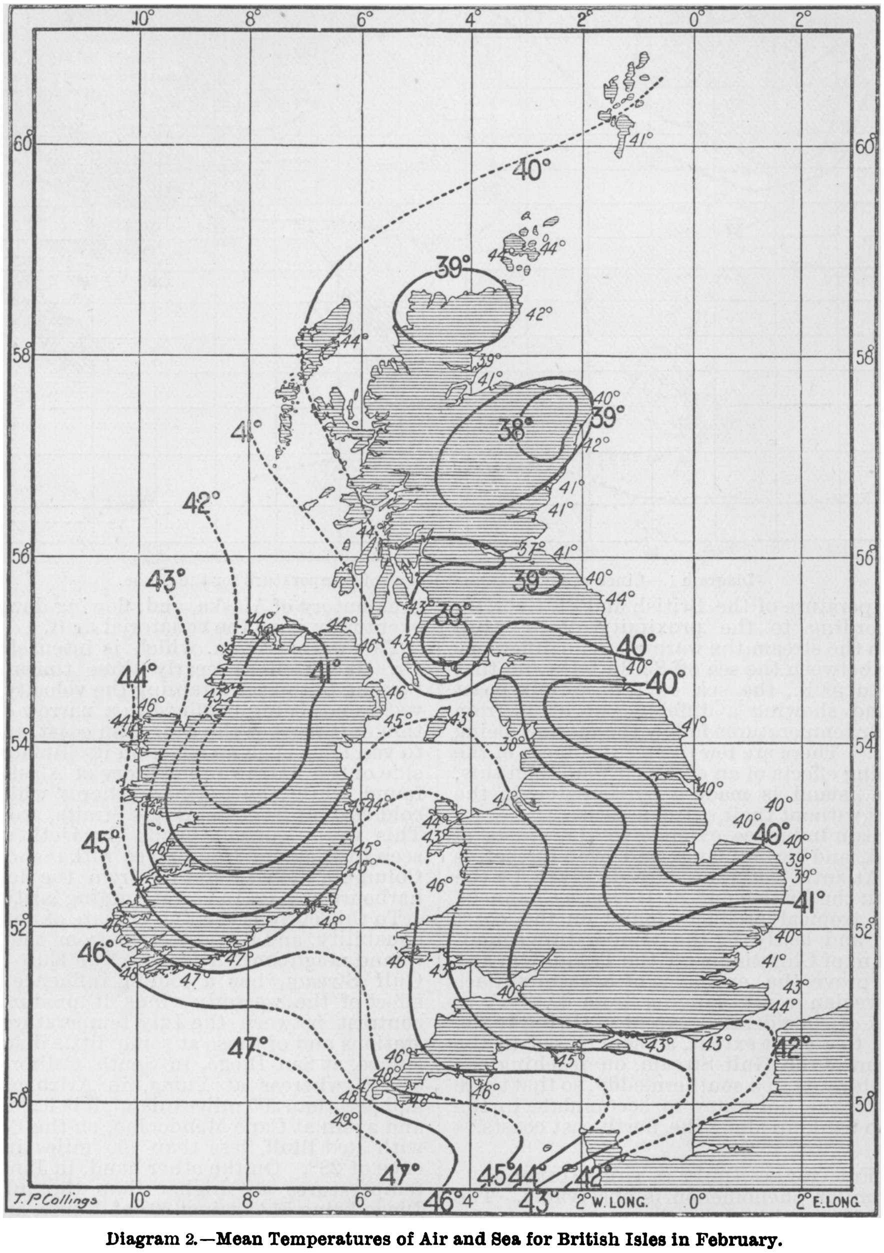

Diagram 2.—Mean Temperatures of Air and Sea for British Isles in February.

SOIL AND VEGETATION.

The sixth factor is soil and vegetation—a purely local one; but their effect on climate is sometimes surprising. The influence of soil on the accumulation of moisture is well known, and the close connection of non-permeability of soil with the production of diseases, such as phthisis, has been proved by our distinguished Fellow and Censor, Sir George Buchanan, Dr. Bowditch, and others. The effect of different soils on the sun's rays and their relative conducting power is also of great interest. It would appear that light loose soils, such as sand or gravel, from their particles not being closely packed together, imprison large quantities of air in the interstices, and thus reduce the heat-conducting power of the soil; whereas heavy, dense soils, such as clay, from their particles being packed together, are better conductors of heat. Therefore light, loose soils are subject to high temperatures and to a greater degree of frost near the surface than dense, heavy soils; but, on the other hand, heat and cold in the form of great frosts and extra temperatures do not penetrate so far down into light as into heavy soils. According to Dr. Buchan,[4] some experiments made in Scotland showed that at 3 inches below the surface the temperature fell to 26.5° F. in loose sandy soils, and at a depth of 12 inches the freezing point was only once reached. On the other hand, in clay soils at a depth of 3 inches the lowest was 28° F., and at 12 inches the tem-

[3] Scott, *op. cit.*

[4] *Handybook of Meteorology.*

perature often fell to freezing, and even at 22 inches 32° F. was once recorded.

In the same way the solar heat does not penetrate so deeply into sand, which is a bad conductor, and instead of conducting the heat to a greater depth as rock, and loam, and clay soils do, it accumulates it, and hence the great heat of the soil of the desert, which has been known to rise to 120° F., 140° F., and even to 200° F. When these particles of sand are lifted into the air by winds, as during the prevalence of the terrible simoons, the atmosphere has been known to rise to 125° F. in the shade, and thus the deserts of Asia and Africa are stated to have a mean summer temperature ranging between 92° and 95° F. At night, however, the soil gives rise to marked radiation and consequent great lowering of temperature, and in this way we get immense thermic ranges. The covering of the soil with vegetation protects it from the sun's direct rays, and the temperature of plants exposed to the sun does not rise so high as the soil itself, because much of the heat is lost through the large evaporation which takes place from the leaves and stems, and which gives rise to air currents tending to reduce the temperature. The result is that the heat is more evenly distributed over the twenty-four hours, and is less intense in the hottest time of the day.

The effects of forests on the temperature and rainfall have often been discussed, and the general conclusion arrived at is that by retaining and absorbing the moisture, they moderate heat. According to Buchan, trees acquire their maximum temperature at 9 P.M., instead of between 2 and 3 P.M., the maximum period of air, and then they radiate it slowly at night. With regard to the influence of forests on increasing rainfall, proof of this has been shown, first by the increase of rainfall in a district following extensive tree planting, and the reverse, namely, denudation of a region of trees, on its ceasing to be cultivated, being followed by reduction of moisture, as the drying up of rivers; for example, that of the Euphrates and Scamander. A good instance of the influence of increased forest growth on climate is this one taken from Dr. Buchan's able work: "The valley of Araqua in Venezuela is shut in on all sides, and the rivers which water it, having no outlet to the sea, unite and form Lake Tacariqua. This lake during the last thirty years of the last century showed a gradual drying up, for which no cause could be assigned. In the beginning of the present century the valley became the theatre of deadly feuds during the war of independence, which lasted twenty-two years. During that time land remained uncultivated, and forests, which grow so rapidly in the tropics, soon covered a great part of the country. In 1822 Boussingault observed that the waters of the lake had risen, and that much land formerly cultivated was at that time under water.

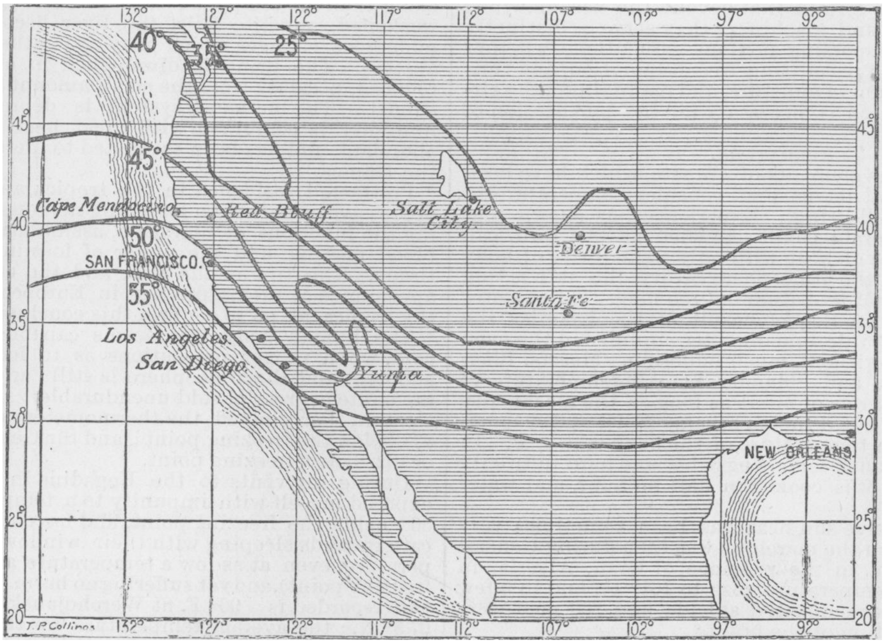

Diagram 3.—Influence of Kuro Siwo Current on Pacific Coast Temperatures.

THE RAINFALL.

This is a factor which unfortunately can make itself very unpleasantly felt, and has been largely studied of late by Dr. Hann, Mr. Symons, and others, and on the whole the causes of excessive and deficient rainfall have been fairly explained.

According to Mr. Scott, the three great agencies in the precipitation of rain are:

(1) Ascending currents which, being lowered in temperature by their ascent, are compelled to deposit their moisture.

(2) The contact of warm air with the cold surface of the ground.

(3) The mixture of masses of air of different temperatures.

Of the first, wind coming across the ocean and striking a lofty range, which forces it upwards and causes it to deposit its moisture, is a good instance, such as may be seen in the south-west monsoon, striking the Khasia Hills, in Assam, and producing the tremendous rainfall of 493 inches at Cherrapunji; of the second the contact of the warm south-west wind with our own Cornish and Devonshire coasts, which being much colder in winter cause rain precipitation. The third agency is to be seen in the regions where ocean currents of varying temperature meet, the aërial currents accompanying them commingle and cause heavy deposition of moisture, as may be seen in the fogs off the Newfoundland banks, where the Gulf Stream and Baffin's Bay currents meet.

When the wind is the rainbringer, as it usually is, localities to the lee of the mountain range have small rainfalls, the moisture having been deposited in the mountains. In regions surrounded by mountain chains, such as Utah, in the United States of America, and Gobi, in Siberia, the dryness produces a desert, the mountains having drained the winds of all moisture before reaching these tracts.

The rule about rainfall is that, other conditions being equal, it decreases in quantity from the equator to the poles, while the number of rainy days increases. Tropical countries have rainy seasons, when rain falls in large quantities for weeks, the rest of the year being free; and in temperate countries rain falls all the year round. In this country the rainfall, according to Mr. Scott, depends "on the Atlantic influence, and on the somewhat irregular succession of barometric depressions and anticyclones which are constantly moving over the earth's surface in the temperate zone." The rainiest month in this country on the west coast is January, and on the east coast and London it is October; the driest month being March. In Europe, north of the Alps, more rain falls in summer; south of the Alps, more falls in autumn. On the Riviera, for instance, there is hardly any rain in summer, and nearly half of the annual amount falls in September, October, and November. As we pass eastward, the summer rainfall increases. In north-west France it is 24 per cent.; in northern Prussia, 36 per cent.; in central Russia, 38; and in the Ural mountainous district, 53 per cent., more than half the total amount falling in summer.

Mountains exercise considerable influence in condensing moisture, and causing rain precipitation, and this property appears to increase with the elevation up to 3,000 feet or 4,000 feet in Europe, and then to diminish above this level.

WIND.

The last, but by no means the least, climatic factor is wind, and the prevailing wind is often the key to the climate of a locality. We have various kinds of winds: (1) permanent, such as the north-east and south-east trades, which blow towards the equator from the poles, to replace the ascending heated air of the tropics, and owing their easterly direction to the earth's rotation. These prevail continuously, but shift their area of prevalence during different seasons of the year; then come the seasonal or periodic winds, of which the north-east and south-west monsoons are a good example. These, according to Sir Joseph Fayrer, arise in April by the heated air over the continent of India being replaced by comparatively cool currents laden with moisture coming from the Indian Ocean from Africa to Malacca. This is the south-west monsoon which, rising to higher regions on being intercepted by the mountain ranges, condenses its moisture in rain on the Western Ghâts and on the Coast of Aracan. Following a north-east course, it loses its influence and its moisture as it approaches the northern limit of the continent, and about October there follows a reversal of the current, which then blows southward as a dry current, till on the Coromandel Coast it brings moisture from the Bay of Bengal, which falls as rain on the coast of the Carnatic and Eastern Ghâts, while some parts of India receive rain with each monsoon.

Other winds are variable, such as most of the winds of the temperate regions, but in some climates special winds are quite characteristic, such as the mistral of the south of France, the sirocco of southern Italy and Sicily, the khamsin of Egypt, the hamattan of the Sahara Desert, and the south-west and east winds of this climate.

But we may be quite certain that beyond the use of winds for propelling vessels and machinery they serve a distinctly hygienic object in dispersing noxious exhalations whether animal or vegetable, in permitting free evaporation, and thus preventing accumulation of moisture, and maintaining the circulation of the air which is necessary for the purification of the atmosphere.

TEMPERATURE.

We now come to the elements of climate, which have been enumerated above, and let us first consider temperature in relation to man's well-being. Experience has shown that the natives of temperate countries, such as our own, can endure great extremes of heat with only a small rise of body temperature provided the atmosphere be dry, the skin acting freely, and the period of probation not too long. Tillet states that at the town of La Rochefoucault at the bakeries the female assistants, as a rule, remained ten minutes in the oven at 132° C. (301.6° F.) without much suffering. Messrs. Blagden, Fordyce, Banks, and Solander bore a temperature of 260° F. with the small rise of $2\frac{1}{2}$° F. as long as the air was dry and perspiration free, but if the air became moist and evaporation was hindered the temperature of the body rose 8° F. In the same oven with the observers eggs became hard in twenty minutes, a beefsteak was cooked in half an hour, and water boiled.

The effect of excessive sun heat has been sometimes very disastrous to troops on the march, as was seen during General Bugeaud's expedition in the province of Oran, Algeria, in 1836, when the sun temperature rose to 161° F., and in a few hours eleven soldiers committed suicide and 200 men were attacked with congestion of the brain.[5]

Sunstroke or insolatio is generally the result of solar or artificial heat in tropical, but occasionally in temperate, climates, and, according to Sir Joseph Fayrer, the most frequent cases are those coming on in houses, barracks, and tents, away from the solar rays, and the subjects most likely to be attacked are those debilitated by disordered health, by dissipation and over-fatigue, rather than those of vigorous constitution or those who have undergone acclimatisation.

For an admirable account of the varieties of sunstroke, I would refer to articles by Sir Joseph Fayrer, in Sir Richard Quain's *Dictionary of Medicine*, and in other publications, and, as he remarks: "Hindu natives, on their bare heads and necks, endure an amount of sunshine which would be fatal to a European; but if the temperature rise above a certain standard all succumb, the natives suffering like others, and dying of sunstroke."

The atmosphere of the plains of India, and especially of Bengal, contains a large amount of moisture, which makes the endurance of heat more difficult, but in the north of India and the dry regions of the United States to the west of the Rocky Mountains great degrees of heat, that is, 118° to 128° F. are tolerated from the dryness of the atmosphere, and, as General Greely, the late Chief Signal Service Officer of the United States Army, remarks, "the inhabitants of the Atlantic and central stations of the country hear with amazement of the extremes of heat reported from the arid regions of Arizona and South Colorado as being within the bounds of human endurance, and cannot believe that the ordinary avocations of life can be pursued without inconvenience; however, the explanation lies in the climate being cloudless and dry, and promoting rapid evaporation, and consequently no suffering ensues, and sunstrokes are unknown."

The effect of great heat on the lungs is to reduce the number of respirations, according to Rattray, from 16.5 in temperate regions to 13.74, and even to 12.74, in the tropics, accompanied by a slight spirometric increase, not enough to account for the decreased number of respirations, and so the respiratory function is reduced at least 8.43 per cent., as the late Professor Parkes puts it, "if 10 ounces of carbon are expired in the temperate zone, only 8.17 ounces would be expired in the tropics." The water exhaled by the lungs is also diminished, and the observations of Parkes and Francis show that the lungs of Europeans dying in India are lighter after death than the European standard. This might be expected from the diminished use of these organs, as witnessed by the lessened number of inspirations. The heart's action is not perceptibly quickened in the tropics, and the pulse is not faster than in temperate regions. The digestive powers are weakened, appetite fails, the liver becomes congested and undergoes changes which may end either in induration or abscess. The urine is diminished in amount, the urea is reduced, possibly from the small amount of animal food consumed. The nervous system is depressed, especially if humidity is combined with great heat, but perspiration is abundant, and has been estimated to increase 24 per cent. in the tropics.

Protracted residence in the tropics appears to exercise a depressive influence in lessening nervous energy and impairing the functions of digestion, assimilation, respiration, and blood making, and the power of forming new and healthy tissue. The tint of the skin and the conjunctivæ, and an appearance of premature age in Europeans long resident in the tropics, all go to confirm this conclusion.

The human body also seems capable of enduring great cold, when proper precautions as to food and clothing are adopted, and the atmosphere is still; any wind renders even moderate degrees of cold unendurable. In the Arctic regions, Captain Parry noted the thermometer as low as −55° F., or 87° below the freezing point; and Sir George Back at −70° F., or 102° below freezing point.

During my visits to the Engadine in winter I have often exposed myself with impunity to a temperature of −4° F., or 36° below the freezing point, and have noted the fact of delicate invalids sleeping with their windows open in that temperature, even at as low a temperature as −11° F. (43° below freezing point), and yet suffering no harm.[6] The lowest temperature recorded is 90° F. at Werchojansk, in Siberia, latitude 67.5° N.; the average temperature for the month of January, 1885, being −63.9° F., and for February −84.3°, for March −77.4°, and for December −78.2°; the maximum of December 33° F. This cold station lies in the valley of the Iana, 330 feet above sea level, and, owing to its latitude, the sun is absent altogether during December, while its elevation above the horizon for the rest of the winter is so slight that the effect of the direct sun's rays are unable to counteract the intense cold caused by the radiation.

In North America the records are also very low, reaching at Poplar River, Montana, to −63.1° F., in January, 1885, besides embracing a large number of records at various stations from −40° to −54°, and many of these interior stations give lower records than the Arctic ones.

The question arises—how do these low temperatures affect the human body? If exposure to cold be prolonged, and the circulation and thermogenic powers cannot be maintained, the blood vessels, especially the smaller arteries and capillaries, become contracted, and no longer permit the passage of blood corpuscles, and all physiological and chemical changes are arrested. Various parts, especially the extremities, become starved, and hence death of these parts takes place by frostbite or gangrene, appearing first in the fingers and toes. The effect of cold on the blood has been well demonstrated by Drs. Bristowe and Copeman in a case of

[5] Boudin, *Géographie Médicale*, vol. i, p. 397.

[6] Greely's *American Weather*, p. 121.

paroxysmal hæmoglobinuria, communicated to the Medical Society in 1889,[7] where careful determination of the number of red corpuscles before and after the application of cold to the patient, showed that exposure to cold air produced a temporary reduction in the number of red corpuscles of 129,000 to 824,000 per cubic millimetre. The same effect was produced by a cold bath, and even by plunging the hands in cold water, the bloodmaking process in each case been gradually restored on returning to a warm atmosphere. Prolonged exposure to extreme cold gives rise to languor, lowering of the sensibility, and the individual loses all power of reaction, and sinks to sleep—often to wake no more—as is witnessed on long marches through the snow, the form of death being coma. Another result of the cold is to produce brain excitement delirium, incoherency and thickness of speech, the symptoms resembling those of intoxication. Death occurs generally by syncope or asphyxia.

The capability of man to endure variations and extremes of temperature has been proved to be very great, for General Greely states that at Fort Conger, U.S.A., in February, 1882, he experienced the low temperature of—66.2° F., and, at another time in the Maricopa Desert, Arizona, he saw noted the air temperature of 114° F., while the metal of his aneroid beside him as he rode assumed a temperature of 144° F.[8]

THE INFLUENCE OF CLIMATE ON LUNG DISEASES.

Having sketched out one of the elements of climate—temperature—we must consider it in reference to its influence on lung diseases, premising that the beneficial effects of a pure atmosphere are not to be assigned to one kind of climate only, as it is well ascertained that patients, and specially consumptive patients, have recovered in all climates—hot and cold, dry and moist, clear and foggy—and that the arrest of tuberculosis may be due to the patient's improved constitutional powers, fostered by more favourable surroundings, of which a propitious climate is one; but where we find a large number of similar cases distinctly improving under change of climate, and the accompanying increased facility for outdoor life and exercise, and where we find the percentage of improvement larger than among similar cases under different climatic conditions, in the absence of other factors, we may fairly assign the improvement to the change of climate.

Before proceeding further, it may be well to allude to the question of immunity from disease, and specially from consumption, with which some climates have been credited, and which has been proposed as a basis of climate selection. The localities stated to be immune vary so greatly in climate conditions, some being of high altitude, some below sea level, some with tropical heat, and some of intense cold, that it is impossible to discover any common qualities possessed by them. This is a subject which I discussed at length in the Lettsomian Lectures before the Medical Society of London some years ago, and I may refer the Fellows to the arguments then adduced; but the great point to bear in mind with regard to immunity from phthisis of any given place, is whether the conditions of life there are such as to foster or produce consumption, and, if so, does this locality remain immune, because this test alone would be a reliable argument for its recommendation on the ground of immunity?

AËRO-THERAPEUTICS OF WARM AND COLD CLIMATES IN LUNG DISEASE.

It will be of no service to discuss absolutely tropical climates, as experience teaches that these are not desirable for the treatment of disease; but it may be of considerable use to state what has been effected by moderately warm climates on patients specially selected for such treatment.

Warm climates may be divided into warm moist and warm dry.

WARM MOIST CLIMATES.

The best type of the warm moist climates is Madeira, as it enjoys the advantages of a marine atmosphere; the air is therefore permeated with a certain amount of saline vapour. Sixty years ago Madeira was the *beau idéal* of a climate for consumption and lung disease, and enjoyed perhaps a higher reputation than any other sanitarium. The annual mean temperature is a little above what we heat our houses to in winter. The winters are warm and the summers cool, the difference between winter and summer mean temperatures not exceeding 9° F. There are no cold winds, and only an occasional *leste* or hot wind from the desert. The nocturnal radiation is slight. The relative humidity percentage is large and the rainy days numerous, equability being the great feature of the climate. The principle of sending patients to Madeira was to keep them in an equable atmosphere, in a sort of aërial warm bath, which soothed the respiratory passages (and how acceptable warm moist air is to irritable lungs!) and promoted expectoration, permitting also of much sitting and lying out of doors. Unfortunately this soft atmosphere had often an injurious effect on the general health, inducing langour, loss of appetite, and even diarrhœa, and apparently promoting progress of the tuberculous disease.

My statistics published in the *Medico-Chirurgical Transactions*, vol. lv., show that among 63 consumptive patients who spent one or more winters on the island, 53.01 per cent., improved, 14.28 per cent. remained stationary, and 31.91 deteriorated, and this unfavourable result was arrived at, although 63 per cent. had tuberculosis without excavation, a favourable outlook, and in not more than 40 per cent. was the disease bilateral. However, many of the improved class not only improved, but improved greatly, and several of the excavation cases also, which formed nearly one-third of the whole number, showed signs of contracting cavity, proving that undoubtedly Madeira does suit some phthisical patients. Dr. Lund's statistics of 100 phthisical patients are somewhat more favourable, but Dr. Renton's are less so than my own. It will be remembered that of 20 phthisical patients sent by the Brompton Hospital to Madeira for one winter, only 3 improved, 1 died, and the rest returned to England worse than they started, and yet these were cases carefully selected by the medical staff as most likely to benefit by the climate.

For the majority of consumptives this sort of climate does more harm than good, but for the catarrhal form of phthisis it is, as my statistics show, a distinct success.

Chronic bronchitis with emphysema, bronchial catarrh, pulmonary congestion in elderly persons unconnected with heart disease, are wonderfully relieved, and the patients often quite lose their symptoms. The influence is most marked in chronic bronchitis, the expectoration becomes easier and at first more abundant, then gradually diminishes, and the cough becomes less troublesome and in due time ceases. Sleep is sounder, and the patient rejoices in being able to breathe more easily. Bronchial asthma often does well in Madeira, especially if associated with much catarrh. I have had three patients with spasmodic asthma, accompanied with catarrh, who each passed one or more winters without attacks there, and were able to take exercise all the season. My general impression of Madeira results is that the patients who improved were those in whom catarrh formed the prominent and most troublesome symptom of the case, whether the illness were asthma, phthisis, or bronchial inflammation; and also that those patients who were able to ride improved more than those who were always carried in hammocks.

THE CANARY ISLANDS.

The Canary Islands, in latitude 27° to 29°, including Teneriffe and Grand Canary, enjoy a climate similar to that of Madeira, but somewhat warmer and drier, and are much frequented by English pulmonary invalids. The winter mean temperature is 64.7°, the range about 11° to 14°, and the rainfall 15 inches.

The great advantage which Teneriffe offers is the variety of sites for residence at different altitudes on this mountainous island, rising as it does from the sea level to the height of 12,200 feet in the famous Peak, and with a choice of villages and hotels at different elevations it is possible to pass the whole year in the island without suffering from the heat.

My experience of this warm climate is limited, but I have seen great benefit derived by patients suffering from asthma and chronic bronchitis, but the few cases of phthisis which I have sent there have not prospered. Warmth and equability combined with dryness appear to be the chief attractions.

[7] *Transactions of the Medical Society*, vol. xiii.
[8] *American Weather*, p. 121.

EGYPT.

Of dry warm climates the most typical is that of the deserts, such as are to be found in the centre of Australia, that of Gobi in Chinese Tartary, the great deserts in the United States, and the tract which stretches from the great Sahara through Arabia into Persia, of which the Egyptian desert is a part. Egypt will serve well as an example, especially as it has long been used as a winter sanitarium, and a certain amount of experience of its effects has been accumulated.

The chief features of the climate of Egypt, most typically exemplified in that of the desert, are, as shown by the works of Marcet, Sandwith, and Zagiell:

1. Warmth. The mean temperature of Cairo in winter is 58.3° F., the summer mean is 76.1° F.; the maximum at Cairo is 111° F., and the minimum as low as 35°.

2. Great difference between night and day temperatures, due to radiation, amounting in winter to 23° F., or even 38° F.

3. Dryness of atmosphere. The rainfall is small: at Cairo, 1.22 inch, falling on from twelve to fifteen days, and is less in Upper Egypt. At Thebes it is rare for any rain to fall, and in the province of Esneh it is almost unknown. The difference between the wet and dry bulbs sometimes amounts to 24° F., and the annual relative humidity percentage varies from 58.46 at Cairo to 45 at Luxor. The atmospheric dryness is proved by the mummies, which remain unchanged for centuries.

4. Great atmospheric purity. According to Prince Zagiell's observations, while ordinary atmospheric air contains 4 parts of CO_2 in 10,000 parts, the air of the desert contains none at all, and putrefaction appears checked; meat exposed to the air becomes, without any trace of decomposition, mummified in three weeks. Surgeons say that wounds and ulcerations heal rapidly. The climate suffers from very hot winds, such as the *khamsin* or south-east, which brings the sand of the desert, and is sufficiently hot to shrivel up roses and other flowers and to warp and crack unseasoned wood. Under its influence both natives and Europeans droop and become listless.

The climate, though warm, is a great contrast to that of Madeira, being dry and largely influenced by the results of radiation, instead of markedly equable, and it has a most beneficial influence on phthisis, provided the amount of lung area attacked is not excessive, and there be no fever.

I have notes of 26 consumptives who have tried this climate for one or more winters, and the results are favourable. The patients were 23 males and 3 females, the average age of the males being 28.43 and that of the females 21.33. The average history of the disease before spending the winter in Egypt was 36.65 months, that is, a little more than three years, thus showing that the cases were not all of early phthisis. Family predisposition was present in 17 cases; hæmoptysis in 18 cases. Seventeen patients had lung tuberculosis alone, and 9 tuberculosis with excavation. In 6 both lungs were implicated, and in 20 the disease was unilateral.

Some patients passed one winter in Egypt, others two, and a few three or more winters, the average length of residence per patient being 6.46 months.

The general results were, improved, 17 or 65 per cent.; stationary, 3 or 11 per cent.; worse, 6 or 23 per cent. The local results were arrest in 1 case, decrease of disease in 10, a stationary condition in 3, advance of disease in 4, advance and extension in 3, extension alone in 3, or local improvement in 11; a stationary condition in 3, deterioration in 10, a much worse result than the general.

This dry climate suits asthma remarkably well, and I have known many asthmatics who have kept entirely clear of attacks during a winter on the Nile. In cases of chronic bronchitis the cough diminishes, expectoration is rapidly reduced, and at last ceases altogether; while the climate suits emphysema on account of the dry warm air and level country, and abundant air without exercise to be obtained on the Nile steamers or dahabiyehs. The patients I have found who do best in Egypt are cases of chronic pneumonia and chronic dry pleurisy, bronchitis and chronic rheumatism, the clearing up of chronic pneumonia and pleurisies, with the cessation of all symptoms, being remarkable. One of the best results is the promotion of sleep, which may be due partly to the cool nights and partly to the absence of marine influence, which is more or less exciting. Needless to add, that to profit by the climate patients should live in the desert, either by ascending the Nile, or residing at Luxor, or even at the Mena Hotel at the foot of the Pyramids, as Cairo has all the disadvantages of a large city for invalid residence.

I subjoin a good example of the effect of the Egyptian climate.

A Greek gentleman, aged 22, consulted me on January 21st, 1877. His father and his brother had died from consumption, the latter of a very acute and obscure form of the disease at 22. He complained of cough and expectoration, but had not lost much flesh, but was somewhat languid. There was no rise of temperature or of pulse. On examining his chest I found slight dulness above the right scapula, tubular sounds above the clavicle, with crepitation on cough, and some tubular sounds above the left scapula, and prescribed cod-liver oil and a tonic. Five months later, after returning from Palermo, where he had been in the interval, I found him suffering from diarrhœa, three to four motions a day, and decidedly thinner, with a reddish tongue, and with increased physical signs. The crepitation was now audible on the right side from the clavicle to the third rib, distinct crepitation was also heard at the left apex. Under dieting and treatment the diarrhœa subsided and the cough diminished, and the patient improved; but in consequence of a relative's death, he travelled from London to Leghorn at the end of June, and was there laid up with a feverish attack and a return of the diarrhœa. I heard no more of him until June 20th, 1878, when I was urgently summoned to Naples, and found the patient greatly emaciated and very weak, suffering from profuse diarrhœa, stools varying from four to twelve a day, loose and ochrey, his cough troublesome with nummular sputa, tongue reddish, evening temperature 100° F., pulse 96, respirations 28. He was scarcely taking any food, but what he did take was solid and of an unwholesome character. On the right side I found tubular sound over the first interspace, on the left side dulness to sixth rib, cracked pot sound in the first interspace, coarse crepitation to the fourth rib and above the clavicle, and distant cavernous sounds in the first two spaces. Posteriorly there was dulness over the upper two thirds; with fine crepitation; breathing was very deficient in the lower portion of the lung.

The Italian medical man whom I met in consultation informed me that the patient had been suffering from diarrhœa for months, which was with difficulty checked and not stopped, and solid food with claret had been permitted. I found the patient with an excellent *sœur de charité*, who complained that she had no system of treatment to pursue; a first-rate cook, quite competent to carry out an invalid dietary, but with no directions; and with a devoted brother and faithful servants longing to be of assistance, and yet the poor man was lying in the sweltering heat of Naples in June, starving for want of suitable food, and such comforts as no hospital patient lacks in England. I succeeded in removing him to Leghorn in an invalid carriage, and he bore the journey well, and under the influence of a liquid dietary and cooler air he soon improved, the diarrhœa being at length brought under by injections of linseed tea. The temperature and pulse fell, and in the autumn he was sufficiently recovered to bear a journey, and I recommended his wintering in Egypt, and ascending the Nile in a dahabiyeh. He returned to Italy next spring greatly improved, having gained flesh, with cough and expectoration reduced, and the physical signs improved, as the doctor in Cairo reported to me. He spent a second winter on the Nile with favourable results, but passed the summer of 1880 at Naples, where he seems to have led an incautious life, and the diarrhœa returned. He died in October, and over his grave his brother has erected a magnificent reproduction of one of the temples at Luxor, as a tribute to the land of Egypt.

In this case the patient was a southerner; the tuberculous disease was hereditary, and developed rapidly and the obstinate character of the diarrhœa and stools passing left little doubt as to the existence of intestinal ulceration. When I visited him at Naples his disease was making such rapid progress that it did not appear probable that he would last many weeks, but with change of climate and careful dietetic and medicinal treatment he rapidly improved, and under the dry and warm Egyptian climate he lived on for more than two years in ease and apparently in great comfort. Doubtless the fact of his southern origin had some influence on the climate of Egypt proving so congenial to him.

GOULSTONIAN LECTURES
ON
THE CHEMICAL PHYSIOLOGY OF THE ANIMAL CELL.

Delivered before the Royal College of Physicians of London.

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LECTURE II.—THE CHEMICAL CONSTITUENTS OF THE NUCLEUS: THE PROTEIDS OF CELL PROTOPLASM.

IN my introductory lecture I indicated how, by microchemical research, it is possible to distinguish between the different materials out of which cells are built up. We have now to pass to the consideration of these chemical constituents, and it will be convenient to take those in the nucleus first.

CHEMICAL CONSTITUENTS OF THE NUCLEUS.

The credit of being the first to break the ground in this direction belongs to a Fellow of this College; it was in his earliest published research that Dr. Lauder Brunton investigated the chemical composition of cell nuclei. He separated the nuclei from the red corpuscles of bird's blood by shaking them with a mixture of ether and water; the nuclei alone remain undissolved and float at the junction of the two liquids. The material so obtained was found to resemble mucin in its viscous properties and in its solubilities. The