themselves, yet are capable of transmitting it to others. The virus has also been found in the alimentary tract of patients and experimental animals with infantile paralysis, a fact which may explain why it is that a gastro-intestinal upset sometimes precedes and appears to be the cause of an attack of infantile paralysis. The virus has been proved to reach the patient's central nervous system, in which its main pathological action is exerted, by travelling along peripheral nerves—the sciatic, the nasal nerves, the optic nerves and tracts, for example—to the spinal cord or brain as the case may be, and this is to be regarded as the normal mode of infection in poliomyelitis; gross infection of the blood stream with the virus may also suffice to infect the brain. Evidence has been adduced to show that certain flies, particularly *Stomoxys calcitrans,* the common stable fly, may act as carriers of the disease. In addition the virus has been found on clothes, handkerchiefs and toys used by patients in the acute stages of infantile paralysis. The careful examination of washings from the mouth or intestine have shown that human beings may remain carriers of the virus for as long as six months. According to Kling, quarantine for infantile paralysis should last at least a fortnight—in New York it now lasts for ten days or thereabouts, we are told—though it is clear that no certainty attaches to any fixed period in this connection. There is reason to believe that the great majority of adults and many children may be infected with the virus without being a penny the worse for it, either because the virus is enfeebled or because the resistance of such individuals is high. Thus it is probable that every patient actually ill with the disease has in his immediate environment a number of mild and abortive cases of infantile paralysis that escape observation or detection and diagnosis, and also a still larger number of perfectly healthy people who are all carriers of the infecting agent and therefore potential sources of infection to others. It would seem as if all these persons developed a relatively high degree of immunity to the virus, a fact which may explain the comparative immunity of European towns or villages visited by epidemics of infantile paralysis to the occurrence of further epidemics during the next few years. In fact, as with cerebrospinal meningitis, the number of the carriers of the infection may be much larger in infantile paralysis than the number of the victims of an epidemic of that disease.—*The British Medical Journal.*

NOTES ON METEOROLOGY AND CLIMATOLOGY

THUNDERSTORMS OF THE UNITED STATES

A THOROUGH study of the distribution of thunderstorms has been made by Mr. W. H. Alexander with the aid of the officials in charge of more than one hundred of the regular weather bureau stations.[1] Following this, Professor R. DeC. Ward has fittingly brought out the significance of the thunderstorm as a climatic phenomenon.[2]

Thunderstorms are produced (1) by the excessive heating of the lower air; (2) by the over- and under-running of winds of different temperatures, which in some way cause moist air masses to rise rapidly; and (3) by the cooling of the upper air. These causes usually are not individually responsible for any thunderstorm; but act in conjunction.[3] Excessive heating of the lower air occurs in summer and most favorably on plains, plateaus and intermont basins. Thus in the United States the maximum number of thunderstorms is to be expected in the Mississippi Valley, and in the western mountain and plateau region. Furthermore, most come in summer: in 126 of 139 stations considered[4] the month with most thunderstorms is June, July or August. Cyclonic activity in a region subject to marked temperature changes is usually responsible for the production of thunderstorms by over-run-

[1] *Mo. Weather Rev.*, July, 1915, pp. 324–340; 13 maps.

[2] Pan-American Scientific Congress; abstract in *Mo. Weather Rev.*, December, 1915, p. 612.

[3] A comprehensive investigation of the physics of the thunderstorm was published in 1914 by Professor W. J. Humphreys. See review in SCIENCE, December 4, 1914, p. 823.

[4] H. Lyman, "Percentage Frequency of Thunderstorms in the United States," *Mo. Weather Rev.*, December, 1915, pp. 619–620.

ning and under-running winds. This leads to the winter and spring thunderstorms; particularly in the southern Mississippi Valley where the lower air is warmest and dampest. The cooling of the upper air while the lower remains relatively warm is characteristic of a marine location. With the aid of cyclones, thunderstorms produced in this way are to be expected in winter and at night. The Pacific coast region thus tends to have its thunderstorms, few at most, in winter.

For illustration, the accompanying table shows the monthly percentage frequencies of days with thunderstorms at seven stations in the United States.[4] A thunderstorm day is now defined as one on which thunder is heard whether or not rain falls at the observing station.

Station	Per Cents. of Ten-year Total Occurring in Each Month												Total Thunderstorms, 1904–1913
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
San Francisco, Cal.	12	50	12	0	0	0	0	0	0	13	0	13	8
Fresno, Cal.	3	14	16	14	16	5	3	0	11	8	5	5	37
Boston, Mass.	2	1	4	4	14	17	23	22	11	2	2	1	180
New York, N. Y.	1	1	3	9	14	18	25	19	9	3	0	0	284
Chicago, Ill.	2	1	6	8	15	16	17	16	12	4	2	0	400
Santa Fé, N. Mex.	0	1	3	4	9	15	29	24	12	3	0	0	732
Tampa, Fla.	1	2	3	3	10	17	24	22	14	3	0	1	944

At San Francisco, atmospheric instability does not often occur in summer. Fresno has its maximum early probably because the air is too dry in mid-summer. The other stations have the greatest number in summer. Boston, New York and Chicago all have an abundance of moisture. The greater number of thunderstorms in Chicago for the year, and particularly in spring, as compared with New York and Boston, is due to its continental position and exposure to rapid temperature changes. The interior location favors more rapid warming in spring than is the case in the east. Even New York appears markedly more continental than Boston. It is noteworthy that there are more thunderstorms in May than in September: May is moister; and the upper air is colder. The great thunderstorm activity at Santa Fé is favored by the mountain location (altitude 7,013 feet) east of the Rio Grande. In June, July and August there is, on the average, a thunderstorm every other day. Thunderstorms are less than half as frequent at the drier, lower places such as El Paso. Tampa has more thunderstorms than any other weather bureau station in the United States. In the three summer months, thunderstorms occur on about two days out of three. The summer on-shore winds supply abundant moisture and the intense sunlight at this low latitude effectively overheats the lower air. Thus the joint distribution of atmospheric instability and moisture dominate thunderstorm frequency.

Parts of Professor Ward's abstract are quoted here:

"As essential characteristics of American climate, thunderstorms have a broad human interest. From the viewpoint of climatology, the distribution of thunderstorms is of more interest than their mechanism. The part played by their rains in watering our crops is of greater importance than the size of the raindrops. The damage done by their lightning[5] and hail[6] concerns us more than the cause of the lightning flash or than the origin of the hailstorms. The thunderstorms of the eastern United States are among the most characteristic of American climatic phenomena. In size, intensity and frequency of occurrence they are unique.

"In relation to man's activities, it is of significance that most thunderstorms occur at a time of year and at the hours when outdoor activities are at their height.

"Thunderstorms bring us much that is of benefit. To them we owe much, in parts of our country even most, of our spring and summer rainfall. Without these beneficent thunderstorms our great staple crops east of the Rocky Mountains would never reach maturity. One good thunderstorm over a considerable area at a critical crop stage is worth hundreds of thousands of dollars to American farmers. Our stock markets time and again

[5] See note on "Thunder and Lightning," SCIENCE, N. S., Vol. XLII., 1915, p. 252.

[6] See note on "Hail," below.

show the favorable reaction of such conditions upon the prices of cereals and also of railroad and other stocks. Thundershowers break our summer droughts, cleanse our dusty air, refresh our parched earth, replenish our failing streams and brooks, bring us cool evenings and nights after sultry and oppressive days."

HAIL

Hail consists of particles of ice from the size of peas to that of oranges or larger which fall from the clouds. True hail, which is usually a summer phenomenon, and is characterized generally by a central core of cloudy ice surrounded by one or more layers of clear ice, should not be confused with the small ice pellets of winter. Hail rarely occurs without a thunderstorm, of which hail may be said to be a violent manifestation. Thus the distribution of hail is limited, and patchy, falling sometimes on parallel strips of land in the same thunderstorm. As hail is an accompaniment of thunderstorms, it occurs in the warm southeast quadrant of a cyclone, or associated with the over- and under-running winds on a wind-shift line. For example, the passage of a wind-shift line over the region from Illinois to Maryland, June 20 to 22, 1915, was accompanied locally by very large hail: "teacups" in Illinois and "baseballs" in Maryland.[7] The annual and diurnal periods of hail occurrence are much the same as those of thunderstorms, although more marked. Thus, in the United States, the month with most hail is May, and the time of day, mid-afternoon; while least hail falls in winter and in the early morning. In distribution over the earth, there is least hail in the polar regions where the air seldom has sufficient moisture or is sufficiently unstable to satisfy hail requirements. On the other hand, near the equator at sea-level hail rarely occurs because the freezing level is too high and the lower air too warm to permit hailstones to reach the earth's surface. Hail may fall on the ocean with the passage of a wind-shift line. Its greatest development comes in the subtropical deserts: there the most frightful hailstorms occur—storms in which men and beasts not killed outright may be frozen to death under the hail.

The annual and diurnal periods and the local distribution just mentioned are easily explained as follows: the moister and the warmer the lower air, and the colder the upper air, the faster and the farther will the warm air rise; and the greater is the opportunity for hail formation. The moisture comes from the lower air, the cold from the expansion of this air on rising. For instance, a mass of air at 30° C. and with a relative humidity of 50 per cent. will reach 0° at 4.8 kilometers, and —20° at 7.9 kilometers' altitude, mixing being disregarded. Hail clouds frequently tower 8 or 10 kilometers above the earth's surface. Apparently, hail originates when snow crystals begin to form among raindrops, which are usually carried up into the level where the temperature is below freezing. A snow-flake and an undercooled drop freeze together into the opaque ice that forms the core of a hailstone. As this ice particle falls through the layer of undercooled raindrops, which may be 3 to 4 kilometers thick, a layer of ice is added. Then it may be caught in one of the tornadic whirls, which evidently occur within thunderstorms, and carried aloft. On being released, perhaps near the top of the cloud, it may accumulate another layer of ice on the way down. This cycle may be repeated many times. Finally, when too heavy to be held in the uprushing currents, or when the whirl collapses, the hail, congealing moisture on its cold surface as it falls, may descend to earth. For example, some of the larger hailstones, 3 to 4 inches in diameter, falling in Annapolis, June 22, 1915, had 20 to 25 layers of ice. The hail was of diverse shapes.[8] That hail must return to the upper part of the cloud after having grown to a considerable size is evident from the temperatures of —5 to —15° C. observed in hailstones. Hail does not occur in spite of hot weather, but because of the heat.[9]

[7] See O. L. Fassig, *Monthly Weather Rev.*, September, 1915, pp. 446–448; and "Climatological Data for the United States by Sections," Vol. 2, June, 1915, Illinois, Indiana, West Virginia and Maryland sections.

[8] See Fassig, *ibid.*

Hail damage is both local and occasional. In some countries, particularly in France, reliance is placed in cannon, rockets or lightning rods to protect crops from hail. Professor Angot, head of the French Meteorological Service, stigmatized these as useless. For example, "the Observatoire de Bordeaux, situated in Floirac . . . was . . . provided with a 'niagara' (lightning rod) September 22, 1912. The commune of Floirac was devastated by hail on August 15, 1887; but for the succeeding 25 years it had been immune. Again in 1912, two disastrous falls of hail occurred at Floirac, one on July 5, before the installation of the 'niagara,' the second on October 20, when a heavy shower of very large hard hailstones fell upon the 'niagara' itself during a period of 2½ minutes."[10] Hail insurance, however, is the usual mode of protection. Insurance companies are without adequate means for fixing the premiums because the average occurrence of hail can hardly be mapped without an excessive number of stations and a very long period of observations. Hail damage is at times extreme. For instance, in South Carolina, July 6 to 7, 1914, crop losses estimated at $955,000 were sustained over an area of about 50,000 acres of crop land. The damage was done mostly by immense quantities of hailstones the size of ordinary marbles.[11] Hail at times destroys live stock also. Thus in Illinois on June 20, 1915, 50 shoats, some sheep and cattle were reported to have been killed by hail. The skulls and backs of some of the hogs were said to have been broken.[12] In cities, skylights, windows and greenhouses sustain the most damage. Plate glass even 1 to 2 centimeters thick may be shattered. Horses frequently and people occasionally are injured.

[9] The material for the summary above, except as specified in foot-notes 7 and 8, was taken from J. von Hann's "Lehrbuch der Meteorologie," Leipzig, 1915, pp. 708–725.

[10] See translation, *Monthly Weather Rev.*, March, 1914, p. 166.

[11] "Climatological Data: South Carolina Section," Vol. 1, July, 1914, p. 56.

[12] "Climatological Data: Illinois Section," Vol. 2, June, 1915, p. 43.

Damage by other features of thunderstorms such as the squall and lightning, is, in general, much greater than the occasional hail destruction. Nevertheless, hail can destroy crops as completely as a tornado or a flood.

R. H. SCOTT, 1833–1916

ONE of the pioneers in synoptic meteorology, Dr. R. H. Scott, died in England, June 18. He was well known as the chief of staff of the Meteorological Office from the formation of the Royal Society's Meteorological Committee in 1867 until his retirement on a pension in 1900. He was also secretary of the International Meteorological Committee from its commencement in 1874, until 1900. In 1861, Fitzroy had begun the issue of forecasts and storm warnings, based on information collected daily by telegraph and charted on maps. The issue of forecasts and storm warnings was suppressed; but at the request of the board of trade the issue of storm warnings was at once revived. The telegraphic service was developed, and the first result of Scott's work appeared in 1876 in a little book, entitled "Weather Charts and Storm Warnings." The issue of forecasts was recommenced on April 1, 1879, and has continued ever since. This was followed in 1883 by Scott's "Elementary Meteorology," which took foremost place as a text-book of meteorology. From that time onward Scott devoted his attention mainly to the administration of the office and to the work of the Meteorological Society.[13]

ALEKSANDR IVANOVICH VOEIKOV, 1842–1916

VOEIKOV (Woeikow), the eminent meteorologist and geographer, died in Petrograd, January 28 (February 10), 1916. He was born in Moscow, and while still young traveled widely in Europe, Asia and the two Americas. In 1884 he published his great work, "The Climates of the World" (German translation, 1887). The following year he was appointed professor of physical geography at the Univer-

[13] From W. N. Shaw, *Nature*, London, Vol. XCVII., 1916, p. 365. A history of British weather forecasting and an account of the organization and work of the Meteorological Office in London is published in the *Monthly Weather Rev.*, September, 1915, pp. 449–452.

sity of St. Petersburg, and later, director of the meteorological observatory there. His meteorological work which was very comprehensive centered most, perhaps, on the relations between the temperatures of air, ground, oceans and lakes. In 1904, Voeikov published "Meteorologia," a handbook of 719 pages in Russian, and at present the leading meteorological text in that language. As a geographer, he is noted particularly for his publications on the rôle of the Pacific Ocean in the world's affairs, an article on the regeneration of Russia, and a French work "Le Turkestan russe." [14]

NOTES

Prince Boris Borisovitch Galitzine died at Petrograd, after a short illness, on May 4 (17), of this year, at the age of 54 years. For the past three years he was director of the meteorological service of the Russian Empire. He is best known for his distinguished work in seismology.[15]

Sir William Ramsay, "the father of the new physical chemistry," and England's foremost chemist, died July 24, 1916. His contribution to meteorology, conjointly with Lord Rayleigh, was the discovery of the four noble atmospheric gases: argon, neon, krypton and xenon. Nitrogen derived from air was found to be denser than that obtained from other sources. By heating atmospheric nitrogen repeatedly with metallic magnesium Ramsay obtained a denser and denser gas which proved to be quite different from nitrogen. At the same time, Lord Rayleigh was able to separate nitrogen from possible impurities by repeating with modern apparatus an experiment devised by Cavendish. These two investigators continuing jointly discovered argon, first of a new class of elements. Incidental experimenting with liquid air led to the discovery of three other elements of this same type—neon, krypton and xenon.[16]

[14] See *Monthly Weather Rev.*, May, 1916, pp. 288–289.

[15] See *Nature, London,* Vol. XCVII., 1916, p. 424.

[16] *Scientific American,* August 5, 1916, p. 117.

Early this year Dr. Th. Hesselberg became director of L'Institut meteorologique de Norvege, Kristiania.

German meteorological magazines dated February, 1915, seem to have been the last ones received in this country.

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SPECIAL ARTICLES

THE BROMINE CONTENT OF PUGET SOUND NEREOCYSTIS (GIANT KELP)

It seems strange indeed that scarcely any mention is made in the American technical literature of the presence of bromine in the seaweeds of the Pacific coast, especially those seaweeds which have been termed "kelp." Available analytical data on the quantities of bromine from the above source is negligible.

The writer considers this to be due to one or more of several possible reasons. Perhaps, if bromine has been previously detected, it was not considered to be present in quantities large enough to be of importance. The content of bromine must vary considerably in amount in the various varieties and species of seaweeds. Either it does not occur in certain species or varieties, or the same variety from different localities contains it in widely different proportions. Again, the difficulty met with in determining bromine quantitatively in the presence of an excess of the other haloid salts is a contending factor in the production of analytical data upon this subject.

A personal experience, which attracted my attention to the bromine content of seaweed, may prove interesting at this point. Some two years ago, while teaching chemistry in the College of Puget Sound, Tacoma, Wash., it was my privilege to often walk along the beach at The Narrows, especially during the time of low tide. The Narrows is situated about four miles west of the city of Tacoma, and borders the mainland on the west and a strip of beach, known as Day Island, on the east. The channel of the sound is less than a half-mile wide