Notices of Tornadoes, &c.;

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HARE, Robert
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HARE, Robert. NOTICES
OF TORNADOES, &c.

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Notices of Tornadoes, &c.; by ROBERT HARE, M. D., Professor of Chemistry in the University of Pennsylvania.

I. *Account of a Tornado, which passed over Providence, and the Village of Somerset, R. I., in August,* 1838.*

I PROPOSE to lay before the Society, for a place in their Transactions, an account of a tornado which occurred in the state of Rhode Island, towards the end of August last.

This phenomenon was first observed near Providence, over the south-western suburbs of which it passed in a course generally from west by north, to south by east. Only a few days subsequently I visited some of the most remarkable scenes of its ravages.

The characteristics of this tornado, from all that I could see or hear, are quite similar to those of the tornado which occurred at New Brunswick, N. J. in June, 1835, and to which I referred in my paper upon the causes of tornadoes and water-spouts, published in the sixth volume of the Society's Transactions.

This recent tornado was advantageously seen by J. L. Tillinghast, Esq. from a window of his mansion, which is so situated, on the brow of a hill on the eastern side of the city of Providence, as to afford an unobstructed view of the country opposite. Mr. Tillinghast alledges that his attention was at first attracted by seeing to the westward a huge inverted cone, of extremely dark vapor, which extended from the clouds to the earth. In the contortions and spiral movements of its lower extremity, this cone was conceived to resemble the proboscis of an enormous elephant, moving about in search of food. Sometimes it was elongated so as to reach the ground; at others it skipped over the intervening space without touching it; but at each contact with the terrestrial surface or bodies resting thereon, a cloud of dust intermingled with their fragments, was seen to rise within the vortex. To those who were sufficiently near to the meteor, a fearful explanation of these appearances was simultaneously evident. Ponds were partially exhausted. Trees uprooted or deprived of their leaves or branches. Houses were unroofed, or uplifted and then

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* From the Transactions of the American Philosophical Society.

dashed to pieces. Farms were robbed of their grain, potatoes, fruit trees or poultry: nor were human beings secure from being carried aloft, and more or less injured by subsequent descent. It was alledged that at Somerset two women were carried from a wagon over a wall, into an adjoining field. Within the same village a cellar door frame, with its doors bolted, was lifted, and then deposited on one side of its previous position; although situated to windward of the mansion to which it belonged. This result was the more striking, because, in consequence of their presenting an inclined plane to the blast, the doors and their frames would have been pressed more firmly upon their foundation by an ordinary wind. In consequence of the same dilatation of the air within the house, which lifted the cellar door, the weather-boarding on the leeward side was burst open, while that to the windward was undisturbed.

About four o'clock on the afternoon during which this tornado passed near Providence, there was heard at the farm at which I resided, twenty-five miles south of Providence and about fifteen miles from Somerset, the loudest thunder which I ever experienced. It made the house in which I was tremble sensibly.

I have received from an estimable friend, Mr. Allen, a most interesting account of this tornado, which passed over the river, and there produced the appearance of a water-spout, while he was sufficiently near for accurate observation. In one respect his narrative tends to justify my opinion, that the exciting cause of tornadoes is electrical attraction. In two instances in which flashes of lightning proceeded from the water, Mr. Allen remarked that the effervescence produced by the tornado in the water very perceptibly subsided.*

Extract from a Letter written by Zachariah Allen, Esq., of Providence.

"It was about three o'clock, P. M., during a violent shower, that I observed a peculiarly black cloud to form in the midst of light, fleecy clouds, and to assume a portentous appearance in the heavens, having a long, dark, tapering cone of vapor extending from it to the surface of the earth. The form of this black cloud, and of the cone of vapor depending from it, so nearly resembled

* See Essay on the Cause of Tornadoes or Water-spouts in sixth vol. American Philosophical Transactions, or in Silliman's Journal, vol. 32, for 1837.

the engraved pictures of 'water spouts' above the ocean, which I had frequently seen, that I should have come speedily to the conclusion that one of these 'water spouts' was approaching, had I not been aware that this phenomenon occupied a space in the heavens directly over a dry plain of land. Whilst attentively watching the progress of the cloud, with its portentous dark cone trailing its point in contact with the surface of the earth, I noticed numerous black specks, resembling flocks of blackbirds on the wing, diverging from the under surface of the clouds, at a great elevation in the air, and falling to the ground. Among these were some objects of larger size, which I could discern to be fragments of boards, sailing off obliquely in their descent. This alarming indication left no room for doubt that a violent tornado was fast approaching, and that these distant, dark specks were fragments of shingles and boards uplifted high in the air, and left to fall, from the outer edge of the black conical cloud. This fearful appearance was repeatedly exhibited, as often as the tornado passed over buildings.

"The whirlwind soon swept towards an extensive range of buildings, within a few yards of me, the roof of which appeared to open at the top, and to be uplifted for a moment. The whole fabric then sunk into a confused mass of moving rubbish, and became indistinctly visible amid the cloud that overspread it, as with a mantle of mist.

"The destructive force of the tornado now became not only apparent to the eye, but also fearfully terrific, from the deafening crash of breaking boards and timbers, startling the amazed spectator in alarm for his personal safety, amid the roar of the whirlwind, and the shattered fragments flying like deadly missiles near him. At one instant, when the point of the dark cone of cloud passed over the prostrate wreck of the building, the fragments seemed to be upheaved, as if by the explosion of gunpowder, and I actually became intensely excited with the fear that the moving mass might direct its march towards the open area of the yard, to which I had resorted, after abandoning a building in which I had previously found shelter.

"Fortunately the course of the tornado was not over the building used as a depot by the Stonington Rail-road Company in Providence, where there was a numerous assemblage of passengers awaiting the departure of the cars; otherwise several lives might have been lost.

"The most interesting appearance was exhibited when the tornado left the shore, and struck the surface of the adjacent river. Being within a few yards of this spot, I had an opportunity of accurately noting the effects produced on the surface of the water.

"The circle formed by the tornado on the foaming water was about three hundred feet in diameter. Within this circle the water appeared to be in commotion, like that in a huge boiling cauldron; and misty vapors, resembling steam, rapidly arose from the surface, and entering the whirling vortex, at times veiled from sight the centre of the circle, and the lower extremity of the overhanging cone of dark vapor. Amid all the agitation of the water and the air about it, this cone continued unbroken, although it swerved and swung around, with a movement resembling that of the trunk of an elephant whilst that animal is in the act of depressing it to the ground to pick up some minute object. In truth, the tapering form, as well as the vibrating movements of the extremity of this cone of vapor, bore a striking resemblance to those of the trunk of that great animal.

"Whilst passing off over the water, a distant view of the cloud might have induced the spectator to compare its form to that of a huge umbrella suspended in the heavens, with the column of vapor representing the handle, descending and dipping into the foam of the billows. The waves heaved and swelled, whenever the point of this cone passed over them, apparently as if some magical spell were acting upon them by the effect of enchantment. *Twice I noticed a gleam of lightning, or of electric fluid, to dart through the column of vapor, which served as a conductor for it to ascend from the water to the cloud. After the flash the foam of the water seemed immediately to diminish for a moment, as if the discharge of the electric fluid had served to calm the excitement on its agitated surface.*

"The progress of the tornado was nearly in a straight line, following the direction of the wind, with a velocity of perhaps eight or ten miles per hour.

"Near as I was to the exterior edge of the circle of the tornado, I felt no extraordinary gust of wind; but noticed that the breeze continued to blow uninterruptedly from the same quarter from which it prevailed before the tornado occurred.

"I also particularly observed that there was no perceptible increase of temperature of the air adjacent to the edge of the whirlwind, which might have caused an ascending current by a rarefaction of a portion of the atmosphere. After passing over the sheet of water, and gaining the shore, I observed the shingles and fragments of a barn to be elevated and dispersed high in the air; and the dark cloud continued to maintan the same appearance which it at first presented, until it passed away beyond the scope of a distinct vision of its misty outlines.

"The above imperfect sketch can convey to your mind only a feeble impression of this exciting scene, which in passing before me excited just enough of terror to impart to the spectacle the most awful sense of the power, sublimity and grandeur of the Almighty, as described in the glowing words of the Psalmist. 'He bowed the heavens also, and came down; and darkness was under his feet; and he did fly upon the wings of the wind. He made darkness his secret place; his pavilion round about him were dark waters and thick clouds of the skies.'"

II. *At Chatenay, near Paris.*

To the Editors of the National Gazette.

Messrs. Editors—You had published a memoir on tornadoes by a distinguished foreigner, Œrsted. Conceiving the impression conveyed by that article less worthy of consideration than those which had been presented in a memoir which I had previously published, I hope that I shall be considered as having had a sufficient incentive for endeavoring through the same channel to correct the erroneous impressions which that memoir was in my opinion of a nature to produce.

In my letter to you of the 26th ult. it was stated that I considered tornadoes as the consequence of an electrical discharge superseding the more ordinary medium of lightning. From an article which has since met my attention in the Journal des Debats, published on the 17th of July at Paris, it appears that a tremendous tornado occurred about the last of the preceding June in the vicinity of that metropolis. The losers applied for indemnity to certain insurers, who objected to pay on the plea that the policies were against thunder storms not against tornadoes. This led to an application to the celebrated Arago, who referred the case to another savant, Peltier.

From the report of Peltier, of which I subjoin a translation, it will be seen that, excepting his neglect of the co-operative influence of the elasticity of the air, he sanctions my opinion that a tornado is the effect of an electrical discharge.*

"Yesterday," says Peltier, "I visited the commune of Chatenay in the canton of Ecouen, department of Seine and Oise, and investigated the disasters experienced in the month of June last, from a tornado which first originated over the valley of Fontenay des Louvres. At present I can give only a summary account of this wonderful phenomenon.

"Early in the morning a thunder cloud arose to the south of Chatenay, and moved at about ten o'clock over the valley between the hills of Chatenay and those of Ecouen. The cloud having extended itself over the valley, appeared stationary and about to pass away to the west. Some thunder was heard but nothing remarkable was noticed, when about midday a second thunder storm coming also from the south and moving with rapidity advanced towards the same plain of Chatenay. Having arrived at the extremity of the plain above Fontenay, opposite to the first mentioned thunder cloud, which occupied a higher part of the atmosphere, it stopped at a little distance, leaving spectators for some moments uncertain as to the direction which it would ultimately take. That two thunder clouds should thus keep each other at a distance, led to the impression that being charged with the same electricity, they were rendered reciprocally repellent, and that a conflict would ensue in which the terrestrial surface would play an important part. Up to this time there had been thunder continually rumbling within the second thunder cloud, when suddenly an under portion of this cloud descending and entering into communication with the earth, the thunder ceased. A prodigious attractive power was exerted

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* I had presented copies of the pamphlet containing my memoir to M. Arago and several other members of the Institute. In a subsequent conversation he referred to some of the suggestions which it contained. As it conveyed a view of the question decisively favorable to the claimants, it may be inferred that it must have been alluded to by Arago and thus have become the source of Peltier's impressions. It may therefore be anticipated that due acknowledgment will be hereafter made by him when he realizes his promise of making a more elaborate report on the tornado of Chatenay. Before entering upon the arguments by which I sustained my hypothesis it was briefly stated in the following words: "*After maturely considering all the facts I am led to suggest that a tornado is the effect of an electrified current of air superseding the more usual means of discharge between the earth and clouds, in those vivid sparks which we call lightning.*"

forthwith, all the dust and other light bodies which covered the surface of the earth mounted towards the apex of the cone formed by the cloud. A rumbling thunder was continually heard. Small clouds wheeled about the inverted cone rising and descending with rapidity. An intelligent spectator, M. Dutour, who was admirably placed for observation, saw the column formed by the tornado terminated at its lower extremity by a cap of fire; while this was not seen by a shepherd, Oliver, who was on the very spot, but enveloped in a cloud of dust.

"To the southeast of the tornado, on the side exposed to it, the trees were shattered, while those on the other side of it preserved their sap and verdure. The portion attacked appeared to have experienced a radical change, while the rest were not affected. The tornado having descended into the valley at the extremity of Fontenay, approached some trees situated along the bed of a rivulet, which was without water though moist. After having there broken and uprooted every tree which it encountered, it crossed the valley and advanced towards some other trees, which it also destroyed. In the next place, hesitating a few moments as if uncertain as to its route, it halted immediately under the first mentioned thunder cloud. This although previously stationary, now began as if repelled bythe tornado, to retreat towards the valley to the west of Chatenay. The tornado after stopping as I have described, would infallibly on its part, have moved on towards the west to a wood in that direction, if the other thunder cloud had not prevented it by its repulsion. Finally it advanced to the park of the castle of Chatenay, overthrowing every thing in its path. On entering this park, which is at the summit of a hill, it desolated one of the most agreeable residences in the neighborhood of Paris. All the finest trees were uprooted, the youngest only, which were without the tornado, having escaped. The walls were thrown down, the roofs and chimneys of the castle and farmhouse carried away, and branches, tiles and other movable bodies, were thrown to a distance of more than five hundred yards. Descending the hill towards the north, the tornado stopped over a pond, killed the fish, overthrew the trees, withering their leaves, and then proceeded slowly along an avenue of willows, the roots of which entered the water, and being during this part of its progress much diminished in size and force, it proceeded slowly over a plain, and finally at the distance of more than a thousand

yards from Chatenay, divided into two parts, one of which disappeared in the clouds, the other in the ground.

"In this hasty account I have, with the intention of returning to this portion of the subject, omitted to speak particularly of its effect upon trees. All those which came within the influence of the tornado, presented the same aspect; their sap was vaporized, and their ligneous fibres had become as dry as if kept for forty eight hours in a furnace heated to ninety degrees above the boiling point. Evidently there was a great mass of vapor instantaneously formed, which could only make its escape by bursting the tree in every direction; and as wood has less cohesion in a horizontal longitudinal than in a transverse direction, these trees were all, throughout one portion of their trunk, cloven into laths. Many trees attest, by their condition, that they served as conductors to continual discharges of electricity, and that the high temperature produced by this passage of the electric fluid, instantly vaporized all the moisture which they contained, and that this instantaneous vaporization burst all the trees open in the direction of their length, until the wood, dried up and split, had become unable to resist the force of the wind which accompanied the tornado. In contemplating the rise and progress of this phenomenon, we see the conversion of an ordinary thunder gust into a tornado;* we behold two masses of clouds opposed to each other, of which the upper one, in consequence of the repulsion of the similar electricities with which both are charged, repelling the lower towards the ground, the clouds of the latter descending and communicating with the earth by clouds of dust and by the trees. This communication once formed, the thunder immediately ceases, and the discharges of electricity take place by means of the clouds which have thus descended, and the trees. These trees, traversed by the electricity, have their temperature, in consequence, raised to such a point that their sap is vaporized, and their fibres sundered by its effort to escape. Flashes and fiery balls and sparks accompanying the tornado, a smell of sulphur remains for several days in the houses, in which the curtains are found discolored. Every thing proves that the tornado is nothing else than a conductor formed of the clouds, which serves as a passage

* See 5th vol. of the American Philosophical Transactions, or Silliman's Journal for 1837, vol. 32, page 154.

for a continual discharge of electricity from those above, and that the difference between an ordinary thunder storm and one accompanied by a tornado, consists in the presence of a conductor of clouds, which seem to maintain the combat between the upper portion of the tornado and the ground beneath. At Chatenay this conductor was formed by the influence of an upper thunder cloud, which forced the lower portion of an inferior thunder cloud to descend and come into contact with the terrestrial surface."

Peltier concurs with me in the opinion that the tornado supersedes lightning by affording a conducting communication between the terrestrial surface and thunder cloud: but he conceives that the cloud by its descent becomes the conductor through which the electric discharge is accomplished: whereas agreeably to the explanation which I suggested, a vertical blast of air and every body carried aloft contributes to form the means of communication. Agreeably to this suggestion the electric fluid does not pass by conduction, but "convection," as explained in my letter of the 26th ult. That the idea of the Parisian savant that the cloud acts as a conductor is untenable, must be evident, since the light matter of which a cloud is constituted could not be stationary between the earth and sky in opposition to that upward aerial current of which the violence is proved to be sufficient to elevate not only water, but other bodies specifically much heavier than this liquid.

So much of the narrative of Peltier as relates to the repulsion between the thunder clouds, is inconsistent with any other facts on record respecting tornadoes which have come within my knowledge. It should be recollected that this part of the story does not depend upon the observation of the author, and may be due to the imagination of the witnesses whom he examined. The most important part of his evidence is that respecting the effect upon the trees, which appears to me to demonstrate that they were the medium of a tremendous electrical current.

In my memoir I noticed the injury done to the leaves of trees, and stated my conviction that "*as it was inconceivable that mechanical laceration could have thus extended itself equally among the foliage, a surmise may be warranted that the change was effected by electricity associated with the tornado.*"

III.—*On Tornadoes, and Œrsted's Memoirs respecting them.*

To the Editors of the National Gazette.

Dear Sirs,—I believe it is generally admitted by electricians that the enormous discharges of the electric fluid, which, during thunder gusts, take place in the form of lightning, are the consequence of the opposite electrical states of an immense stratum of the atmosphere coated by the thunder clouds, and a corresponding portion of the terrestrial surface. In a memoir published in the 5th volume of the American Philosophical Transactions, republished in Silliman's Journal, vol. 32, for 1837, I had endeavored to show that the tornado was the consequence of the same causes producing in lieu of lightning, an electrical discharge by a vertical blast of air, and the upward motion of electrified bodies. In your Gazette of the 30th ult., you have republished an article by the celebrated Œrsted, in which it is alledged that tornadoes or water-spouts cannot be caused by electricity, because there is no evidence proving that persons exposed to them have experienced electrical shocks. To me it appears evident that the scientific author confounds the different processes of discharge to which I have alluded, the one occurring in thunder gusts, the other in tornadoes; also that he has forgotten that a shock can be given neither by a blast of electrified air, nor by a continuous electrical current, a transient interruption of the circuit being indispensable to the production of the slightest sensation of that nature. If a person, having a conducting communication between one of his hands and a charged surface of a well insulated battery, hold in the other hand a pointed wire, the battery will be discharged through him and through the wire, producing a blast of electrified air from the point, without his experiencing any shock; neither would a shock be given to any person by exposure to the blast thus produced.

This form of electrical discharge to which I ascribe tornadoes, in which electricity is conveyed from one surface to another by the motion of air or other movable bodies intervening, is by Faraday designated as "*convection*," from the Latin "conveho," to carry along with.

In the comparatively minute experiments of electricians, the process of convective discharge, is exemplified not only by the electrified aerial blast, but likewise by the play of pith balls, the

dance of puppets, or the vibration of a pendulum, or bell clapper. The passage of sparks is found to arrest or to check such movements, and in like manner the passage of lightning has been observed to mitigate the vertical force of a tornado.

While a meteor of this kind, which passed over Providence last year, was crossing the river, the water, within an area of about three hundred feet in diameter, was found to rise up in a foam, as if boiling. Meanwhile two successive flashes of lightning occurring, the foam was observed to subside after each flash. It is thus proved that a discharge by lightning, is inconsistent with the discharge by convection, and that so far as one ensues, the other is impeded.

In an account of a tremendous storm of the kind of which I have been treating, published in Silliman's Journal for July last, it is mentioned that at its commencement it was only a violent thunder gust. This is quite consistent with the experience acquired by means of our miniature experiments, in which a discharge by sparks may be succeeded by a discharge by convection, or vice versa; or they may prevail alternately. In one case the electric fluid passes in the gigantic sparks called lightning, in the other it is conveyed by a blast of electrified air. In the former case, animals are subjected to deleterious shocks, while in the latter no other injury is sustained than such as results from collision with the air, or other ponderable bodies.

In the case of the tornado, the vertical blast is accelerated by the difference between the pressure of the air at the earth's surface, and at the altitude to which the blast extends. Should this be a mile there would be a difference nearly of one hundred and forty four pounds per square foot. During the tremendous gale which prevailed at Liverpool last winter, the greatest pressure of the wind was estimated at only thirty pounds per square foot. So far as the ingenious inferences and observations of Mr. Espy, as to the buoyancy resulting from a transfer of heat from aqueous vapor to air hold good, the vertical force so alledged to arise, will co-operate to aid the influence of electric discharges by convection.

The distinguished author of the memoir alluded to at the outset of this communication, conceives that were electricity the cause of tornadoes, the magnetic needle should be disturbed by them; and without advancing any proof that such disturbance

does not take place, founds thus an objection to electrical agency. I conceive that it would be unreasonable to expect a magnetic needle to be affected by an electrified blast of air if protected from its mechanical force.

It has been shown by Faraday that without peculiar management, tending to prolong the reaction, the most delicately suspended needle cannot be made to diverge in obedience to the most powerful discharges of mechanical electricity. An electrical spark may impart a feeble magnetism, but is too rapid and transient, to affect a needle. Moreover, when a needle is at right angles to an electric current which would be quite competent to influence it if parallel to it, there can be no consequent movement, since the current tends to keep it in that relative position. The direction of every electrical discharge inducing a tornado must necessarily be nearly at right angles to the needle, since it must be vertical, while the needle is necessarily horizontal when so supported as to traverse with facility.

I do not perceive any facts or suggestions in the article by Œrsted, which are competent to render the phenomenon of which he treats more intelligible than it was rendered by the accurate survey and examination of the track of the New Brunswick tornado, by Pres. A. D. Bache, and Mr. Espy, in connexion with the accounts published by other witnesses of that and other similar meteors.

It seems to be admitted on all sides, that within a certain space there is a rarefaction of air tending to burst or unroof houses; that the upward blast consequent to this rarefaction, carries up all movable bodies to a greater or less elevation; and that an afflux of air ensues from all quarters to supply the vacuity which the vertical current has a tendency to produce. Trees within the rarefied area are uprooted and sometimes carried aloft, but on either side of it, or in front, or in the rear, are prostrated in a direction almost always bearing towards a point which during some part of the time in which the meteor has endured has been under the axis of the column which it formed.

It appears to me that all the well authenticated characteristics enumerated by Œrsted, are referable to the view of the case thus presented. This distinguished author assumes that there is a *whirling* motion, although between American observers, this is a debated question. It seems in the highest degree probable that

gyration does take place occasionally, if not usually, since in the case of liquids rushing into a vacuity, a whirlpool is very apt to ensue. But as slight causes will in such cases either induce or arrest the circular motion, such movements may be contingent. It would however appear probable that when gyration does exist, it may, by the consequent generation of a centrifugal force, tend to promote or sustain the rarefaction and thus contribute to augment the force, or prolong the duration of a tornado.

From observations made upon the track of the recent tornado at New Haven, I am led to surmise that there was more than one axis of gyration and vertical force. I conceive that in consequence of the diversities in the nature of the bodies or the soil, there was a more copious emission of electricity from some parts of the rarefied area than others. In two instances wagons with iron wheel tires and axles, were especially the objects of the rage of the elements. Trees equally exposed were unequally affected, some being carried aloft, while others were left standing. The area of a tornado track may be more analogous to a rough surface than a point, and the electricity may from its well known habitudes, be given off only from such bodies as are from their shape or nature most favorable to its evolution.

Since these inferences were made, I have observed in Reid's work upon storms, that similar impressions were created by facts observed during a hurricane at Mauritius, in 1824. It was remarked that narrow, tall and decayed buildings, ready to tumble into ruins, escaped at but little distance from new houses, which were overturned or torn into pieces. It was inferred there were local whirlwinds, subjecting some localities to greater violence than others in the vicinity. In the case of other hurricanes similar facts have been noticed.

It may be expedient here to subjoin, that I consider a hurricane as essentially a tornado, in which an electric discharge by "*convection*," associated with discharges in the form of lightning, takes place from a comparatively much larger surface. In the case of the hurricane, however, the area of the track is so much more extensive, that the height of the vertical column to the diameter of the base being proportionably less, there is necessarily a modification of the phenomena, which prevents the resemblance from being perceived. In the case of the hurricane, the column is too broad to come within the scope of a human eye.

So much has lately been presented to the public, either through the newspapers, journals, or lectures, which I consider demonstrably incorrect, that I can hardly, consistently with my love of true science, remain an inactive observer of the consequent perversion of the public mind. Unfortunately it is difficult if not impossible to discuss such subjects without a resort to language and ideas, which are too technical and abstruse for persons who have not made chemistry and electricity an object of study. I have however prepared a series of essays, in which the causes of storms are stated, agreeably to my view of this important branch of meteorology.