Prof. S. C. Harland described how plant selectors and hybridists without any genetical knowledge had obtained great success. But this was due to the accommodating nature of their material, and the use of genetical principles would have speeded the results. The concept of 'gene erosion' was a problem which all breeders had to face. Rigorous selection for one character was usually accompanied by a loss of 'fitness' genes. For example, the selection of large flowers in sweet peas had produced sterility under certain conditions. Such unbalanced types would not survive in the wild; but the unbalance was to a certain extent counteracted by the artificial environment of agriculture. Thus the main problem is one of genotype and environment, the study of which requires both genetics and physiology. Another important factor was mutability, for the problem of releasing variability in some material is a real handicap to the breeder. To-day, plant improvement rests largely on complex characters such as disease resistance, and hence a full knowledge of the genetics and biochemistry of physiological races is necessary.

The problems of human genetics have to be tackled differently from those in animals and plants. Prof. L. R. Penrose showed how many different morphological and physiological peculiarities are known now to be due to single genes. Some of these effects can be mitigated by treatment, others cannot. There was a fallacy in the argument advanced by some geneticists that under the cover of improved hygiene and nutrition the population is said to be deteriorating genetically. The example of the relationship between sickle-cell anæmia and resistance to malaria was evidence for this fallacy, for it showed that a gene need not necessarily be wholly good or bad. The gene for sickle-cell anæmia in a heterozygote confers complete resistance to malaria, a property which is of obvious advantage in tropical countries. In this case the hygienic control of malaria actually reduces the incidence of the sickle-cell gene. The full physiological effects of genes and the future requirements of the human race are not known, and since variety is generally advantageous it was an unsound policy to try and get rid of genes by sterilization.

The physiological effects of genes was discussed by Dr. D. Lewis, who stated that the gene, although its conception had changed from the billiard ball to a piece of chromosome of varying complexity and length, was still a working physiological unit. The effects of the gene controlling sexual incompatibility in plants was known in sufficient detail to enable us to draw a close parallel between the type of genetic control and the physiological mechanism. This relationship between genetics and physiology had a predictive value which could be applied to quite different systems; for example, to the relationship between a host plant and its fungal parasite. The cytoplasm—that other hereditary factor, less rigorous and usually subservient to the gene but a factor which plays the major part in differentiation, ageing and perhaps short-term adaptation—was now beginning not to obey rules but at least to show remarkably similar properties in organisms as diverse as the tomato, fruit fly, *Paramecium* and yeast. Since the gene was the prime cause of all physiological effect, and the cytoplasm was the means of transmitting that effect, a genetic study from the gene outwards and a physiological study inwards provided a fruitful meeting ground for collaboration.

The application of genetics to micro-organisms, particularly those which have no normal sexual cycle, was described by Dr. J. A. Roper (in a joint contribution with Dr. G. Pontecorvo). On the classical genetic theory the reassortment of genes required sexual reproduction, but in several asexual micro-organisms a 'para sexual' phenomenon occurred which made genetic analysis possible. In bacteria, transformation by a pure nucleic acid occurred; in filamentous fungi, exchange of whole chromosomes or even somatic crossing-over occurred. Micro-organisms were particularly suitable for physiological genetics where the specificity of each gene determining a single biochemical reaction had been found in great numbers.

The importance of micro-organisms was emphasized by Prof. C. D. Darlington in his summing-up. In micro-organisms development was telescoped in such a way that the gene was closer to the character, until in the virus the gene and the character were one. The almost unnoticed demonstration in 1924 of the precise segregation of characters in the four spores of a moss transferred Mendel's laws from a statistical to a direct observational basis. The taking of genetics into the field and city, that is, into real life, had begun, and a similarity of the field-work of Dr. Ford on butterflies and the sickle-cell anæmia by Allison referred to by Prof. Penrose indicated that the whole of human society could be a vast genetic experiment. But Prof. Darlington ended his talk by saying that in view of the failure of the universities and especially the social scientists to keep abreast of the advances in fundamental or genetic biology, Dr. E. D. Adrian's suggestion, in his presidential address, that mankind should be handed over for treatment to the social scientists made him "gasp".

The genes are, to use Darlington's phrase, the "long-range determiners" of not only morphological peculiarities but also of human behaviour: this is still not realized in universities and many research institutes. As for the public, it has always loathed the idea of genetic determination and has clung to the cherished and flattering old wives' tales that come within the framework of Lamarckism and not of genetics. D. Lewis

WEATHER FORECASTING

THE discussion on weather forecasting, arranged by Section A (Mathematics and Physics) of the British Association and held in Oxford on September 6—as might be expected after a disastrous summer with weather more than usually a matter of public concern—drew a large gathering to the Sheldonian Theatre. The chair was taken by Prof. E. H. Neville and later by Sir Harold Spencer Jones, who introduced the guest speaker from Sweden, Prof. C. G. Rossby, now director of the Meteorological Institute of the University of Stockholm but equally renowned for his work in the United States, having held chairs in both Chicago and the Massachusetts Institute of Technology.

In opening the discussion with a paper on weather forecasting as a problem in physics, Dr. R. C. Sutcliffe first remarked that weather forecasting is something more than the science on which it rests; it is a scientific profession with some hundreds of practitioners issuing some thousands of forecasts daily for a wide variety of purposes. In a short paper it was possible only to indicate the general nature of the scientific problems; but in weather forecasting where it is impossible for every interested member of the public to be given personal advice on his own particular problem, it is particularly important that the client should have some understanding of the subject.

The problems of weather forecasting may be regarded as falling within the scope of hydrodynamics, but the methods which have been successful in other fields have so far contributed relatively little to the practical problems of weather prediction as they arise from day to day. This is because the problems are extremely complex, being concerned with non-steady and turbulent motions in the compressible fluid of a heat engine working against friction. The system is not even closed, and the composition of the fluid is continuously changing by evaporation, condensation and precipitation. Meteorology must therefore be studied as a science in its own right, and predictions about the atmosphere must depend on its observed structure and behaviour.

Dr. Sutcliffe was mainly concerned to emphasize the different scales of atmospheric systems. On any one day the circulation of the atmosphere differs widely from the long-term climatological mean, and examples from surface and upper-air weather maps of the northern hemisphere were used for showing how depressions and anticyclones frequently form over periods of one or two days. These systems are well understood scientifically and, as Prof. Rossby showed later, can be predicted by hydrodynamical theory; but they are essentially a form of large-scale turbulence and after a period of one or two days predictions become very uncertain.

Variability is present on many smaller scales—frontal systems, vertical convective systems down to variations on the scale of kilometres and metres. Much of this variability is beyond the reach of regular observations and can only be treated in statistical terms.

Weather forecasting, Dr. Sutcliffe remarked, can be regarded as based on five considerations: (1) the change in the large-scale synoptic situation; this can give for one or two days ahead the broad character of the weather and wind; (2) the effects of fronts—allowing fairly accurate timing of rain areas and major changes of wind, temperature, etc., for periods of some 12 hr. ahead; (3) the convective properties of the air masses—permitting statistical-probability statements on showers, thunderstorms, convective cloud, visibility, etc.; (4) diurnal changes—these are major considerations for temperature, humidity, convective phenomena and visibility; and (5) topographical effects—these introduce many local differences in weather.

Although formally these aspects may be considered separately, they are not independent.

Owing to the rapidity with which changes take place and to the element of dynamical instability which enters into the developments, there seems no present prospect of eliminating uncertainty from weather forecasts. Dr. Sutcliffe expressed himself as optimistic about dynamical meteorology, which has made great progress in very recent years; but he was not optimistic about persuading the atmosphere to behave in a more orderly way.

Mr. V. R. Coles spoke of the work of a practising forecaster. The forecaster depends in the first place on obtaining adequate observations, and the absence of reporting ships in some areas, for example, south of Greenland and even in the Bay of Biscay, is often a serious handicap. The stationary ocean weather ships in the Atlantic are a great boon. The erratic behaviour of depressions was illustrated by examples where extrapolation would give a good prediction and others where it failed completely. In recent years much attention has been given to upper-air conditions, and relationships between the consideration of the upper thickness or thermal patterns and the development and movement of surface depressions have been established. Mr. Coles illustrated the success of this method with an example of the rapid formation of a new anticyclone which had been very satisfactorily predicted. The methods of extrapolation, the use of tendencies and the indications from the upper air are not always consistent, and Mr. Coles thought that if much greater accuracy in forecasting is to come, it will probably be by the use of objective methods of calculation using electronic methods.

The first two speakers were mainly concerned with forecasts for some 24 hr. ahead made familiar to the public by Press and broadcasting, and it fell to Dr. J. M. Stagg to consider the possibilities of prediction for longer periods. Experience has shown, he said, that attempts to extend the forecasts to a few days ahead by the methods discussed by earlier speakers meet with little success; the accuracy falls away very quickly after the first 30–36 hr. But nevertheless, it is a commonplace observation that weather has a 'moodiness', and generally bright or dull or rainy weather may persist for long periods. Meteorologists have therefore looked for something in the atmosphere more enduring than the simple depressions and anticyclones.

Dr. Stagg referred first to certain purely empirical methods to which much attention has been given. The field of surface pressure has been elaborately analysed for periodicities and correlated with measures of geomagnetic and solar activity, and although much has been learned about the modes of oscillation of our atmosphere, little of prediction value has resulted. A phenomenon referred to as symmetry in the pressure–time curve has been discovered in Germany, in which variations of pressure have been shown to repeat in reverse order after a point in time known as a 'symmetry point'. But tests made in England were no more successful than others based on extrapolations of pressure trends; by the time a trend has become established it is already on the way to another rhythm or pattern. Methods of correlation, although they have had some success in India for monsoon prediction, generally fail in a similar way. It is not surprising that the atmospheric machine produces good relationships for a time in a particular area, as these would reflect the mode of circulation during the period; but if the mode changes, so will the correlations, and their prediction value may well be slight.

Dr. Stagg sees more of scientific interest in the dynamical-synoptic studies using mean weather charts for periods of days. In the United States, the Weather Bureau has introduced forecasts for five days, and more recently for thirty days ahead, on the basis of continuity in the evolution of mean upper-air charts over these periods. The methods have apparently had a measure of success, but are still mainly empirical, depending largely on the extrapolation of trends which may suddenly change for no known reason.

In the U.S.S.R. most attention has been given to the movements of anticyclones as the more enduring features of the synoptic patterns, and Dr. Stagg thinks it is no coincidence that long-range forecasting has been established in the great continental areas. Over the British Isles we are next door to one of the world's worst cockpits of weather disturbances, and even a slight error in predicting the mean tracks of depressions can make a forecast completely wrong for the whole country. Dr. Stagg stressed the need for physical understanding of the processes, and referred to research going on in the Meteorological Office; but he also reminded the audience of a remark made by Sir Gilbert Walker, speaking to the British Association twenty-one years ago: "Though the prestige of a meteorological service may be raised for a year or two by the issue of longer range forecasts, the harm done to the science will inevitably outweigh the good if the prophecies are found unreliable".

Prof. Rossby introduced the subject of 'numerical weather forecasting' by referring again to the broad spectrum of frequencies in atmospheric disturbances which was the theme of Dr. Sutcliffe's paper. 'Weather', in the sense of clouds and rainfall, is produced mainly by the smaller-scale disturbances which have relatively large vertical components of motion. The largest scale motions, with dimensions of some 5,000 km., are necessarily quasi-horizontal, and it is these motions which have now been shown to be amenable to direct calculation with useful accuracy. The calculations will not produce a detailed weather forecast; but they may still prove to be of much assistance to the forecaster by keeping him on the correct broad lines over periods of one or two days.

The conception of forecasting by calculation on the basis of the physical equations originated in Britain with the late L. F. Richardson some thirty years ago, but the ideas were at that time quite premature as there was no practicable way of carrying out the heavy computations. It was not until 1947 that the subject was taken up seriously at the Institute of Advanced Studies in Princeton, and since then there has been rapid progress on a research basis not only in the United States but also in Britain, where the work of Sawyer and Bushby is outstanding. In Sweden, with its present limited facilities for electronic computing, Prof. Rossby has confined attention to the simplest model of large-scale atmospheric behaviour, but he expects to be in a position to introduce more elaborate and realistic calculations in the near future. The basic idea was put very simply by Prof. Rossby. It has been shown that the vorticity (about the vertical axis) of the mean motion of the atmosphere is nearly a conservative property. It can therefore be advected with the mean motion. But by integration, with known boundary conditions, the motion itself can be calculated from the vorticity field so that, using a step-by-step method, it is possible to begin with the present known motion, determine the new field of vorticity for, say, one hour ahead by advection, compute the new field of motion by integration and so continue indefinitely until such time as accumulated errors render the calculations worthless. Mathematical refinements have improved on this simple scheme, but the principle remains the same.

Prof. Rossby remarked that "a weather forecast is a rather perishable commodity which must be marketed quickly". Only electronic methods can reduce the time of calculation to anything reasonable, as even in his present simple model there are 10^7 operations to carry out to produce a 24-hr. prediction. But it now seems that the time spent in calculation will not be the most serious item. Much more time will be spent in making, transmitting and collecting the observations from the large area involved (some six hours) and in plotting and analysing the charts (some three hours). Attention will have to be given to these factors, and already objective analysis and diagrammatic recording are being studied.

To show once more that the computations can deal only with the broad synoptic situation and not with the details of weather, Prof. Rossby provided a diagram showing the distortion which may take place in a layer of fluid over a period of a day or two. Beginning as a chequered square of some 500 km. side, the 'fluid element' altered shape by hydrodynamical 'deformation' as though it were a handkerchief flourished in the magician's hand, with all pattern becoming confused in the folds. To analyse such motion in the practical case would require the number of observations to be increased by one or two orders of magnitude.

It was regrettable that time did not permit of general discussion after the papers, but perhaps the mistake had been in making the subject so broad. Weather forecasting is concerned to some extent with almost the whole science of meteorology, and any one of the four papers could have provided the basis for a profitable morning's symposium.

OBITUARIES

Dr. E. S. Russell, O.B.E.

In the death of E. S. Russell, on August 24, zoology lost one of its foremost thinkers. Many knew Russell as a friendly and quiet companion, who even as president of the Linnean Society of London always seemed to be as it were 'off duty'; but the formidable character underneath was revealed, for example, in the concluding passage of "Form and Function" (Murray, 1916):

"Dogmatic materialism and dogmatic theories of evolution have in the past tended to blind us to the complexity and mysteriousness of vital phenomena. We need to look at living things with new eyes and a truer sympathy. We shall then see them as active, living, passionate beings like ourselves, and we shall seek in our morphology to interpret as far as may be their form in terms of their activity.

"This is what Aristotle tried to do, and a succession of master-minds after him. We shall do well to get all the help from them we can."

Those were remarkably confident words from a man not thirty years of age. By now, thirty-eight years later, we have experienced part of the fulfilment of his demand, in the insight gained into the nature of animals by von Koehler and Bierens de Haan, by Lorenz, von Fritsch and Tinbergen; and the corresponding morphology is clearly on its way, indeed begun, by Baerends and others.

All Russell's books are exciting, alike for their scholarly marshalling of facts and for their heterodoxy. Lamarck and Samuel Butler receive honour only a little less than that accorded to his chosen