frequency of sulphur. It is well known, too, that coloured forms can be obtained of many simple salts which normally are colourless, such as sodium chloride, by supplying energy to them.

The phenomena of fluorescence and phosphorescence are also due to molecular phases. If a molecule absorbs a phase quantum which, for instance, is ten times the molecular quantum, this energy can be radiated in two ways. It may either be radiated as 10 molecular quanta, when the fluorescence will be in the infra-red, or it may be radiated partly as one quantum characteristic of a lower phase—say, that phase with frequency five times the molecular frequency—and partly as molecular quanta. In the second case the fluorescence will be visible.

Since the essential characteristic of the phases of a molecule from the chemical point of view is their force fields, the variation in which causes their different reactivities, it might be argued that this theory is only a re-statement of the secondary valency hypothesis. Such an argument would not, however, be sound, for the secondary valency hypothesis does not explain absorption. At best it only succeeds in showing that different distributions of secondary valency can generally be written where the same molecule has been found to exhibit different absorption under different conditions. The present theory establishes the existence of different phases of any inorganic or organic molecule, each of which has its own energy content, its own reactivity, its own frequency and power of absorbing light. The theory attempts to correlate all the phenomena of absorption and to place them on a quantitative basis, and in this attempt it would seem to meet with some success. Although in this article we are not concerned with the chemical aspect of the differences in the force fields of the phases, it may also be claimed that this theory offers a quantitative explanation of the phenomena of reaction and reactivity.

Artificial Production of Rain.

By DR. HAROLD JEFFREYS.

IN an article in the *Times* of October 17 an account is given of the achievements of Mr. Charles M. Hatfield in producing rain. The method used is not described in any detail. A tank filled with certain unspecified "chemicals" was exposed at a height of 25 ft. above the ground, and it is claimed that this had the effect of producing 8 in. of rain in three months at Medicine Hat, 22 miles away. The theory of the method is that the apparatus draws clouds from other parts to the Medicine Hat district and causes them to precipitate their moisture there. No direct observations of the motions of clouds are mentioned in confirmation of this theory, though they should not have been difficult to obtain.

The official raingauge at Medicine Hat during May, June, and July, the period of the contract, recorded 4·8 in., which was 1·3 in. below the normal for the station for those months. Further comment on the success of the experiments is unnecessary.

The financial side of Mr. Hatfield's contract with the United States Agricultural Association of Medicine Hat is interesting, for the association was apparently prepared to pay Mr. Hatfield as if 8 in. of rain had fallen. Still more interesting is the fact that he was promised 4000 dollars for 4 in., and 6000 dollars for 6 in. Since the normal rainfall is 6·1 in., Mr. Hatfield would have been much more likely than not to make a substantial profit even if he had done nothing at all.

It may be mentioned that at Calgary, Alberta, the rainfall was 3·0 in. below normal; at Edmonton it was 3·1 in. above; and at Qu'Appelle (Sask.), 300 miles to the east, it was 3·85 in. above normal.

It is also stated that at Los Angeles, in the first four months of 1905, Mr. Hatfield guaranteed 18 in. of rain, and that his own raingauge showed 29·49 in. If this is correct the rainfall must have been extremely local, for the official raingauge at Los Angeles in those months showed only 14·98 in. Still, this was 4·4 in. above normal. At San Diego, however, which is 200 miles away, the excess was 4·6 in., and it appears likely that the abnormality at both stations was due to more widespread causes than Mr. Hatfield's chemicals.

Attempts have on many previous occasions been made to produce rain by artificial means, but the results have been uniformly unsuccessful. The reason is not difficult to see. To make the water vapour in the air condense it is necessary to cool the air in some way to a temperature below the dew point. This may be done in two ways. One may cool the air directly, for instance by the evaporation of liquid carbon dioxide or liquid air. This certainly would produce a little condensation; the fatal objection to it is that it would be thousands of times cheaper to distil sea water. The other method is to raise the air. The pressure decreases with height, and to reduce the pressure on a particular mass of air is known to cool it. The difficulty is to raise it enough. To produce an inch of rain over an area of 100 square miles requires the condensation of 6 million tons of vapour, and to achieve this some hundreds of millions of tons of air must be lifted up. The distance it must be raised depends on how nearly saturated it was originally, but it could not be less than a kilometre in ordinary fine weather conditions. We have no source of energy at our command great enough to achieve this.

It is often suggested that rain may be produced

by exploding shells or otherwise agitating the air. The action is compared with that of a trigger, a large amount of energy being released by a small effort. An essential feature is, however, overlooked. For a trigger to work, there must be a large supply of potential energy only awaiting release. Precipitation from partially saturated air would require an actual supply of new energy. Therefore a trigger action cannot produce precipitation.

Obituary.

Prof. Ch. François-Franck.

CH. FRANÇOIS-FRANCK, the distinguished physiologist, and officer of the Legion of Honour, who passed away in September last at the age of seventy, was the successor, at the Collège de France, of Marey, whose assistant he had been from the time of his arrival from Bordeaux to work for the degree of Doctor of Medicine. The acquaintance was most fortunate. Marey, always in more or less delicate health and naturally desirous of saving his strength, seldom delivered the annual course of forty lectures which necessitated so much original work—for the lectures of the Collège de France are not given for the instruction of students in preparation for examinations, but to further the advancement of science. Marey continued in his own laboratory that admirable series of experiments on the flight of birds, the motions of the horse and man, and the compilation of his book, "La Méthode Graphique," of universal renown.

François-Franck was therefore appointed by Marey to lecture in his stead, and thus he gained the opportunity of doing original work for the foundation of the lectures. His subject was the physiology of the circulation in general and of the heart and lungs in particular; and for more than thirty years François-Franck delivered the course of lectures annually. The number of experiments he made must have been enormous, for all the lectures were illustrated on the board in the room by means of most ingenious apparatus and registering instruments. The talent for exposition he possessed and the extreme precision of the details and results he showed were never forgotten by those who attended the lectures.

It was in another department of physiology that François-Franck accomplished his *magnum opus*, "La Physiologie du Cerveau," published in 1887. He was on intimate terms of friendship with Pitres, afterwards the distinguished professor of neurology at Bordeaux, who, coming with François-Franck to take the degree of Doctor of Medicine in Paris, had gone direct to Charcot at the Salpêtrière. At that time Charcot was working very hard to establish what he called "la belle doctrine" of cerebral localisation, and Pitres became his most enthusiastic and useful assistant. He engaged the interest of François-Franck in this field of work, and they began a series of experiments which ultimately was continued and terminated by François-Franck alone. The work is a remarkable production, as physiologists know, both for the originality of treatment and the extreme precision of the experiments. François-Franck also published a number of articles in the "Dictionnaire des Sciences Médicales" of Dechambre that are models of lucidity and sound learning, on the sympathetic nervous system, besides more than eighty papers or notes in the "Comptes rendus de la Société de Biologie," the meetings of which he seldom missed; he had also been a vice-president of this society. The reputation he had gained amongst physicians was such that he had become a much-sought consultant for heart and circulatory disorders and diseases, although he was never connected with any hospital.

François-Franck lived in retirement for the last few years owing to failing health, and was much missed by his scientific friends. Some twenty years ago the Academy of Medicine had most justly elected him to take a seat near the masters, Marey and Channeau, for he was the one man in France who was able to demonstrate in detail the great work of these physiologists who established the unalterable foundations of our knowledge of the functions of the heart and the circulatory organs.

E. J. Bevan.

Mr. Edward John Bevan, who died suddenly on October 17, in his sixty-fifth year, was educated at private schools, and at the age of seventeen entered the laboratory of the Runcorn Soap and Alkali Co. Thence, in 1877, he proceeded to Owens College, Manchester, where he met Mr. C. F. Cross, and the student friendship continued after the college career, each entering upon research work in connection with cellulose industries, upon which they kept up an active correspondence and a certain amount of collaboration. This resulted in a definite joint adventure, and the work was continued at the Jodrell Laboratory, Kew Gardens.

The publication of results in the Journal of the Chemical Society (1882–83) led to a research appointment with the firm of Thomson, Bonar and Co., actively engaged in the pioneer development of the "Ekman" wood pulp (cellulose) process; the work was undertaken under the formal partnership "Cross and Bevan." They were next engaged in technical research work in connection with textile bleaching processes—the "Thompson" process, the "Hermite" electrolytic process—and as a necessary incident prosecuted investigations of the alkali-boiling treatments by which