carbon monoxide will do exactly the same thing when the air is laden with coal-dust, whilst the temperature of ignition is slightly lower than with methane, so that in the case of the Camerton Colliery, it being perfectly well ascertained that the air was charged with coal-dust, the probabilities are that not 10 feet, but a far larger volume of explosive mixture was formed by the rapid escape of the products of combustion into the coal-laden air; and this being ignited, either by the flame or red hot solid products driven out into it by the blown-out shot, would initiate a considerable area of explosion.

The classical researches of Prof. H. Dixon have shown that hydrocarbons and, probably, carbon burn in air to carbon monoxide, and that this carbon monoxide will not form explosive mixtures with air, or even with oxygen, if they are absolutely dry; but if water vapour is present, they explode owing to the oxidation of the carbon monoxide to dioxide, causing the propagation of an explosive wave, which reaches its maximum velocity when the percentage of water vapour, between 5 and 6 per cent., and inasmuch as the air of the mines would always contain some moisture, and as the products of combustion also would give a large volume of water vapour, these requirements would be amply fulfilled.

Still more conclusive on this point were Mr. Hall's experiments. In these a charge of blasting powder was fired from a cannon suspended in a shaft, the air of which was proved by careful chemical analysis to be absolutely free from any trace of combustible gas.

In order to get some idea of the condition of the air inside the pit during the explosion, samples of air were taken and were analysed. Two brass tubes were fastened to the rope that was used to lower the cannon, one twenty yards from the bottom, the other forty yards from the bottom.

These tubes were so arranged and constructed that the explosion, as it passed the tubes, unsealed the outlet pipe, and the escaping water sucked in a sample of air which was trapped by a special arrangement, and kept in the tube until the rope could be wound up. By this method it was intended that the sample of gas taken should represent that state of the air whilst the flame was passing, or directly afterwards.

The tube nearest the bottom, as the analysis will show, did partly collect the gas in the above condition. The tube at the top, however, commenced to act prematurely, and was probably started by the sound wave which preceded the explosion. This tube simply contained ordinary air.

The following is an analysis of the gases found in the lowest tube:—

	Per cent.
Oxygen ...	3 9
Nitrogen ...	75·9
Carbon dioxide ...	12·1
Carbon monoxide ...	8·1
	100·0

This ingenious arrangement was due to Mr. W. J. Orsman, and it is probably the first successful attempt which has been made to get a sample of gas during the progress of explosion, and there is not the slightest doubt that the presence of such an amount of carbon monoxide converts mixtures of coal-dust and air into a highly explosive body.

As the explosion takes place, and as the carbon monoxide ready produced is oxidised to carbon dioxide by the action upon it of water vapour present, and also by its direct combustion with oxygen, the hydrogen of the water vapour is set free, whilst the heated coal-dust also yields certain inflammable products of distillation to the air, and partial combustion also of the coal-dust gives a considerable proportion of carbon monoxide once more, and these driven rapidly ahead of the explosion form with more coal-dust and air a new explosive zone, and so by waves and throbs the explosion is carried through the dust-laden galleries of the mine.

The experiments made by Mr. Hall, and investigations in various colliery explosions, make it abundantly manifest that no explosive should be licensed for use in mines unless it can be absolutely proved that it gives off no imflammable products of combustion. The following table will show the results given by some of the explosives most largely used, which point very clearly to the fact that, with the exception of the Sprengel explosives, such as roburite and nitroglycerine, none of the bodies in use conform to this important requirement.

Products of Combustion of Blasting Explosives.

Powder.	Carbon dioxide.	Combustibles. Carbon monoxide.	Hydrogen and marsh gas.
Gunpowder ...	50·6	10·5	3·1
Blasting power ...	32·1	33·7	7·9
Sprengel explosives—			
Roburite ...	32·0	nil	nil
Ammonite ...	33·0	nil	nil
Nitroglycerine explosives—			
Nitroglycerine ...	63·0	nil	nil
Gelignite ...	25·0	7·0	nil
Carbonite ...	19·0	15·0	26·0
Blasting gelatine ...	36·5	32·3	8·6

Whilst not only these considerations, but Mr. Hall's experiments, point to the absolute necessity of legislative enactments at once forbidding the use of blasting powder in any coal mines, no matter how free they may appear to be from fire-damp or from dust, if the returns made as to deaths caused by gunpowder and other explosives in mines for the year 1893 are examined, it will be clearly seen that the exclusion of gunpowder, in handling alone, would do away with 80 per cent. of the accidents. So that if explosives of the Sprengel class were employed, accidents due to the explosives used would be practically eliminated from the mining death roll; and it is only a question of time as to when England will foll w the action of France and Germany in altogether prohibiting the use of blasting power in dusty mines.

THE POSSIBILITIES OF LONG-RANGE WEATHER FORECASTS.[1]

IF we had perfect command of this subject, we should be able to trace the motion of a particle of aqueous vapour from point to point over the whole earth, and could predict whether at any time in the future it will fall as rain, or rise and fly away as an invisible gas. In the absence of this higher knowledge the only long-range forecasts that we are at present able to make are based upon empirical and very imperfect rules deduced from our study of the accumulated climatological statistics. Of course, such predictions do not imply any special knowledge of meteorology. Among the methods adopted in long-range forecasts are the following:

(*a*) The average rainfall, temperature, &c., for any period, such as a month, and deduced from many years of observation. is called the normal. The excess or deficiency of this month in any given year is called the departure for that year. A general prediction may be made to the effect that the rainfall for a given month and place may be expected to lie within the range of the values indicated by these known departures.

(*b*) The series of annual or monthly values just mentioned gives us the means of finding out whether there is any simple sequence or connection between them and the apparently unconnected values that occur from year to year. Thus, it sometimes happens that rainy seasons come after two or three dry seasons, or that after the same month has been dry in three successive years, one is then justified in predicting a wet month. Thus, Governor Rawson elaborated a system for the prediction of rain and the sugar crop in Barbados.

(*c*) Slight but appreciable widespread, rather regular fluctuations of temperature, pressure, and rain have been revealed in the climate of Europe by Dr. Brückner, who finds that a deficient temperature and an excess of rain have alternated with excess of temperature and deficiency of rain in periods of thirty-six or thirty-seven years during the past two or three centuries; the glaciers increase and diminish in volume, or advance and retreat, in correspondingly regular but somewhat retarded intervals. Predictions may be based on these well-established periods.

(*d*) Droughts are sometimes due to what happens in distant regions: thus, if there is a heavy snow on the Himalayas during the winter, there is a special liability to drought in lower India in the following summer, so that the prediction of a drought may be based upon the reports of snow-fall in a distant region several months before the drought occurs; but other droughts may occur without this preliminary snow-fall. This connection

[1] Reprint of an article contributed by Prof. Cleveland Abbe to the U.S. *Monthly Weather Review*.

is, so far as at present known, a local, arbitrary, or accidental one, and has not yet been found to recur in any other portion of the globe.

(*e*) Droughts or floods may occur every year in some portion of an extensive region, so that it may become possible to predict the occurrence in a special section one year because one has occurred in another section a previous year. Thus, a serious drought in the lower Indian peninsula has, on five occasions, been followed by one in northern India the next year.

(*f*) If we had maps of the weather of the whole globe for every month for a long series of years we should, undoubtedly, be able to find many similar coincidences, so that a drought for a given section might be predicted from the rain-fall, the snow-fall, the temperature, the pressure, or other conditions in a distant part of the globe. As a rule, important climatic crises are the results of changes that have been going on slowly for a long time in distant parts of the earth. The general circulation of the air constitutes a complex system in which the areas of high pressure and dry clear air are the results of slowly descending winds moving toward the equator; the general rains are formed wherever a descending current of air, a mountain range, or other obstacle has an opportunity to push up the moister air of the earth's surface. From this point of view rainy and dry and cold and hot seasons depend largely upon the varying relations of the upper and lower currents to the continents and even to each other. The long-range prediction of the climate of any season must depend upon the prediction of the general character of the horizontal and vertical movement of the air. In our present geological epoch the continents are permanent features, and we consider only the changes that take place in the atmosphere, but in studying the climatic changes of earlier geological epochs we have to consider the changes in elevation of the continents themselves.

(*g*) Such apparent connections as that between snow-fall on the Himalayas and the subsequent drought in northern India are not to be thought of as cause and effect respectively. It might be argued that the layer of snow must be evaporated, or melted, thereby absorbing more heat than would have been required if it had fallen as rain and rapidly drained away; but this cooling influence is distributed over many weeks, and through the immense quantity of air that has passed over the snow-fields during the winter and the spring, and is thereby rendered too slight to have any great local influence in India. A broader view of the subject shows us that the winter snow-fall and the summer drought are simply two features of an extensive system of changes in which the whole atmosphere of the earth takes part. The whole globe may be divided into regions where the lower stratum is moving either horizontally or upward or downward, and where the upper stratum has similar diversities of movement. These systems of motion determine whether we shall have fair weather or rain, hot weather or cold, from day to day and accumulatively from month to month. Now these three movements are related to each other in such a way that the sum total of the energy involved throughout the atmosphere is sensibly constant, while the localities at which the upward and downward motions are taking place are undergoing perpetual changes.

The centres of high pressure over the oceans and continents slowly sway east and west or north or south; the paths of the storm-centres vary in a similar manner to suit the changes of these larger areas, and the centres themselves move rapidly or slowly in response to these same changes. The air that ascends between the northern and southern tropical regions of high pressure descends sometimes in high latitudes, giving them cold weather with rain or snow; at other times in low latitudes, giving them warm weather with droughts. It matters not whether the droughts in southern regions chronologically follow or precede the snows of the northern regions; in neither case can either one be spoken of as the cause of the other, but each is in its turn the result of changes in the so-called general circulation of the atmosphere.

This general circulation, with all its variations, diurnal, annual, and secular, is dependent upon the intrinsic density of each portion of the atmosphere and on numerous forces, such as the heat received from the sun, the attraction of the sun, moon, and earth, the resistance offered by the irregular surface or the earth, and the interaction of slow and rapidly moving masses of air. The proper study of this subject constitutes the application of hydrodynamics to meteorology.

The meteorological problem has some analogy to that offered by the hydraulics of the Mississippi River, where cut-offs, caveins, mud-banks, and crevasses are continually forming and re-forming. We do not expect to be able to foretell when and where these will occur many years in advance, but we do keep a watch on the condition of the river; and when conditions are favourable for the formation of any important change, we watch the process until the catastrophe becomes more or less imminent, and then begin to make estimates, that may be called predictions, as to the exact time and place of the event.

In meteorology the best we can do at present in long-range predictions is to chart and study the occurrence of abnormal weather conditions over the whole globe; these phenomena must be interpreted in the light of all the knowledge we have of the mechanics of the atmosphere, for they are the results of purely mechanical operations covering the whole range of the mechanics of heat, gases, and vapours.

SCIENTIFIC SERIAL.

The Quarterly Journal of Microscopical Science, November.—On Julinia, a new genus of compound ascidians from the Antarctic Ocean, by W. T. Calman (plates 1–3). The colony is described as irregularly cylindrical in shape, measuring 78·5 cm. in length, and from 1·5 to 2·5 cm. in diameter; it was found floating on the surface of the sea in the north of Erebus and Terror Gulf; a considerable quantity was seen; no attaching fibres were found, but it was probably an attached form. The species is described as *Julinia australis*, and it is provisionally placed in the Distomidæ.—Hermaphroditism in mollusca, by Dr. Paul Pelseneer (Ghent) (plates 4–6). Hermaphroditism is found in the Amphineura, the Gastropoda, and the Lamellibranchia. It is not self-sufficient, is sometimes protandric; it would seem to the author to be not a primitive arrangement, but to be derived from the unisexual state, and to have been established upon the female organism.—Description of the cerebral convolutions of the chimpanzee known as "Sally," with notes on the convolutions of the brains of other chimpanzees and of two orangs, by W. Blaxland Benham (plates 7–11).—On the inadequacy of the cellular theory of development and on the early development of nerves, particularly of the third nerve and of the sympathetic, in Elasmobranchii, by Adam Sedgwick, F.R.S. More than ten years ago the author called attention to the inadequacy of the cellular theory of development: "Embryonic development can no longer be looked upon as being essentially the formation by fission of a number of units from a single primitive unit, and the coordination and modification of these units into a harmonious whole. But it must rather be regarded as a multiplication of nuclei and a specialisation of tracts and vacuoles in a continuous mass of vacuolated protoplasm." And "although opinions have changed on this important subject, and although there are some who think that they have escaped from the domination of this fetish of their predecessors, yet as a matter of fact the cellular theory of development is still rampant, still blinds men's eyes to the most patent facts, and still obstructs the way of real progress in the knowledge of structure." When a student begins his zoology he is told that "the various structures present in a protozoon are all parts of one cell, whereas in a metazoon the various parts are composed of groups of cells which differ from one another in structure." When in a later period of his studies he begins embryology, "the importance and distinctness of the cell meets him at every step, from the complete cleavage which he is led to believe is primitive, to the development of nerves according to the views of His." If we take the so-called mesenchyme tissue of elasmobranch embryos, it is described as consisting of "branched cells lying between the ecto- and the endo-derm," while, as a matter of fact, "the separate cells have no existence," but "there is a reticulum of a pale non-staining substance holding nuclei at its nodes. And far from the development of nerves being an outgrowth of cell-processes from certain central cells, it is simply a differentiation of a substance which was already in position." This important memoir is so condensed as to make it extremely difficult to condense it further, but enough has been given to indicate its nature.—On *Benhamia caecifera*, n. sp., from the Gold Coast, by W. B. Benham (plate 12). This large species (20 inches) was found at Axim in the Fantee country, on the west coast of Africa.