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XVIII. *Essay on the Gales experienced in the Atlantic States of North America.* By ROBERT HARE, M.D. Professor of Chemistry in the University of Pennsylvania*.

OF the gales experienced in the Atlantic States of North America, those from the north-east and north-west are by far the most influential: the one, remarkable for its dryness—the other, for its humidity. During a north-western gale, the sky, unless at its commencement, is always peculiarly clear, and not only water, but ice, evaporates rapidly. A north-east wind, when it approaches to the nature of a durable gale, is always accompanied by clouds, and usually by rain or snow. The object of the following essay, is to account for this striking diversity of character.

When, by a rise of temperature, the lower portions of a non-elastic fluid are rendered lighter than those which are above them, an exchange of position must ensue. The particles which were coldest at first, after their descent, becoming the warmest, resume their previous elevation; from which they are again displaced by warmer particles. Thus, the temperatures reversing the situations, and the situations reversing the temperatures, a circulation is kept up, tending to restore the equilibrium.

Precisely similar would be the case with our atmosphere, were it not an elastic fluid, and dependent for its density on pressure as well as on heat. Its temperature would be much more uniform than at present—and all its variations would be gradual. An interchange of position would incessantly take place, between the colder air of the upper regions, and the warmer, and of course lighter, air, near the earth's surface, where there is the most copious evolution of solar heat. Currents would incessantly set from the poles to the equator below, and from the equator to the poles above. Such currents would constitute our only winds, unless where mountains might produce some deviations. Violent gales, squalls, or tornadoes, would never ensue; gentler movements would anticipate them. But the actual character of the air, with respect to elasticity, is the opposite of that which we have supposed. It is perfectly elastic. Its density is dependent on pressure, as well as on heat; and it does not follow, that air which may be heated, in consequence of its proximity to the earth, will give place to colder air from above. The pressure of the atmosphere varying with the elevation, one stratum of air may be as much rarer by the diminution of pressure, consequent to its altitude,

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as denser by the cold, consequent to its remoteness from the earth—and another may be as much denser by the increased pressure arising from its proximity to the earth, as rarer, by being warmer. Hence when unequally heated, different strata of the atmosphere do not always disturb each other. Yet after a time, the rarefaction in the lower stratum, by greater heat, may so far exceed that in an upper stratum, attendant on an inferior degree of pressure, that this stratum may preponderate, and begin to descend. Whenever such a movement commences, it must proceed with increasing velocity; for the pressure on the upper stratum, and of course its density and weight, increases as it falls; while the density and weight of the lower stratum must lessen as it rises. Hence the change is at times so much accelerated, as to assume the characteristics of a tornado, squall, or hurricane. In like manner may we suppose the predominant gales of our climate to originate. Dr. Franklin long ago noticed, that north-eastern gales are felt in the southwesternmost portions of the continent first; the time of their commencement being found later, as the place of observation is more to the windward.

The Gulf of Mexico is an immense body of water—warm, in the first place, by its latitude,—in the second place, by its being a receptacle of the current produced by the trade-winds, which blow in such a direction as to propel the warm water of the torrid zone into it, causing it to overflow and produce the celebrated Gulf stream, by the ejection, to the north-east, of the excess received from the south-east. This stream runs away to the northward and eastward of the United States, producing an unnatural warmth in the ocean, as well as an impetus, which, according to Humboldt, is not expended until the current reaches the shores of Africa, and even mixes with the parent flood under the equator. The heat of the Gulf stream enables mariners to ascertain by the thermometer when they have entered it: and in winter, this heat, by increasing the solvent power of the adjoining air, loads it with moisture—which, on a subsequent reduction of temperature, is precipitated in those well-known fogs with which the north-eastern portion of our continent, and the neighbouring seas and islands, especially Newfoundland and its banks, are so much infested. An accumulation of warm water in the Gulf of Mexico, adequate thus to influence the ocean at the distance of two thousand miles, may be expected, in its vicinity, to have effects proportionally powerful. The air immediately over the Gulf must be heated, and surcharged with aqueous particles. Thus it will become comparatively light: first, because it is comparatively warm; and in the next place, because aqueous vapour,

vapour, being much lighter than the atmospheric air, renders it more buoyant by its admixture.

Yet the density, arising from inferiority of situation in the stratum of air immediately over the Gulf, compared with that of the volumes of this fluid lying upon the mountainous country beyond it, may to a certain extent more than compensate for the influence of the heat and moisture derived from the Gulf: but violent winds must arise, as soon as these causes predominate over atmospheric pressure, sufficiently to render the cold air of the mountains heavier.

When, instead of the air covering a small portion of the mountainous or table land in Spanish America, that of the whole north-eastern portion of the North American continent is excited into motion, the effects cannot but be equally powerful, and much more permanent. The air of the adjoining country, first precipitates itself upon the surface of the Gulf, and afterwards, that from regions more distant. Thus a current from the north-eastward is produced below. In the interim, the air displaced by this current rises, and being confined by the table land of Spanish America, and in part, possibly, by the trade-winds, from passing off in any southernly course, it is, of necessity, forced to proceed over our part of the continent, forming a south-western current above us. At the same time its capacity for heat being enlarged, by the rarefaction arising from its increased altitude, much of its moisture will be precipitated; and the lower stratum of the south-western current, mixing with the upper stratum of the cold north-eastern current below, there must be a prodigious condensation of aqueous vapour.

The reason is obvious why this change is productive only of north-eastern gales—and that we have not northern gales, accompanied by the same phænomena. The course of our mountains is from the north-east to the south-west. Thus no channel is afforded for the air proceeding to the Gulf, in any other course, than that north-eastern route which it actually pursues.

That the table lands of Mexico are competent to prevent the escape over them of the moist warm air displaced from the surface of the Gulf, must be evident from the peculiar dryness of their climate—and the testimony of Humboldt. According to this celebrated traveller, the clouds formed over the Gulf never rise to a greater height than four thousand nine hundred feet; while the table land, for many hundred leagues, lies between the elevation of seven and nine thousand feet. Consistently with the chemical laws which have been experimentally ascertained to operate throughout nature, air, which

which has been in contact with water, can neither be cooled nor rarefied, without being rendered cloudy by the precipitation of aqueous particles. It follows, that the air displaced suddenly from the surface of the Gulf of Mexico, by the influx of cold air from the north-east, never rises higher than the elevation mentioned by Humboldt as infested by clouds. Of course it never crosses the table land, which, at the lowest, is 2000 feet higher.

Our north-western winds are produced, no doubt, by the accumulation of warm moist air upon the surface of the ocean, as those from the north-east are by its accumulation on the Gulf of Mexico. But in the case of the Atlantic, there are no mountains to roll back upon our hemisphere the air displaced by the gales which proceed from it, and to impede the impulse, thus received, from reaching the eastern continent. Our own mountains may procrastinate the flood, and consequently render it more lasting and violent, when it can no longer be restrained. The direction of the wind is naturally at right angles to the boundary of the aquatic region producing it, and to the mountainous barrier which delays the crisis.

The course of the North American coast is, like that of its mountains, from north-east to south-west; and the gales in question are always nearly north-west, or at right angles to the mountains and the coast. The dryness of our north-west wind may be ascribed not only to its coming from the frozen zone, where cold deprives the air of moisture, but likewise to the circumstance above suggested, that the air of the ocean is not, like that of the Gulf, forced back over our heads to deluge us with rain.

Other important applications may be made of our chemical knowledge. Thus, in the immense capacity of water for heat, especially when vaporized, we see a great magazine of nature provided for mitigating the severity of the winter.—To cool this fluid, a much greater quantity of matter must sustain a proportionable increase of its sensible heat.—Aqueous vapour is incessantly a vehicle for conveying the caloric of warmer climates to colder ones. Mistaking the effect for the cause, snow is considered as producing cold, by the ignorant; but it has been proved, that as much heat is given out during the condensation of aqueous vapour as would raise twice its weight of glass to a red heat. Water, in condensing from the aëri-form state, will raise ten times its weight one hundred degrees. The quantum of caloric which can raise ten parts one hundred degrees, would raise one part one thousand degrees nearly (or to a red heat visible in the day); and this is independent of the caloric of fluidity, which would increase the result.

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Further,

Further, The quantum of heat which would raise water to 1000, would elevate an equal bulk of glass to 2000. Hence we may infer, that from every snow there is received twice as much caloric as would be yielded by an equal depth of red-hot powdered glass.

It is thus that the turbulent wave, which at one moment rocks the mariner's sea-boat on the border of the torrid zone, transformed into a cloud, and borne away towards the arctic, soon after supports the sledge or the snow-shoe of an Esquimaux or Greenlander; successively cooling or warming the surrounding media, by absorbing or giving out the material cause of heat.

XIX. *On the Number and Situation of the Magnetic Poles of the Earth.* By Professor CHRISTOPHER HANSTEEN*.

THE attraction of iron by the magnet was known to the naturalists of Greece and Rome, but it is uncertain at what time the Europeans became acquainted with that remarkable property of the magnet which we call Polarity; distinct traces, however, of the use of the compass are found towards the end of the twelfth century. There is no doubt that the Chinese knew it long before, and it is very probable that the Venetians obtained some information respecting it while trading on the Red Sea.

Our Northern ancestors were in this respect not behind the inhabitants of Southern Europe, as may be seen in the *Landnamabok*, part i. chap. 2 and 7, where we are told that the famous Viking Floke Vilgerdason, the third discoverer of Iceland, who sailed about the year 868 from Rogaland in Norway, in order to seek for *Gardarsholm* (Iceland), took three ravens with him, which were to serve him as guides. For on letting birds fly on the open sea, and finding them to return, it was considered as a sign of there being no land near. But if they flew away, the vessel followed them, with a view of reaching the nearest shore. In order to consecrate these ravens for his purpose, Floke offered up a great sacrifice at *Smörsund*, where the ships lay ready for sailing; for "at that time the navigators in the Northern countries had no magnets" (*þvíat þá höfðu hafsiglingarmen engir leidarstein i þan þima á norderlöndum*). As the *Landnamabok* was apparently written at

* From Dr. Kämtz's translation into German of the original memoir, published in the *Magazin for Naturvidenskaberne*, udgivet af Professorer ne Lundh, Hansteen og Muschmann, vol. i. p. 1—46.