tion). This would mean 20,000 individual and fairly distinct types. Then from the weather data on any given date we could identify the weather type on that date, and the forecast for a number of days would be the successive stages in the corresponding type-series.

This method of weather forecasting is used at present, but by no means as elaborately as it should be. This I pointed out in a paper in the U. S. *Monthly Weather Review* for October, 1918.

This same paper also contained a suggestion as to a possible method of weather control, and it seems to me to be worth while to enlarge on this suggestion, for, in my opinion, it deserves actual trial. Essentially the method is the use of the "back fire" in the fighting of a prairie or forest fire.

In the first place, the local energy of a storm is undoubtedly derived from the local potential energy of a widespread unstable state, just as the local energy of a line of standing dominoes is derived from the local potential energy of the standing dominoes when the whole line is made to collapse by touching the end domino. Let us discuss the recent Porto Rico and Florida hurricane; of course the discussion will have to be based on assumed data, and we will find that the word control is rather a strong term to use for what might conceivably be accomplished.

The energy of the storm at Palm Beach came undoubtedly from a local region fifty miles or so in radius, and the local energy was released by the progressive and somewhat systematic collapse of a widely extended unstable state of the atmosphere, this progressive collapse being the whole progress of the storm movement from far beyond Porto Rico—very much like the progressive collapse of a row of standing dominoes.

Suppose we could have known of the widespread and threatening unstable state of the atmosphere in the region near the Florida coast a short time before the actual arrival of the storm at Palm Beach, and suppose that we had "touched off" this unstable state at three or four points and at three or four times in the Bahamas and along the Florida coast. We might thus have caused the local energy of the unstable state of the atmosphere to have been frittered away in several *unrelated* storm movements, each of very moderate violence, and no energy would have remained in the neighborhood to support the great systematic collapse which constituted the actual storm.

The knowledge of the threatening state of the atmosphere could certainly have been established by observations in time for the remedial measures; but how to "touch off" the unstable state of the atmosphere—that is the question which must be answered by trial.

The most promising thing to try would be as follows: Suppose that, anticipating the need in the Florida region, we had erected twenty or thirty very large steel cones, fifteen or twenty feet in diameter at the base, forty or fifty feet in diameter at the top, one hundred feet high, and open at the top. These would be distributed thinly over southern Florida and on the Bahama Islands. A large charge of gun powder (a ton or more for a cone) exploded in the base of a cone would drive the air in the cone (60,000 cubic feet of air) upwards as a gigantic vortex ring, or "smoke ring," which would carry a very considerable upward impulse to an elevation of several thousand feet, and thus start a rising column of warm, moist air in the lower strata of the atmosphere. Would this work? Nobody can tell except by trial. Would a trial cost very much? It certainly would cost several millions of dollars. Would a trial be worth while? Ask the people of southern Florida. I am purposely making what seems to me an overestimate of the size of cones required, and perhaps also an overestimate of the number.

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A FURTHER NOTE ON THE DIFFICULTIES ENCOUNTERED BY LAND VERTEBRATES IN THEIR DEVELOPMENT[1]

IN addition to the difficulty presented by the respiratory requirements of vertebrates, in emerging from water to land, one must reckon also the changes which were necessary in the uro-genital system. Further experiment and reflection on the development of the respiratory system have brought out certain new problems with reference to the tenth cranial nerve and its peripheral afferent and central nervous endings. From the point of view of the student of the phylogenetic development of the neuro-muscular mechanisms of respiration, the pulmonary components of the vagus have changed from something which every physiologist and every anatomist thought he knew about to practically unknown territory in the amphibian and in the reptile. The chapter on the respiratory mechanism is thereby lengthened. But coincident with the development of the mechanism which brought about the adjustment of vertebrates to the free, rather than to the dissolved, atmosphere, there were changes in two other systems: one, the development of an epidermis which could survive in an atmosphere containing little water vapor, and, two, the development of a mechanism to protect the young from this atmosphere and its attendant dangers until they had reached a certain stage of development. The fertilization of the ovum floating free in the

[1] F. H. Pike, SCIENCE, 59: 402, 1924.

water by sperm also floating free in the water was no longer possible in land vertebrates. From the knowledge gained by study of the development of the respiratory mechanism,[2] one may look forward to finding a similar extensive and profound change in the neuro-muscular as well as glandular mechanisms in the development of the reproductive system of land vertebrates. The internal fertilization of the ovum and its subsequent encasement in a calcareous shell is, indeed, an advance shown by reptiles and birds over fish and amphibians. The process seemed adequate for the needs of the poikilothermal reptiles which left the eggs in the sand and fared forth in search of food. With the development of homoiothermal conditions in birds the sand no longer possessed sufficient constancy of temperature. Nest-building, incubation and the consequent restriction of range during the period of incubation were necessary developments. The restriction of range would be a serious handicap to any form in which search over a considerable region is necessary for obtaining food and water. The viviparous habit, appearing sporadically in fish and reptiles, has become constant in mammals. It is difficult to imagine animals with the other characteristics of mammals but without the viviparous habit or without the development of the reproductive system of mammals.

From the point of view of the student of comparative physiology we have, in the development of the reproductive system, a shifting of old afferent, efferent and central nervous endings as well as the development of new nervous and muscular structures which is at present an unknown and unworked field. The fundamental biological need for sex arose much lower in the animal phylum than the vertebrates and seems to me to be related more to the problem of regulation of body form[3] than to some of the other phenomena which have been associated with it in biological thought. The failure of parthenogenesis in all but the simpler forms becomes intelligible or understandable when considered in relation to regulation of body form. The thing to be explained about parthenogenesis seems not so much its occurrence in some forms as its absence in the higher forms. Regulation of body form implies a regulation of some sort of growth and development of all the constituent cells of the organism. Such control would obviously be impossible if ova were parthenogenetic and likely to start development at any time. Control of development, which is a necessary postulate for regulation of body form, means also control of fertilization. Such control of fertilization could hardly exist without sex.

[2] F. H. Pike and H. C. Coombs, SCIENCE, 56: 691, 1922. M. G. Springer, "Archives of Neurology and Psychiatry," 19: 834, 1928.

[3] F. H. Pike, *Ecology*, 4: 420, 1923.

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THE INVENTION OF THE DYNAMO

THE mistake that was noted in SCIENCE concerning the celebration last spring by the Franklin Institute has been corrected by Dr. Thomson's letter. It will be interesting, I think, to give some data as to the first dynamo of which there is positive information. This was constructed by Joseph Saxton, an American, resident at the time (1833) in England. He presented a description of it to the British Association for the Advancement of Science at its meeting that year. The original instrument is now in the collection of the Franklin Institute and is figured, with many other interesting early inventions, in the article I wrote for the booklet published on the occasion (1924) of the Centennial celebration of the founding of the institute.

The *Journal* of the Franklin Institute for 1834 (vol. 17, p. 155) contains an extract of a letter from Saxton to Isaiah Lukens, of Philadelphia, in which he says among other things: "Since writing to you last I have fitted up a magnet, which I believe produces much more powerful electrical effects than any other which has yet been made. It weighs five pounds and a quarter, and has a permanent power capable of supporting ten pounds. By the aid of this magnet, I can decompose water rapidly, and the shocks given to the tongue and mouth are so violent that few will take them a second time."

The investigation as to the efficiency of the dynamos for sale in 1878 was in charge of a sub-committee composed of Messrs. E. J. Houston, Elihu Thomson and Theodore D. Rand. Mr. Rand was in the banking business and was a mineralogist of ability, who industriously searched the vicinity of Philadelphia and enriched the local collections with many valuable specimens. It is stated in the final report that "Mr. Rand's business engagements prevented his taking active part in the work of this sub-committee."

Regarding the dynamos exhibited at the Centennial Exhibition the reports and awards of Group XXV in the official volume published by the exhibition authorities (item 24, page 136) state: "Several specimens of the well known Gramme machine without steel magnet constitute this collection and some of them were shown in action producing the electric light." Another volume of the reports states that one of Farmer's machines was also exhibited.

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